Original article

A birth cohort study in South-West Ethiopia to identify factors associated with infant mortality that are amenable for intervention

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Abstract: A one year live birth cohort of all identified children born in Jimma, Keffa and Illubabor Zones of Southwest Ethiopia, was followed from birth to the end of the first year of life, or to an earlier death, to investigate factors associated with mortality. All identified live-born infants were visited as soon as they were born and then bimonthly to the age of one or early death or lost for follow-up. Information was collected on socio-economic, behavioral, biological, and environmental factors for infants, mothers, and family immediately after birth and in consecutive visits. Overall, infant mortality was 106.2/1000, with estimates of 97.0/1000 and 113.5/1000 for urban and rural areas, respectively. Based on the results of the final Cox Proportional Hazards Model, mortality was associated with mothers' education and with antenatal care follow-up: there was better survival with at least one antenatal care follow-up. It was not associated with the mother's age per se but with marital status. Birth weight was strongly associated with infant mortality, and boys were more likely to die than girls. Twins were much more likely to die than signletons, even after taking their birth weight into account. Once adjustment had been made for these variables, there was no independent effect of the mothers' ethnic group or religion, or of family income. Family size was found to be significantly associated with infant mortality and higher mortality rate to families with the 2-4 persons. The type of water supply to the home was not associated with mortality, but habit of use of soap by the mother in washing her hands was. These results suggest that improvements in survival could be brought about by attempts to improve maternal education, antenatal care attendance, and habit of soap use in washing her hands which are amenable for change with local resources. [*Ethiop. J. Health Dev.* 2000;14(2):161-168]

Introduction

Ethiopia is one of the poor African countries with a GNP per head of about $120. It has a correspondingly high infant mortality rate, estimated for 1991 at 130/1000 for Ethiopia as a whole (1). It is not surprising that there are various estimates of infant mortality in a country where there is no vital events registration. The variation mainly emanates from method difference in the study reports. According to the 1994 National Census of Ethiopia, the estimated infant mortality rate was 116/1000 (2). Shamebo et al (1993) in a cases-referent study at nine rural and one urban kebeles, reported an infant mortality rate of 136/1000 (3).

In South-West Ethiopia, the most recent estimates are 153/1000 for Kefecho Shekacho, 120/1000 for Illubabbor and 147/1000 for Jimma Zones and 93/1000 for Jimma Town (2). Asefa et al (1997) in an epidemiological survey based on one-year birth cohort presented an overall infant mortality rate of 105.8/1000 (4). All the above findings show high infant mortality rate in Ethiopia.

Victora et al (1992) in a longitudinal study in Brazil showed that birth-weight and income strongly influence infant mortality (5). In Butajira, Ethiopia, Shamebo et al (1993) in a

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case-referent study showed that illiterate father and poor ventilation of a house are risk factors for infant survival (3). As regards maternal child rearing practice, Ketsela et al (1990) in Ethiopia and Dikassa (1993) in Zaire clearly showed the influence of hygiene on child morbidity (6,7). Jayachan-dran and Jarvis (1988) in a study based on sixty less-developed countries from UN Statistical Yearbook showed that good nutrition and the presence of informally trained health care personnel are more significantly related to low rates of infant mortality (8). In Jimma Town, Ethiopia, Asefa et al (1997), in a longitudinal study, showed that improved sanitation has a positive influence in growth (9).

Researchers on child health agree that the cause of infant mortality in developing countries is multi-factorial. The baby's survival depends on the interaction of socio-economic, biological, behavioral and environmental factors (10,11,12). Hence to understand infant survival one has to see the relation and interactions among the different socio-economic, biological, behavioral and environmental webs.

In a country, even where there is no vital events registration, to design a study which addresses the above-mentioned webs at the same time is challenging and rare. In order to address the above-mentioned gap, we design a community-based longitudinal follow-up comprehensive study which comprises socio-economic, biological, behavioral and environmental factors. This type of study could help to analyze factors that influence survival independently by considering most possible variables. Within the identified independent influencing factors, it is also possible to look for factors that are amenable for change by considering local resources.

In order to answer the study questions, a birth cohort study was conducted in 46 urban and 64 rural kebles in Jimma, Illubabor, and Keffecho Administrative Zones, in Southwest Ethiopia.

Methods

The population in the 46 urban and 64 rural kebeles was estimated to be about 300,200 at the time of the study, 1992-94. There is no vital events registration in Ethiopia. In order to identify live births all the traditional birth attendants (TBAs) both in urban and rural kebeles collaborated in the study. TBAs are women residents of the kebele they serve and, by tradition, they visit and assist women during pregnancy and delivery. Each TBA was responsible to her respective kebele, and went house to house regularly to locate pregnant women in their second trimester. The interviewer registered the address of the expectant mother. After registration both the TBA and the interviewer monitored the expectant mother so as to reach her on time soon after delivery.

