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Neonatal Mortality in Rural Bangladesh: An Exploratory Study

Mahbub Elahi Chowdhury[1,2], Halida H. Akhter[1], Virasakdi Chongsuvivatwong[2], and Alan F. Geater[2]

[1]Bangladesh Institute of Research for Promotion of Essential & Reproductive Health and Technologies, House 105, Road 9/A (New), Dhanmondi Residential Area, Dhaka 1209, Bangladesh and [2]Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Hat-Yai 90110, Thailand

ABSTRACT

Bangladesh has a neonatal death rate that is substantially high and demands urgent attention. To assess the causes of neonatal mortality, 1,019 pregnant women were followed up in eight randomly-selected rural areas of the country. Trained female interviewers visited the households of the subjects at four-week intervals to record neonatal deaths (within 28 days after birth). For each death, they administered a structured verbal autopsy questionnaire to the mother and/or a close family member. Based on these field data, three neonatologists arrived at a consensus to assign two causes of death—an originating cause and a direct cause. The neonatal mortality rate was 53.5 per 1,000 livebirths. The originating causes of death were pre-maturity/low birth-weight (30%), difficult labour (16%), unhygienic birth practices (16%), others (4%), and unknown (34%). The direct causes were sepsis (32%), asphyxia (26%), tetanus (15%), respiratory distress (6%), others (6%), and unknown (14%). According to the prevailing causes of neonatal deaths, implementation of intervention programmes, often in the community, that do not depend on highly-technical training or sophisticated equipment should be implemented.

***Key words*:** Causes of death; Neonatal mortality; Bangladesh

INTRODUCTION

Every year, over 10 million children, aged less than five years, die globally before their first birthday, and about 40% of these deaths take place within the first 28 days of life, i.e. the neonatal period (1,2). Neonatal mortality rates vary from five in developed countries to 34 per 1,000 livebirths in the less-developed regions of the world (3). Although there has been a remarkable worldwide decline in child mortality in the last quarter of the 20th century, this reduction in death rate has occurred mainly among older children, mostly due to the effects of immunization and infectious disease-control programmes. According to the World Health Report, infant mortality declined by about 25% in developing countries during 1983-1995, whereas during the same period neonatal mortality fell by no more than 10% (4). To achieve further reductions in infant and child mortality rates, a substantial reduction in neonatal death is of major public-health importance (5). Updated knowledge on the cause of death in neonates is needed from a country perspective, both for policy-making and for monitoring and evaluating the existing health programmes.

In developing countries, 63% of deliveries take place at home (6). In rural Bangladesh, this proportion is about 94% (7). Hospitals with facilities for neonatal care are not accessible to the rural population. Most neo-natal deaths take place at home, and the cause of death is not recorded owing to a deficient death-registration system.

Correspondence and reprint requests should be addressed to:
Dr. Mahbub Elahi Chowdhury
Reproductive Health Unit
Public Health Sciences Division
ICDDR,B: Centre for Health and Population Research
GPO Box 128, Dhaka 1000
Bangladesh
Email: melahi@icddrb.org
Fax: (8802) 8826050

Lay reporting or verbal autopsy data from home visits remain the only sources of information for identifying causes of neonatal deaths in developing countries.

In general, neonatal deaths are the consequence of events usually associated with poor maternal health and non-availability of care during delivery or immediately after birth. Death usually originates from a cause that triggers a sequence of morbidities that ultimately precipitates death. It is, therefore, important from an epidemiological point of view to distinguish the originating causes from the direct causes, so as to apply interventions to remove the originating causes, thereby preventing the direct cause from operating. According to ICD-10 (8), an originating cause is defined as "the disease or injury which precipitated a train of morbid events leading directly to death." We defined a direct cause as "the apparent morbid condition occurring immediately before death, that might have arisen due to another disease or injury or consequences of some circumstances."

