

Neonatal mortality of low-birth-weight infants in Bangladesh

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Objective To ascertain the role of low birth weight (LBW) in neonatal mortality in a periurban setting in Bangladesh.

Methods LBW neonates were recruited prospectively and followed up at one month of age. The cohort of neonates were recruited after delivery in a hospital in Dhaka, Bangladesh, and 776 were successfully followed up either at home or, in the event of early death, in hospital.

Findings The neonatal mortality rate (NMR) for these infants was 133 per 1000 live births (95% confidence interval: 110–159). The corresponding NMRs (and confidence intervals) for early and late neonates were 112 (91–136) and 21 (12–33) per thousand live births, respectively. The NMR for infants born after fewer than 32 weeks of gestation was 769 (563–910); and was 780 (640–885) for infants whose birth weights were under 1500g. Eighty-four per cent of neonatal deaths occurred in the first seven days; half within 48 hours. Preterm delivery was implicated in three-quarters of neonatal deaths, but was associated with only one-third of LBW neonates.

Conclusion Policy-relevant findings were: that LBW approximately doubles the NMR in a periurban setting in Bangladesh; that neonatal mortality tends to occur early; and that preterm delivery is the most important contributor to the NMR. The group of infants most likely to benefit from improvements in low-cost essential care for the newborn accounted for almost 61% of neonatal mortalities in the cohort.

Keywords Infant mortality; Infant, Low birth weight; Prospective studies; Cohort studies; Bangladesh (*source: MeSH*).

Mots clés Mortalité nourrisson; Nourrisson faible poids naissance; Etude prospective; Etude cohorte; Bangladesh (*source: INSERM*).

Palabras clave Mortalidad infantil; Recién nacido de bajo peso; Estudios prospectivos; Estudios de cohortes; Bangladesh (*fuentes: BIREME*).

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Introduction

Perinatal and neonatal mortality are increasingly important public health issues in many developing countries, as postneonatal mortality rates fall (1). In Bangladesh, for example, the infant mortality rate appears to have fallen this century from over 200 deaths per thousand live births to approximately 80 deaths per thousand live births (2–4). By contrast, neonatal deaths now account for about two-thirds of the 8 million infant deaths that occur globally each year (5), and the neonatal mortality rate (NMR) in Bangladesh was recently estimated to be 65 deaths

per thousand live births (6). However, the NMRs can differ by rural, urban and other locations (2, 7), even within large demographic surveys (8).

Low birth weight (LBW) is defined as a birth weight of less than 2500 g and is a well-documented risk factor for neonatal mortality (9, 10). In Bangladesh, for example, the LBW prevalence varies between 23% and 60% (11–13) and this has presumptive effects on stillbirth and neonatal death rates. Despite the apparent importance of LBW as an indicator, there have been few prospective studies of outcome for LBW infants in developing countries, largely because of the difficulties inherent in community-based data collection. The definition of LBW also fails to distinguish between LBW neonates who are premature and those who are merely small for their gestational age. As a result, there is a lack of information about infant mortality in the first four weeks of life, and this has hindered the development of appropriate neonatal interventions. In this paper we report the findings of a prospective cohort study of LBW infants in Dhaka, Bangladesh, and have modelled the effects of essential newborn care.

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Materials and methods

Study area

Bangladesh has a population of 126 million and a growth rate of 2.0%. Per capita income is US\$ 370 per annum. The literacy rate is 63% for men and 48% for women. The average household size is 5.6 people and 16% of households do not own land (3). Up to 90% of women in Bangladesh marry by 18 years of age and most conceive in their teens (14). Health care for mothers and children is minimal: community-based support during pregnancy is available from family welfare assistants, but the responsibilities of the assistants are often unfeasibly broad. For example, they bear the burden of referring the estimated 600 000 high-risk pregnancies in visitors to family welfare centres each year.

The study cohort was recruited via the maternity service at Mitford Hospital, a government-run centre which hosts about 4000 deliveries per year. Although services are free in principle, attendance involves both explicit and implicit costs (15). The hospital is adjacent to the Buriganga river in the old part of Dhaka and draws clients from urban, suburban and rural areas. Seventy-five per cent of service users are classified as living in poverty. The high uptake of services at the hospital is probably explained by the low cost of the services and by the difficulties of delivering home services in the nearby congested slums. After presentation at the hospital, the majority of births take place within two days. The subsequent hospital stay is usually six hours, unless the mother or infant experiences problems. It is recommended that mothers stay in hospital for 10 days after caesarean section, or for as long as infants require specialized care. Specialized care is provided in a neonatal unit in the form of incubator care, antimicrobials and nasogastric or intravenous hydration. Hospital records suggest an LBW prevalence of 30%, and there is usually more than one infant per incubator.

Study design

The cohort of infants was recruited at the time of birth in the hospital and consisted solely of LBW infants, who were to be followed up at home. The objective was to quantify mortality in this high-risk population over the course of the first month of extrauterine life. Ethical approval for the study was obtained from the Bangladesh Medical Research Council.

