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The impact of neonatal mortality on subsequent survival in rural Ethiopia

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Summary In countries where most deliveries occur at home and most available information is hospital-based, accurate information on neonatal mortality is difficult to obtain. This study was conducted in a rural community in Ethiopia that has been under monthly demographic surveillance since 1987. The analysis in this paper was based on data collected in the 1st decade (1987–96) and this database was used to calculate mortality incidence rates and analyse survival. The overall neonatal mortality rate was 27/1000 live births (95% CI 24.5–29.5). The rates in the early and late neonatal periods were 20 and 8/1000 live births, respectively (95% CIs 18.0–22.9 and 6.6–9.4). The mortality incidence rates show that, every day, three of every 1000 newborns die in their 1st week of life. Neonatal mortality accounted for 43% of infant mortality. If all neonates survived the 1st week of life, life expectancy would increase by 1 year. Increased risk of neonatal mortality was found to be associated with living in a rural lowland area, twin births and male gender. This paper also addresses the need for further identification of the complex environmental and behavioural risk factors for neonatal mortality and for instituting appropriate and affordable interventions to reduce neonatal mortality.

Introduction

Worldwide, there are eight million infant deaths every year. Of the five million of these that are neonatal, 98% occur in developing countries. However, neonatal mortality has not been widely studied in African communities where mortality rates are extremely high and most deliveries take place at home without the help of professional birth assistants. The few studies undertaken show that about half the deaths in the 1st year of life occur during the neonatal period.[1,2] Despite this, public health interventions to reduce excessive infant mortality in most developing countries have focused largely on causes of post-neonatal deaths such as vaccine-preventable and diarrhoeal diseases.[3]

Maternal factors such as young age, poor reproductive history (previous stillbirth) and prematurity are associated with an increased risk of neonatal mortality.[1,4] High parity has traditionally been considered an important risk factor,[5] although recently this has been disputed.[6,7] Various studies have shown that there is an increased risk of neonatal mortality in boys and in multiple pregnancies.[1,8,9] In rural, agriculture-based societies, neonatal mortality peaks in the pre-harvest season (wet season) when food is scarce and agricultural activity intense.[1]

In many developing countries there are few community-based data, but surveillance systems such as the Butajira Rural Health Programme,[10] part of the International Network of Field Sites for the Continuous Demographic Evaluation of Populations and their Health in Developing Countries (INDEPTH),[11] could serve for epidemiological analysis. Continuous surveillance also offers the possibility of person-time calcu-

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lations accounting for dynamic population changes. In this study of the neonatal mortality incidence rate (NMIR), person-time at risk is used as a denominator, thus allowing for day-by-day assessment of the risk of death in the neonatal period.

The aims of this study were to analyse the extent of neonatal mortality, its contribution to infant mortality and the implications for life expectancy by calculating both the neonatal mortality rate per live births and the neonatal mortality incidence rate per person-time.

Subjects and Methods

The study was conducted in south central Ethiopia in the districts of Meskan and Mareko, Gurage Zone. The area's principal town, Butajira, is 130 km south of the capital city, Addis Ababa. The health centre in the town provides the highest level of health care in the district. The nearest hospital providing surgery is 100 km away on a badly maintained, dusty gravel road. There is no well established referral system to or from the health centre. Public transport is poor and unaffordable to most of the rural population.

The district's topography is diverse, varying from a lowland area bordering the great East African rift valley in the east to mountain ranges in the west. On average, the study district is 2100 m above sea level. In this paper, areas less than 1500 m above sea level were considered lowland and those 1500 m or above as highland. The lowland areas are hot and dry with frequent food shortages and high malaria endemicity. The study site is also officially divided into urban and rural areas based on population size and the availability of basic developmental infrastructures.

Data presented in this study were extracted for the period 1987–96 from the demographic surveillance system maintained by the Butajira Rural Health Programme (BRHP). The BRHP undertake monthly surveillance in ten randomly selected *kebeles* (the smallest administrative unit in Ethiopia) of the district. The surveillance covers approximately 10% of the district's population. Data are collected on structured forms through house-to-house enquiry by lay interviewers and vital events registered monthly include births, deaths and migration. Details of the field operation have been given elsewhere.[10] The variables maternal age, previous infant deaths and siblings were obtained by linking children to their mothers in the dataset using a unique identification number for the mother on the child's record. In this way, information was obtained for 8197 of the 15,667 newborns. Linkage was not possible for all because the unique identification number was not introduced from the start of the surveillance system.