In Bangladesh, very few studies have reported the causes of early and late neonatal deaths in the community (9,10), and there is a dearth of recent published data on this issue. Baqui *et al*., while documenting the causes of childhood mortality using data from the Demographic and Health Survey 1993-1994, reported the causes of late neonatal deaths (11) but did not classify the causes of early neonatal deaths owing to a deficiency of data. None of the above studies objectively addressed the originating and the direct causes of neonatal mortality.

To fill the knowledge gap, we conducted a follow-up study of pregnant women in rural Bangladesh to obtain verbal autopsy data in the cases of early or late neonatal deaths, from which originating and direct causes were assigned. We also examined the variability of early and late neonatal deaths with sociodemographic and reproductive characteristics of mothers, their delivery complications, and use of health services.

MATERIALS AND METHODS

Study sites and subjects

We observed a cohort of pregnant women for their pregnancy- and childbirth-related complications, including the health outcome of their neonates among a population of 145,000 in selected rural areas of all the four former administrative divisions (Dhaka, Chittagong, Rajshahi, and Khulna) in Bangladesh. We randomly selected one district from each division, one upazila (sub-district) from each selected district, and two unions (the lowest administrative unit) from each of the four selected upazilas. The field workers, by making door-to-door visits to each household in all eight selected unions, identified 1,019 pregnant women who were less than or equal to 24 weeks of gestation to enroll into the study. Trained female interviewers followed up these women at home every four weeks throughout the remaining pregnancy and neo-natal periods. The study took place from October 1992 to September 1993.

Experienced researchers provided a two-week intensive training and testing on data collection to 12 non-physician college-graduate female interviewers. In addition to training on basic interview techniques and use of study instruments, the training emphasized pregnancy complications and symptoms of common causes of neonatal death. The interviewers were also trained to ask the respondents each question consistently. A structured questionnaire was used for interviewing mothers about their socioeconomic and reproductive characteristics, including maternal complications, use of health services, and neonatal health status. For each neonatal death, the interviewer filled up a separate checklist covering symptoms of disease conditions of the neonates before death, which included cough or cold, fever, vomiting, stopping of feeding, convulsions, diarrhoea, and other diseases. At the end, they recorded an unprompted description of the illness that led to death as stated by the mother and/or a close family member. The quality of data was assured by field-level scrutiny of every completed questionnaire and regular study-monitoring visits by the investigators.

We designated three teaching neonatologists at the Department of Pediatrics, Songklanagarind Hospital, Thailand, to assign the cause of death after reviewing the field data. They were provided with two papers as a guideline for classification of verbal autopsy data consisting of (a) 14 clinically-significant categories of perinatal mortality used in a study in the United Kingdom (13), reclassified from the 'P list', consisting of 100 common causes of stillbirth and early neonatal mortality contained in the Eighth International Statistical Classification of Diseases, Injuries and Causes of Death, and (b) 16 classified causes of neonatal death for verbal autopsy data as proposed in an Indian study by Bang *et al*. (14). However, the neonatologists were not required to strictly follow the algorithms postulated in the study by Bang *et al*., but rather to use their own judgement in arriving at an originating and a direct cause for each

death. The assignment of cause of death was carried out in two different phases. In the first phase, each neonatologist independently assigned the cause of death for each case. In the second phase, at a meeting, three of them jointly assigned a cause based on consensus judgement for each case.

Statistical analysis

We used the kappa-statistic for each cause (15) to test the agreement among the judgements of three physicians who independently assigned the cause of death. To test the variation of neonatal deaths at different levels of various factors, we used Fisher's exact test. For analysis of trends, logistic regression was used considering neonatal outcome as the dependent variable.

Ethics

The Technical Sub-committee and the Human Subjects Sub-committee of the Bangladesh Institute of Research for Promotion of Essential & Reproductive Health and Technologies (BIRPERHT) approved the study protocol.