Infants were enrolled consecutively between May 1994 and September 1995. Enrolment ran for six days per week, excepting religious holidays (15 days) and strikes (10 days). The theoretical sample size required to yield 90 deaths (for risk factor analysis) was projected from population estimates of NMR (16, 17) at a power of 80% and a two-sided alpha of 0.05. During the enrolment period, every birth in the maternity unit was attended by a member of the study team. Verbal

informed consent for participation was obtained from each mother before data collection.

Criteria for including an infant in the study cohort were as follows:

- The infant had completed more than 28 weeks of gestation, and had a birth weight less than 2500 g.
- The family residence was within 80 km of the study site and the household location was verifiable.
- The mother gave verbal consent to inclusion.

Neonates who did not meet all of the above inclusion criteria, or who suffered a significant congenital anomaly, were excluded from the study. Both stillbirths and livebirths were recorded, but only the latter are reported here. Data were collected by a team of four paediatric medical officers and one clerical assistant. Their one-month induction period comprised a week of discussion, planning and questionnaire design; a week of anthropometric and clinical assessment training; a week of clinical practice; and a week of questionnaire pretesting, modification and piloting.

Infant anthropometric data were recorded at the time of birth. Birth weight was measured with infants undressed on a portable Soehnle 831 000 scale, with an accuracy to within 10 g. Birth length was measured with a portable, non-stretch/shrink-toughened plastic roll-up mat with an accuracy of 0.5 cm (Rollametre). The circumference of the head, mid-upper arm and chest were measured using a plastic tape with an accuracy of 1 mm. Gestational age was assessed clinically by the method of Dubowitz, as adapted by Capurro (18). Maternal postdelivery weight was measured with women lightly clothed on a Soehnle 7209 scale with a weight range of 0–130 kg and accuracy to within 200 g. Height was measured with a wall-hung plastic injection-moulded scale with an accuracy of 1 mm (Minimeter 183). Questionnaires were administered within a few hours of birth and covered areas that included past obstetric history, history of the present pregnancy and socio-economic factors.

LBW was defined as a birth weight of less than 2500 g, regardless of gestational age. Preterm delivery implied a gestation at birth of less than 37 completed weeks, while term was defined as a gestational age of 37–42 completed weeks. NMR was defined as the number of deaths in the first 28 days after birth per thousand live births. Early NMR (ENMR) refers to deaths on days 0–6; late NMR (LNMR) to deaths on days 7–28.

If an infant died before discharge from the hospital, an immediate verbal autopsy was sought and the diagnosis confirmed with attending doctors. Death at home was assessed after a period of 28 days by the principal investigator, who recorded the age at death and conducted a verbal autopsy by parental interview. The verbal autopsy method used a format developed by a WHO advisory team and allowed for 15 causes of death, including a category for unknown

causes (19). For ethical reasons, infants received medical treatment if the investigators felt that it was required at enrolment or follow-up.

Data from seven questionnaires were entered into loose-leaf paper files that were collected and reviewed weekly, and compiled in an electronic database by the principal investigator. Data cleaning and analysis were performed within STATA (Intercooled STATA 5.0 for Macintosh, Stata Corporation, USA). Baseline characteristics were analysed with two-sample comparison of means, one-way ANOVA and analogous nonparametric tests. Mortality rates were computed arithmetically and confidence intervals estimated using binomial methods.

Results

Characteristics of the sample

The outcomes for cohort infants during this study are summarized in Fig. 1. Of 937 liveborn infants enrolled, outcome data were available for 776, representing a loss to follow-up of 17%. Selected socioeconomic and demographic findings for the cohort families are presented in Table 1. The monthly income of most cohort families was under 3000 taka (US\$ 66), although 53% of the fathers were in regular employment as skilled manual workers (predominantly as operatives in factories).