All identified newborn infants in the above mentioned urban and rural kebeles were recruited into a one-year birth cohort study. All newborns were visited as soon as possible after birth and then at two months intervals for one year or to an earlier death.

For this study, in addition to age of the infant at the time of interview and date of death for dead infants, data were collected on a range of other variables. These include the ethnic group, religion, age, education, marital status, fertility history of the mother, the size of the family, soap use habit of mother in washing hands, housing variables, sanitation and water supplies, and family income. Infants anthropometric measurements were collected as soon as possible, i.e. within 24 hours after birth, and the infant was weighed at the same time, providing a proxy measure for birth-weight. Details of the study methodology have been given elsewhere (4,9).

Both bivariate and multivariate analyses were used to determine mortality rates and independent determinant factors of mortality. For these life table analysis with the Kaplan Meier, which is appropriate for censored observations, Log rank test of significance and a Cox Proportional Hazards Model with forward stepwise likelihood ratio method was used to establish which variables had independent predictive power for mortality. A Cox Proportional Hazards Model is the most frequently used model to study the relationship between time of death and a set of independent variables. It is the basic model for survival data and it is analogous to the multiple regression analysis where the time when an event occurs is considered rather than simply whether or not an event (death) has occurred. The regression model defines the hazard for a person at a given time (16). All variables used in the Kaplan Meier analysis were entered into the Cox Hazards Regression Model. Analyses were conducted in SPSS version 8 for windows.

Results

The total initial sample size from the three zones was 8273. Table 1 shows the numbers entering every two months interval, and the number of reported cumulative deaths at different ages. The cumulative proportion surviving to the end of the first year was 0.8938 with SE 0.0035. This is an infant mortality rate of 106.2 per 1000. The cumulative proportion surviving the first seven days was 0.9814 with SE 0.0015. This is an early neonatal mortality rate of 18.6 per 1000.

Table 1: **Cumulative proportion surviving and its standard error at different ages**

Time interval	number entering this interval	Cumulative deaths	Cumulative proportion surviving	SE of cumulative proportion surviving
At birth	8273	69*	0.9917	0.0010
One week	8039	153	0.9814	0.0015
Four weeks	7911	265	0.9681	0.0019
0-59	8273	373	0.9546	0.0023
60-119	7792	527	0.9256	0.0027
120-179	7513	623	0.9236	0.0029
180-239	7309	711	0.9124	0.0031
240-299	7125	783	0.9031	0.0033
300-360	6963	846	0.8942	0.0034
364		847	0.8938	0.0035

(*) Deaths that occurred after birth and before 24 hours of age

Table 2 shows separate estimates of mortality, based on the life table analysis, for the different factors considered. The non-parametric Log Rank test (X^2_{LR}) based on the Kaplan Meier Statistic was used to test differences in survival outcomes between the different levels of each factor. The bivariate analysis presented in Table 2 shows that, of the socio-demographic factors, mortality is associated with ethnicity, marital status, mothers family status, education, family income, family size, and availability of radio. Of the environmental and sanitary factors, type of roof and floor of the house, latrine facility, and soap use habit for washing hands are associated with mortality. None of the maternal factors (parity, history of abortion, and still birth) was found to be significant. Attendant of delivery and antenatal follow-up have an association with mortality. In addition sex of the infant, birth weight, and type of birth