A neonatal death is defined as the death of a live-born baby within 28 days of birth. Early neonatal death refers to death within the 1st 7 days and late neonatal death to death after the 7th day. Early neonatal mortality rates (early NMR) and neonatal mortality rates (NMR) are expressed as deaths/1000 live births. Early neonatal mortality incidence rates (early NMIR) and neonatal mortality incidence rates (NMIR) are calculated by dividing the number of cases by person-days of follow-up in the respective period.

Almost all births in the district take place at home, generally with the help of relatives and friends. As in some other countries in sub-Saharan Africa, traditional birth attendants (TBAs) are usually consulted for difficult labour.[12] Antenatal care and immunisation services cover a very small proportion of the population. Neonatal care facilities and specialist paediatric care are non-existent in and around the study district.

Data were processed with the aid of customised project software using the dBase platform. Analysis was done using Epi Info version 6.04 and Cohort statistical software, version 1.0.[13] All background factors in Table 1, except previous infant death which was excluded because there were too

TABLE 1. *No. of live births, stillbirths, early and late neonatal deaths, early neonatal mortality rate (early NMR), neonatal mortality rate (NMR) per 1000 live births, early neonatal mortality incidence rate (early NMIR) and neonatal mortality incidence rate (NMIR) per 1000 person-days and relative risks (95% confidence intervals) by different risk factors in Butajira, Ethiopia, 1987–96.*

	Live births	Died within 1st week	Died between days 8 & 28	Early neonatal person days	Late neonatal person days	Early NMR	NMR	Early NMIR	NMIR	Early NMIR Rate ratio (95% CI)		NMIR Rate ratio (95% CI)	
Overall	15,550	305	121	107,228	319,511	20	27	2.84	1.00				
Area													
Highland	6952	125	49	48,015	143,125	18	25	2.60	0.91	2.31	(1.42–3.74)	1.87	(1.29–2.71)
Lowland	6164	161	58	42,224	125,469	26	36	3.81	1.31	3.38	(2.10–5.44)	2.67	(1.86–3.86)
Urban	2434	19	14	16,989	50,917	8	14	1.12	0.49	Ref.		Ref.	
Female	7674	113	47	53,207	157,668	15	21	2.12	0.76	0.60	(0.47–0.76)	0.61	(0.50–0.74)
Male	7876	192	74	54,021	159,153	24	34	3.55	1.25	Ref.		Ref.	
Singleton	5768	33	18	40,120	119,128	6	9	0.82	0.32	Ref.		Ref.	
Twin	185	35	4	1068	3067	189	211	32.8	9.43	40.6	(25.2–65.3)	29.5	(19.4–44.7)
Maternal age													
⩽19 y	1016	4	6	5419	16,047	4	10	0.74	0.42	0.42	(0.15–1.19)	0.61	(0.30–1.24)
20–29 y	3316	36	22	20,559	61,034	12	18	1.75	0.33	Ref.		Ref.	
30–44 y	3101	42	13	20,973	62,082	14	18	2.00	0.21	1.15	(0.73–1.79)	0.97	(0.67–1.40)
⩾45 y	355	5	1	2453	7308	14	17	2.04	0.14	1.18	(0.46–3.01)	0.90	(0.39–2.08)
No. of children in family													
1	1643	16	6	11,396	33,771	10	13	1.40	0.18	0.93	(0.53–1.63)	0.81	(0.51–1.29)
2–4	5192	54	32	36,005	106,667	10	17	1.50	0.30	Ref.		Ref.	
⩾5	1322	26	10	9085	26,840	20	27	2.86	0.37	1.92	(1.20–3.06)	1.66	(1.13–2.45)
Previous infant deaths													
0–1	8020	79	35	55,630	164,948	10	14	1.42	0.21	Ref.		Ref.	
2–3	137	17	13	856	2330	124	219	19.9	5.58	13.9	(8.23–23.48)	18.22	(12.19–27.24)

(Ref, reference category; RR = 1).

many missing cases, were analysed using a Poisson regression model. Incidence rates are expressed per person-days. Relative risks and 95% confidence limits were also calculated.