RESULTS

Neonatal mortality rates

Of the 1,019 women enrolled in the study, 964 (95%) could be observed for their pregnancy outcome at 28 weeks or more gestational age. Ten subjects were lost to follow-up, and 45 reported having either a miscarriage or an abortion. Eleven women had a twin delivery, and there were 934 livebirths and 41 stillbirths. There were 50 neonatal deaths, giving a neonatal mortality rate of 53.5 per 1,000 livebirths, comprising an early neonatal death rate of 37.4 per 1,000 livebirths (death of the neonate within 7 days of life) and a late neonatal death rate of 16.1 per 1,000 livebirths (death of the neonate within 8-28 days of life).

Causes of neonatal deaths

Table 1 shows that prematurity or low birth-weight, difficult labour, and unhygienic birth practices were the major originating causes of neonatal deaths, whereas sepsis, asphyxia, and tetanus were the major direct causes of neonatal deaths in rural Bangladesh. Among the originating causes, prematurity/low birth-weight accounted for approximately one-third of all deaths, whereas difficult labour and unhygienic birth practices (defined as the use of unsterilized delivery instruments and non-compliance with hand-washing) combinedly accounted for another one-third. Of the direct causes, sepsis (collectively defined as septicaemia, meningitis, and pneumonia) accounted for 32% of all neonatal deaths, and birth asphyxia and tetanus for 42%. Birth asphyxia was the major direct cause for early and sepsis for late neonatal mortality, accounting, respectively, for 34% and 53% of neonatal deaths.

Table 1. Neonatal death rates per 1,000 livebirths (number of deaths) by neonatal periods and by causes in rural Bangladesh

Cause of death	Neonatal period		
	Early 1-7 day(s)	Late 8-28 days	1st 4 weeks of life
Originating causes			
Pre-maturity/low birth-weight	12.8 (12)	3.2 (3)	16.1 (15)
Difficult labour	7.5 (7)	1.1 (1)	8.6 (8)
Unhygienic practices	4.3 (4)	4.3 (4)	8.6 (8)
Others*	1.1 (1)	1.1 (1)	2.1 (2)
Unable to specify	11.8 (11)	6.4 (6)	18.2 (17)
Direct causes			
Sepsis	8.6 (8)	8.6 (8)	17.2 (16)
Birth asphyxia	12.8 (12)	1.1 (1)	13.9 (13)
Tetanus	4.3 (4)	4.3 (4)	8.6 (8)
Respiratory distress	3.2 (3)	0.0 (0)	3.2 (3)
Others†	2.1 (2)	1.1 (1)	3.2 (3)
Unable to specify	6.4 (6)	1.1 (1)	7.5 (7)
All causes	37.5 (35)	16.1 (15)	53.5 (50)

* Maternal complications/post-term; † Feeding problem/hypothermia

Agreement among neonatologists

A fair-to-high agreement among the neonatologists in identifying different originating and direct causes of death is shown in Table 2. Among the originating causes, agreement in assigning prematurity/low birth-weight, difficult labour, and unhygienic conditions among the neonatologists was high (kappa=0.63-0.84). Among the direct causes, agreement in assigning birth injury, tetanus, and respiratory distress was also high (kappa=0.67-0.85), but for assigning sepsis was only fair (kappa=0.57).

Table 2. Agreement among three neonatologists in independently identifying causes of death using verbal autopsy data

Cause of death	Number of diagnoses by each neonatologist			
	First (n=50)	Second (n=50)	Third (n=50)	Reliability kappa
Originating causes				
Pre-maturity/low birth-weight	16	13	15	0.84
Difficult labour	6	5	7	0.81
Unhygienic practices	7	11	9	0.63
Others*	3	1	1	0.17
Unable to specify	18	20	18	0.77
Direct causes				
Birth asphyxia	11	12	11	0.85
Sepsis	15	13	14	0.57
Tetanus	7	10	9	0.67
Respiratory distress	5	2	3	0.67
Others†	6	2	9	0.27
Unable to specify	6	11	4	0.45

* Maternal complications/post-term
† Feeding problem/hypothermia

Variability in neonatal mortality with socioeconomic characteristics

Table 3 shows no evidence of variation in neonatal mortality across socioeconomic factors but shows modest relationships with place of delivery and attendant. A higher proportion of early neonatal deaths occurred among deliveries taking place in health facilities or those attended by skilled service providers that included medical doctor, nurse, and midwife. However, this relationship was reversed for late neonatal deaths. No protective effect of antenatal care was observed for visiting a health centre at least once during pregnancy.