Table 2: **Infant mortality rates (IMR) based on the life table estimates**

Factors	Number of Infants	Number of deaths	IMR per 1000①	χ^2_{LR}	P-Value
Age of the mother				4.57	0.3347
<20	976	114	122.2		
20-24	2209	218	102.9		
25-29	2157	213	103.5		
30-34	1526	148	99.6		
≥35	1395	153	114.4		
Ethnic group of mother				14.51	0.0428
Oromo	5525	594	111.5		
Amhara	673	56	87.6		
Keffa	613	62	110.0		
Daworo	517	63	126.2		
Gurage	428	31	77.0		
Yem	296	27	95.6		
Tigre	116	9	80.0		
Other	91	3	35.9		
Mother's religion				2.30	0.1294
Christian	2579	239	98.7		
Muslim	5680	606	109.5		
Marital status				32.32	<0.001
Married	7668	750	101.1		
Single	309	50	175.9		
Divorced	210	15	159.0		
Widowed	74	30	208.7		
Mother's family status				19.42	<0.001
Wife	7590	750	102.1		
Daughter	326	48	155.7		
Head of household	191	26	147.4		
Other	154	22	170.3		
Mother's education				22.73	<0.001
Illiterate	5021	579	118.5		
Elementary	1866	167	93.1		
Junior and above	1368	99	77.7		
Family size				10.88	0.0043
2-4	3115	355	119.9		
5-7	3636	359	101.6		
+8	1512	132	89.4		
Monthly family income				24.07	<0.001
<100	4880	546	114.2		
100-299	1915	187	193.5		
300+	984	56	61.4		
Availability of radio				15.17	<0.001
Yes	2243	178	85.4		
No	6018	668	114.0		
Type of roof				5.11②	0.0237
Thatched	4423	489	112.7		
CIS③	3801	355	99.7		
Other	39	2	52.3		
Type of floor				10.64	0.0138
Earth	7253	766	108.6		
Cement	783	53	79.2		
Wood	51	7	145.7		
Other	176	20	124.3		

(Table 2 continued)

Factors	Number of Infants	Number of deaths	IMR per 1000①	X^2_{LR}	p = value
Source of drinking water				5.37	0.2517
River or pond	1487	164	112.5		
Unprotected spring	2571	283	112.5		
Protected spring	2602	258	103.2		
Public tap	1179	107	95.1		
Private tap	422	34	97.9		
Type of latrine				21.48	<0.001
None	5232	597	116.5		
Private pit	1883	139	77.7		
Shared pit	870	84	103.9		
Flush toilet	275	26	114.2		
Hand washing with soap				6.07	0.0137
Yes	7153	712	103.1		
No	1109	134	126.1		
Number of children born				3.76	0.2882
1	1890	204	113.3		
2-4	3725	363	101.7		
5-7	1992	203	103.7		
≥8	646	76	118.6		
History of abortion				0.62	0.4310
Yes	644	72	115.1		
No	7619	774	105.5		
History of still birth				1.36	0.2441
Yes	179	23	131.6		
No	8084	823	105.7		
Antenatal care attendance				34.78	<0.001
Yes	4262	354	87.4		
No	4011	493	126.2		
place of delivery				3.72	0.0539
Health Institution	1381	118	90.8		
Home	6892	729	109.2		
Attendant of delivery				9.86	0.0198
Health personnel	1615	134	88.6		
TTBA	1712	189	117.0		
Relatives	2772	311	114.8		
Non-relatives	2174	213	100.0		
Sex of infant				5.00	0.0254
Female	4068	387	98.0		
Male	4205	460	114.2		
birth-weight				246.10	<0.001
≥2500 g	7274	550	79.2		
<2500 g	793	185	239.3		
Type of birth				377.62	<0.001
Single	8050	749	96.8		
Multiple	223	98	444.8		
Residence				6.67	0.0098
Urban	3798	346	97.0		
Rural	4475	501	113.5		
Total	8273	857	106.2		

X^2_{LR} = Log rank Chi square statistic
① Estimates based on the life table analysis = 1-Cumulative proportion surviving at end
② *comparison is for thatched and CIS roofs only*
③ CIS = Corrugated Iron Sheet
In some of the variables total does not add up to total infants (8273). This is because of missing data specially for birth-weight that included only those infants weighed within 24 hours from birth.

were found to be associated with infant mortality.

Further analyses were carried out using a Cox Proportional Hazards Model, so that the factors investigated could be controlled for one another. The coding of the variable was the same as for the bivariate analyses. Expecting mortality in the perinatal period to have varied causes from mortality later in infancy, we presented determinants of infant mortality for all infant deaths and for those deaths after the first week of life separately. Results from the Cox Proportional Hazards Model are presented in Table 3 and 4 for the analyses made to all variables.

Table 3: **Factors independently associated with infant mortality**

Factors	HR④	95% CI for HR
Birth weight		
≥2500 g	1	
<2500 g	2.60	(2.14, 3.17)
Sex of infant		
Female	1	
Male	1.35	(1.16, 1.57)
Type of birth		
Single	1	
Multiple	3.32	(2.51, 4.39)
Marital status		
Married	1	
Single	2.67	(1.76, 4.04)
Divorced	1.35	(0.76, 2.40)
Widowed	1.75	(0.94, 3.29)
Education		
Elementary	1	
Illiterate	1.28	(1.05, 1.56)
Grade 7 and above	0.87	(0.65, 1.16)
Family siz		
≥8	1	
2-4	1.39	(1.11, 1.73)
5-7	1.19	(0.96, 1.49)
ANC follow-up		
Yes	1	
No	1.26	(1.07, 1.47)
Soap use		
Yes	1	
No	1.32	(1.07, 1.63)

④HR = Hazard Rate (Relative Risk)

Parameter estimates for the final model are shown in Table 3. Marital status, education, family size, and antenatal care follow-up, all the child variables (sex, birth weight and type of birth) were independently statistically significant. Of the environmental and economic variables only soap use habit remained statistically significant. These variables are also associated with post neonatal mortality with small modification in magnitude (Table 4).