Results

During the study period, 1987–96, 15,667 births in the study area were followed for 426,739 person-days. Of these, 15,550 were live births. There were 305 early neonatal (0–6 days) deaths and 121 late neonatal (7–27 days) deaths. The early NMR was 20/1000 live births (95% CI 18.0–22.0) and the late NMR 8/1000 live births (95% CI 6.6–9.4), giving an overall NMR of 27/1000 live births (95% CI 24.5–29.5). Incidence rates calculated using person-days as the denominator resulted in an early NMR of 2.8/1000 person-days and an NMIR of 1/1000 person-days (Table 1).

Life expectancy at birth was highest for girls in the urban area and lowest for boys in rural lowlands. Incidence rates were calculated for early neonatal, neonatal and infant mortality. Combining the three measures shows that neonatal mortality accounts for a substantial 35–43% of infant mortality (Fig. 1). A life expectancy of 51 years at birth would increase by 1 year if the newborn survived the 1st week of life. For the subsequent 3 weeks, life expectancy increased by another 7 weeks. The gain in life expectancy for the next 11 months was 2.8 weeks and 1.4 weeks for 1–4 years (Fig. 2). When stratified by area, the lowland villages showed the shortest life expectancy at birth and the urban areas the longest. Rural areas in general had higher mortality rates than the urban area, with the lowlands having the highest rates. Girls had lower mortality rates than boys (RR 0.60–0.61).

High maternal age was a risk factor. However, no increased risk was seen for maternal age under 20 years. This is probably owing to under-registration of cases of stillbirth and neonatal death for these mothers. There was a 60–90% excess NMR in new-

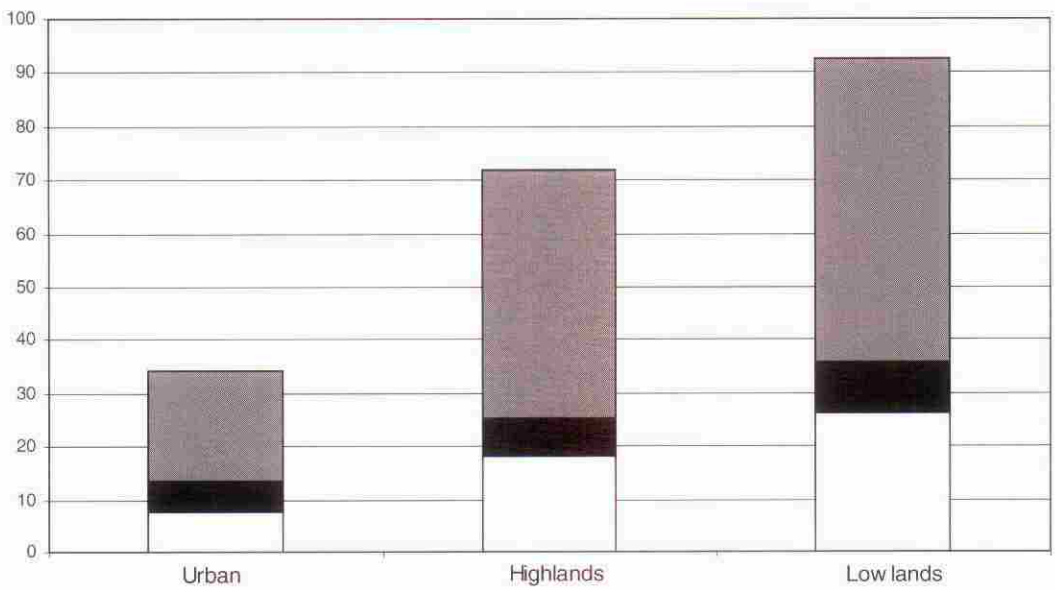

FIG. 1. Mortality rates per 1000 person-years for infants, neonates and early neonates by area in Butajira, Ethiopia, 1987–96. □ 1st week, ■ weeks 1–3, ▨ months 1–11.