Variability in neonatal mortality with reproductive characteristics

Substantial differences in neonatal mortality were found with various reproductive characteristics as shown in Table 4. Women with 2-3 gravidity had significantly lower early neonatal mortality than those who were primi or more than three-gravida. However, late neonatal mortality appeared to decrease with increasing gravidity (p value=0.09 for trend). The pattern of early and late neonatal mortality rates with maternal age was roughly consistent with that across the gravidity levels. Neonatal mortality for pre-term deliveries (before 37 completed weeks of gestation) was more than four-fold that of full-term pregnancies (39-41 weeks). Malpresentation of the foetus and twin foetus also resulted in greatly increased overall neonatal mortality.

DISCUSSION

The neonatal mortality rate in our study population was very high. Prematurity/low birth-weight, difficult labour, and unhygienic practices were the major originating causes of neonatal death, accounting for 30%, 16%, and 16% of deaths respectively. Sepsis, asphyxia, and tetanus were the major direct causes accounting for 32%, 26%, and 16% of deaths respectively. In this setting, socioeconomic factors were not associated with neonatal outcome. The indicators of the use of health services were confounded by severity of complications. Cases in point are that early neonatal mortality rate was high among infants delivered in facilities and by skilled personnel. Women with complications in pregnancy with high risk for neonatal mortality are more likely to come to facilities for care by professional personnel.

In our study, the neonatal mortality rate of 53.5 per 1,000 livebirths during 1992-1993 is similar to the findings from neighbouring India for neonatal death rates ranging from 50 to 65 per 1,000 livebirths during 1993-1998 (16). When compared with within-country data, our estimate is close to 53.3 per 1,000 livebirths found in 1993 in the comparison area of the Maternal and Child Health-Family Planning (MCH-FP) Project of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) (12). The lower neonatal mortality rate of 42.0 per 1,000 livebirths in 1998-2000 reported by the Demographic and Health Survey (13) may be due to a reduction in death rate primarily due to neonatal tetanus. In rural areas, the proportion of pregnant women receiving tetanus toxoid has increased substantially from 64.5% in 1991-1993 to 79.1% in 1998-2000, whereas during the same period other indicators of neonatal mortality have remained almost unchanged (17). Although our data are about 12 years old, there is insufficient evidence that, in rural Bangladesh, there has been any substantial change during 1992-2004 in major causes of neonatal death, except neonatal tetanus.

Among the originating causes of neonatal death, prematurity/low birth-weight (defined as delivery before 37 weeks of gestation or small-for-gestational-age) was the leading cause contributing about one-third of early neonatal deaths in our study. This figure is comparable with 39% of neonatal deaths due to low birth-weight (defined as pre-maturity or small for date) in Matlab (9). Both prematurity and low birth-weight decrease the infant's chance of survival (18) and are highly prevalent in developing countries (10,19), including Bangladesh (20,21). The high proportion of neonatal deaths can be lowered by reducing the prevalence of poor nutrition, which is associated with low birth-weight (22) and anaemia, which itself is associated with both pre-maturity (23) and low birth-weight (24).

Table 3. Neonatal death rates per 1,000 livebirths (number of deaths) according to socioeconomic characteristics of mothers