Table 4: **Factors independently associated with post neonatal mortality**

Factors	HR④	95% CI for HR
Birth weight		
≥2500 g	1	
<2500 g	2.36	(1.92, 2.91)
Sex of infant		
Female	1	
Male	1.37	(1.17, 1.60)
Type of birth		
Single	1	
Multiple	3.18	(2.35, 4.29)
Marital status		
Married	1	
Single	2.83	(1.85, 4.32)
Divorced	1.46	(0.83, 2.59)
Widowed	1.58	(0.78, 3.18)
Education		
Elementary	1	
Illiterate	1.27	(1.03, 1.55)
Grade 7 and above	0.88	(0.65, 1.18)
Family siz		
≥8	1	
2-4	1.36	(1.09, 1.71)
5-7	1.15	(0.92, 1.44)
ANC follow-up		
Yes	1	
No	1.24	(1.05, 1.46)
Soap use		
Yes	1	
No	1.30	(1.05, 1.62)

④ HR = Hazard Rate (Relative Risk)

Discussion

The overall mortality rate estimate for the regions we studied (106.2/1000) was lower than the most recent census estimate for the Jimma, Illubabor and Keficho Shekacho (147, 120, and 153/100 respectively) Zones. The estimates for urban areas are almost similar (97.0 against 98.0) and lower for rural areas (113.5 against 121.0) for this study and the nation as a whole (2).

Maternal variables associated with mortality were marital status, education, antenatal follow-up, and soap use habit in washing hands. Infants born to single mothers had a higher rate of mortality compared to those from married mothers. The independent hazard rate (HR) or relative risk being 2.67 (95% CI: 1.76 to 4.04) for those from single compared to married mothers. The determination of literacy should be reliable, since all mothers who said they could read were asked to read a piece of text to the interviewer. There is a higher mortality in the children of mothers who were not educated, the HR being 1.28 (95% CI: 1.05 to 1.56) compared with mothers educated up to grade six. As indicated larger family size was beneficial for infant survival, for reasons that need further investigation.

Mother's antenatal follow-up at least once, clearly indicates a beneficial effect. Those infants born to mothers who had no antenatal follow-up during pregnancy had a 1.26 (95% CI: 1.07 to 1.47) higher risk of dying than those who had at least one follow-up.

Early weights strongly predicted mortality, as one would expect (13). The mortality in the low birth-weight group (early weight <2500 g) is 2.60 time higher than in those weighing above 2500g. There were 110 pairs of twins and one set of triplets in the cohort, a rate of 13.6/1000. The adverse effect of multiple births was not simply due to their lower birth weight. Even adjusted for birth weight it was a substantial effect, the risk in multiple births being over three times as high. This is a substantially larger effect than was found in Malawi (1) in which the risk ratio for post perinatal mortality was 1.53. Infant mortality was also higher in males, as was found in the 1994 census (2).

Income, as measured, was no longer significantly associated with mortality once other variables were taken into account, although in a bivariate analysis it was associated with mortality in the expected direction. This may be because income has important effects via the mother's nutrition, and this would act partly or wholly through a pregnancy effect on birth weight (15). There was no clear benefit associated with particular types of water supply. In the bivariate life tables analysis this factor fell far short of statistical significance (p=0.2517) and adjusting for all other variables initially entered into the Cox regression did not improve on this, so not even a marginal effect was detectable. Though, in the bivariate analysis, latrine facility had significant association with mortality, it does not show detectable significant effect when entered into the final model. Infants born to mothers who did not use soap for washing hands had 1.32 (95% CI: 1.07 to 1.63) times higher risk of dying than those who used soap. This might be directly related to hygienic practices that reduce contamination and infections.

In the final model an attempt to examine the four major areas of socio-economic, behavioral, biological, and environmental factors at the same time, has led to the effects of some expected variables to disappear and some to be attenuated. Factors like income, water, sanitation could have effects through mothers soap use behavior.

In the light of this finding it will be a worthwhile attempt to literate mothers, improve access to antenatal care, and encourage soap use that seems to a certain extent manageable at the grass-root level to improve the lives of children both at the perinatal and postnatal periods.

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