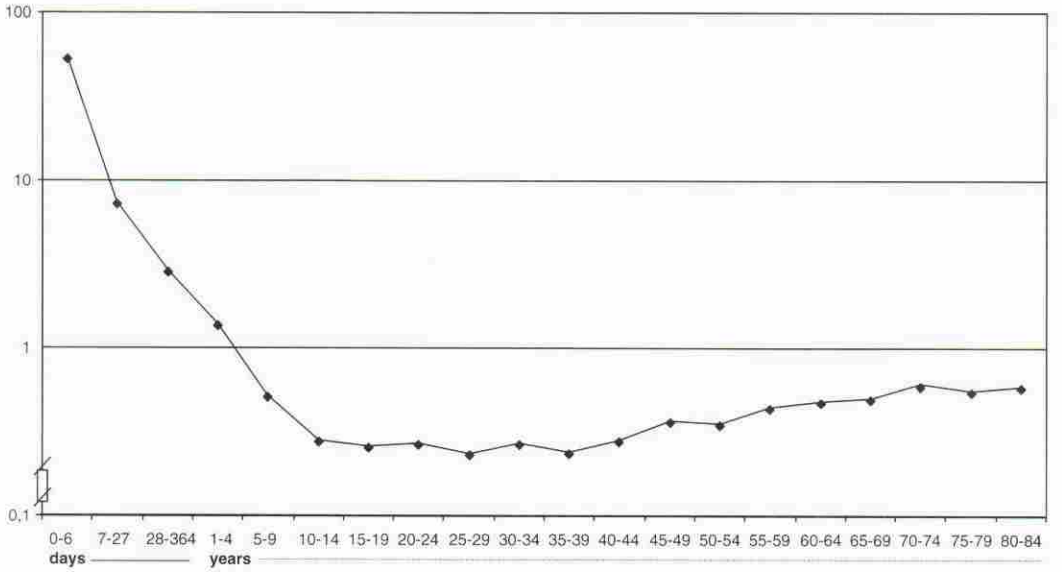

FIG. 2. The ratio of life-weeks saved per life-weeks lived computed from life table analysis in Butajira, Ethiopia, 1987–96. Log scale on Y axis.

borns from large families (five or more children) compared with families of two to four children. More than one previous infant death among the siblings gave a relative risk (RR) of 13.9 and 18.2 for early and overall NMR, respectively. There were 93 pairs of twins and one set of triplets. Thirty-three twins died in the 1st week of life and 18 in the next 3 weeks (relative risks 40.0 and 29.5, respectively). One of the triplets died in the 1st week of life.

In a Poisson regression model including all variables except previous infant death, living in a rural area and twin birth were maintained as risk factors while being female maintained its protective effect.

Analysis of seasonal variation in neonatal mortality showed a peak in April, for both the early neonatal period and the neonatal period as a whole. Apart from this, monthly variations were quite small.

Discussion

This study shows that substantial gains in life expectancy could be achieved by reducing neonatal mortality. One year can be added to life expectancy by surviving the 1st week of life. Neonatal death accounts for almost half the infant mortality rate and is highest among boys, multiple births and in the semi-arid lowland areas.

In the villages studied, vital events were identified and recorded through monthly house-to-house visits and the data are fairly complete.[10] However, it is likely that some neonatal deaths were not recorded as there are cultural constraints on reporting such deaths in the study area. Jaffar has also shown that in Africa mortality data are generally poorer than birth data from the same area.[14] Information on mothers was obtained by linking children's information with their mothers using a unique identification number. This system was not introduced to the surveillance system until 1994, which is why a large proportion of newborns were not linked with their mothers' characteristics. Information on mothers' parity and reproductive history and the children's birth order was not collected but obtained instead through the linkage. The weaknesses of this are that some linkages are missing and that

it does not include much data about mothers who left the study villages before the linkage was implemented. Some important determinants of neonatal mortality were not explored because of a lack of information about the mother's past reproductive history. Since almost all births took place at home, birthweights were not available. Pregnancies were not followed in the surveillance system. These shortcomings make it probable that neonatal mortality is under-estimated in this study. Empirical data also show that NMRs in this study were lower than rates reported from studies involving pregnancy follow-up.[15,16] NMRs reported in other studies from Ethiopia vary between 16 and 70/1000 live births.[17] Only one of these studies used community-based data. A study conducted in the early 1980s in the capital, Addis Ababa, reported similar NMRs,[18] but the setting is completely different from our study and the rates cannot be directly compared.