Characteristics	Neonatal period			
	No.	Early 1-7 day(s)	Late 8-28 days	1st 4 weeks of life
Education of mothers				
None	512	31.3 (16)	19.5 (10)	50.8 (26)
Primary	264	45.5 (12)	11.4 (3)	56.8 (15)
Higher than primary	158	44.3 (7)	12.7 (2)	57.0 (9)
p value		0.50*	0.77*	0.71†
Monthly per-capita expenditure (taka)				
≤300	391	46.0 (18)	17.9 (7)	63.9 (25)
301-500	422	33.2 (14)	11.8 (5)	45.0 (19)
>500	121	24.8 (3)	24.8 (3)	49.6 (6)
p value		0.22†	0.50*	0.48*
Use of health services				
Received antenatal care				
Yes	528	32.2 (17)	20.8 (11)	53.0 (28)
No	406	44.3 (18)	9.9 (4)	54.2 (22)
p value		0.37*	0.29*	1.00*
Place of delivery				
Home	917	34.9 (32)	16.4 (15)	51.3 (47)
Facility	17	176.5 (3)	00.0 (0)	176.5 (3)
p value		0.02*	1.00*	0.02*
Attendant				
Skilled	32	125.0 (4)	00.0 (0)	125.0 (4)
Unskilled	902	34.4 (31)	33.7 (15)	51.0 (46)
p value		0.03*	1.00*	0.09*

* Fisher's exact test; † Test for trend

Difficult labour, responsible for one-fifth of early neonatal deaths, can be reduced by training health workers in methods to reduce birth trauma. In rural Bangladesh, the proportion of institutional deliveries is only about 6% of total births, and the population-based cesarean section rate is only 1.6% of deliveries (7), whereas 15% of births are supposed to take place in the health facility (25) and 5% cesarean section (26) are the minimum expected rates for management of pregnancy-related complications in a population. Early identification and timely referral of complicated deliveries to appropriate facilities should be strengthened to reduce associated mortality.

In our study, 16.0% of overall neonatal deaths attributed to tetanus is extremely high and is consistent with the figure of 14.9% reported in 1998 (11). The current coverage of 79.3% of tetanus toxoid vaccination among pregnant women (17) is still too low to protect the newborns and, thus, must be increased in conjunction with improvements in the hygiene of health workers' practice (27).

Birth asphyxia is the major cause of early neonatal mortality contributing about one-third of early neonatal deaths in our study. Small-for-gestational-age (28), maternal pre-eclampsia (28,29), and vaginal breech

Table 4. Neonatal death rates per 1,000 livebirths (number of deaths) according to reproductive characteristics of mothers

Characteristics	Neonatal period			
	No.	Early 1-7 day(s)	Late 8-28 days	1st 4 weeks of life
Maternal age				
≤19	312	44.9 (14)	22.4 (7)	67.3 (21)
20-24	309	25.9 (8)	12.9 (4)	38.8 (12)
25-29	188	42.6 (8)	16.0 (3)	58.5 (11)
≥30	125	40.0 (5)	08.0 (1)	48.0 (6)
p value		0.59*	0.68*	0.45*
Gravidity				
1	254	55.1 (14)	27.6 (7)	82.7 (21)
2-3	349	17.2 (6)	14.3 (5)	31.5 (11)
≥4	331	45.3 (15)	09.1 (3)	55.4 (18)
p value		0.03*	0.09†	0.02*
History of abortion/stillbirth				
Yes	193	25.9 (5)	5.2 (1)	31.1 (6)
No	741	40.5 (30)	18.9 (14)	59.4 (44)
p value		0.40*	0.17*	0.15*
Gestation at delivery (weeks)				
≤36	115	104.3 (12)	34.8 (4)	139.1 (16)
37-38	181	49.7 (9)	33.1 (6)	82.9 (15)
≥39	638	21.9 (14)	7.8 (5)	29.8 (19)
p value		<0.01†	0.01†	<0.01†
Prolonged labour				
Yes	94	63.8 (6)	10.6 (1)	74.5 (7)
No	840	34.5 (29)	16.7 (12)	51.2 (41)
p value		0.15*	0.66*	0.33*
Presentation of foetus				
Normal	910	33.0 (30)	15.4 (14)	48.4 (44)
Malpresentation	24	208.3 (5)	41.7 (1)	250.0 (6)
p value		<0.01*	0.33*	<0.01*
Number of foetus				
Single	912	35.1 (32)	15.4 (14)	50.4 (46)
Twin	22	136.4 (3)	45.5 (1)	181.8 (4)
p value		0.05*	0.30*	0.03*

* Fisher's exact test; † Test for trend

delivery (29) are the major risk factors for asphyxia. Again, well-performed antenatal care and a referral system with qualified medical personnel and adequate facilities are needed. Although the data show a high mortality rate among mothers who sought care from skilled providers, these were a high-risk group who might have experienced an even higher mortality rate if delivered by a lay person.