In this study, the advantage of having longitudinal surveillance data has been exploited by calculating person-time incidence rates and by performing a survival analysis. Furthermore, the longitudinal data permitted analysis of life expectancy. The neonatal mortality incidence rate provided a more quantitative measure of risk at different times in the neonatal period. It showed that the risk of dying in the early period (1st week of life) was three times greater than in the later period.

Other studies have shown that a history of stillbirth is a significant risk factor for perinatal or neonatal death.[1] For reasons mentioned earlier, information on stillbirths was not available to make a proper assessment. However, previous infant death was strongly associated with neonatal death in both univariate and multivariate analysis.

High parity showed an increased risk of neonatal death. When combining all variables in a multivariate model, no remaining increased risk among highly parous women was seen. Other studies have also shown that parity as a risk factor is reduced or even lost when maternal age is taken into consideration.[6,7] This is in contrast with earlier findings which have claimed that grand multiparity is a risk factor for poor obstetric outcome.[5,19,20]

The gender difference in neonatal mortality in this study was statistically significant both in univariate analysis and after adjusting for other factors in the Poisson regression model. This finding is consistent with earlier findings.[9,21] Early in life, more biological factors appear to favour girls. Geographic differences in neonatal mortality were consistent with the general pattern in both children and adults in this area, the most favourable rate being in the urban area and the worst in the semi-arid lowland area.[10,22,23] Compared with the highland study areas, the lowland area suffers severe food shortages owing to low agricultural yield, a high disease burden related to malaria endemicity and a high level of malnutrition, and poorer access to health services.

Because mothers and their newborns are inseparable, most problems affecting women during pregnancy and childbirth, such as poor nutritional status, obstructed labour, antepartum haemorrhage, infection and pregnancy-induced hypertension, have a strong negative impact on the baby. Thus, interventions to reduce neonatal mortality should be closely linked to improving the health of women and making motherhood safe.[24,25] As some of the causes of poor obstetric outcome are deeply rooted in the raising of girls and the status of women in that society, it is extremely important to pay attention to women's health throughout their lives and not only during pregnancy.

Only recently has the importance of reducing neonatal death been given attention,[26] and it is being recognised increasingly that the causes of perinatal and neonatal mortality and morbidity can be prevented and treated even with limited resources.[17,26] Preventable causes of neonatal death, such as infection and asphyxia, account for the majority of neonatal deaths in developing countries and inexpensive interventions have

been developed.[17] The importance of TBA-assisted and hygienic delivery is well known and the effects of such interventions have been studied.[7,8,26]

The factors that affect neonatal mortality are many and complex and there is therefore a need for community-based studies to identify the risk factors amenable to intervention.[3] The surveillance system should also include pregnancy follow-up in routine data collection in order to get complete information on adverse outcome of pregnancy, especially perinatal death.

Interventions aimed at reducing neonatal mortality should generally include improvement of obstetric services and reduction in the number of pregnancies per woman by increasing access to family planning services. In areas where these services are not yet widely available, improving the neonatal mortality rate is a formidable challenge for health managers/planners. However, strategies such as kangaroo mother care can improve newborns' well-being even in resource-poor settings.[27] Operational research might play a crucial role in introducing and evaluating affordable health care strategies. We strongly recommend therefore that an integrated health care approach to improving neonatal survival be introduced at the grassroots level using simple and affordable technologies. Such efforts need to be strengthened by creating an emergency referral system and mechanisms such as maternity waiting homes to encourage early referral of high-risk mothers.[28] If these steps are not taken, infant mortality rates, a sensitive health indicator worldwide, will remain unacceptable despite efforts later in infancy.

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