In developing countries, neonatal sepsis dominates as the major cause of deaths of younger infants (16,18). It also accounts for the majority of late neonatal deaths in our study. Strategies of low-cost community-based postpartum care should be implemented for reducing neonatal morbidity and mortality from infectious diseases (30). In rural areas of developing countries, in the absence of specialized neonatal facilities, cost-effective home-based neonatal care provided by health workers was effective in reducing about two-thirds of neonatal deaths due to sepsis (16). Formulation of similar health packages will be helpful in substantial reduction of neonatal mortality in countries where there are resource constraints.

In our study, lack of association of neonatal mortality rates with socioeconomic status (defined as mothers' education and monthly per-capita expenditure) may be due to a small sample size. Although higher socioeconomic status is inversely related with infant mortality, which may depend more on access to quality health services, this association is not strong with early neonatal mortality (31). In our study, increased early neonatal mortality in extremes of maternal age and gravidity is similar to the findings of another study on perinatal mortality in Bangladesh (32). Although not statistically significant, the apparently-decreased late neonatal mortality rate for greater maternal age and gravidity is also similar to the findings on determinants on childhood mortality (33). This decreased mortality may be due to the greater experience of the mother on how to recognize and deal with infant morbidities.

The coverage of antenatal care was poor (56%), and the neonatal death rate was not lower among antenatal care-seekers, implying that antenatal care may have been of poor quality or that the high-risk group may have selectively used antenatal care. This is different from findings in Viet Nam (34) where antenatal care was shown to be preventive. However, the Viet Nam study was conducted in an urban area where the quality might be much better than in our study settings. There is a strong need to increase the coverage of antenatal care which is also a predictor for use of skilled attendance at delivery (35). Thus, if antenatal care is promoted, supported by an effective referral system, it may become an effective tool to facilitate better use of obstetric and neonatal care.

In rural areas in developing countries, verbal autopsy is always carried out by lay persons due to inadequate health facilities (36). In assigning the causes of death from verbal autopsy data, we found fair-to-high agreement among the neonatologists. Despite this, the originating and the direct causes of 34% and 14% of deaths respectively still remained unknown. These high percentages of unknown causes are due to the incompleteness of information from verbal autopsies. Reduction of the unknown proportion would enable better planning of interventions. Another major drawback of the study is the small sample size that allowed poor precision of the estimates. For example, the precision for our estimated proportion of deaths where the originating cause was pre-maturity/low birth-weight was ±13 percentage points of the true population proportion with 95% statistical confidence. The association of neonatal mortality with sociodemographic and reproductive factors also lacked enough power due to the small sample size. Further research to develop a verbal autopsy questionnaire and to administer it among a sufficiently large number of subjects may overcome these problems.

Judging from the pattern of originating and direct causes, it is expected that high neonatal mortality in Bangladesh can be reduced by appropriate improvement in the existing healthcare system. For cost-effective and sustainable reduction in neonatal mortality, neonatal care programmes should be addressed from a wider platform of improving maternal and child health as emphasized in the conceptual framework for neonatal care for home and community in developing countries (37). The findings of our study also support the identified interventions targeted to mothers and neonates in the community and priority research activities to advance the state of the art in newborn care (38). Low-cost proven interventions covering improved maternal, obstetric and newborn care should be delivered through the framework of ongoing safe motherhood and child healthcare programmes. The community also should be motivated for seeking timely and proper care for mothers and newborns. Implementation of these intervention programmes for lowering neonatal mortality is urgently needed in Bangladesh.

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