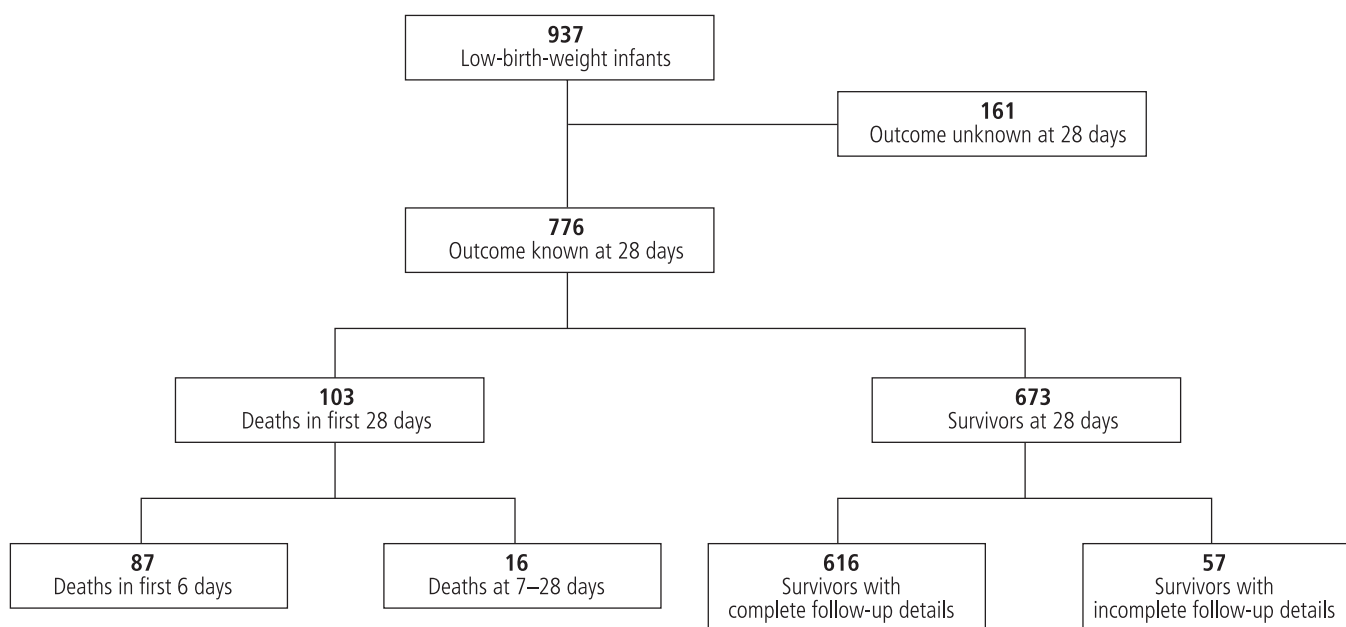
Most of the mothers were Muslim (77%) and about one-third had received no formal schooling, one-half had been educated at primary level, and 13% had progressed to secondary school. Twenty-seven per cent of them had married in their teens. Maternal postdelivery weight was normally distributed about a mean of 47 kg (standard deviation (SD) = 6.1 kg);

345 women weighed less than 45 kg (37%). Mean height was 150 cm (SD = 4.7 cm) and the 10th centile was 145 cm. Some 731 women (78%) had blood haemoglobin levels below 11 g/dl and were considered to be anaemic on this basis. Twenty-three per cent of the mothers received no antenatal care, 374 (48%) were primiparous, and 23 (3%) had delivered their fifth child or higher. Maternal age ranged from 14 to 45 years (interquartile range: 20–26 years; median: 22 years). Many of the women did not know their age, and clustering in the data distribution around multiples of five may result from digit preference.

The birth weights of the cohort infants were at the lower end of a normal distribution and were therefore nonparametrically distributed. The lowest values observed were approximately 500 g; but 92% of the infants weighed 1500 g or more, and 69% weighed 2000 g or more. Birth lengths ranged from 25 cm to 54.5 cm (interquartile range 42.8–46.5 cm), head circumferences from 18 cm to 39.5 cm (interquartile range 23–37 cm), and chest circumferences from 16–36.6 cm (interquartile range 28–30.5 cm).

Gestational age at birth and birth weight were available for 931 infants, allowing the generation of categorical variables for preterm and term delivery and for birth weight band (Table 2). Predictably, preterm birth contributes disproportionately to the lower birth weight bands: 94% of infants with birth weights less than 1500 g were preterm, compared with only 25% of infants with birth weights between 2000 and 2499 g. The relative importance of each birth weight band is also presented in the table: over 70% of LBW infants fell into the 2000–2499 g group.

Fig. 1. Progress through the study



Outcome

The contribution of birth weight and gestational bands to overall mortality is summarized in Table 3. There were 103 neonatal deaths, of which 43 occurred within 48 hours of birth, and 87 within the first six days; 81 of the deaths occurred in hospital, 22 at home. Verbal autopsy implicated birth asphyxia (as encephalopathy) in 34% of the cases, and infection (as either generalized sepsis or pneumonia) in 9% of neonatal deaths. In 45% of the cases, no cause other than LBW or preterm delivery could be identified. Kaplan–Meier survival plots for bands of birth weight and gestation are shown in Fig. 2, which underscore the impressions that infant mortality varies with birth weight and gestation period, and that the greatest risk of infant death occurs early in the neonatal period.

Over one-third of all infant deaths occurred in the very low-birth-weight (VLBW, below 1500 g) group (38% of deaths, Table 3), despite the low prevalence of VLBW infants (7% of all LBW, Table 2). Similarly, preterm births are implicated in 75% of neonatal deaths (Table 3), but account for only 39% of LBW infants in the cohort (Table 2). Thirty-nine per cent of deaths occurred in infants who weighed less than 1500 g at birth, were born at less than 32 weeks gestation, or both; conversely, 61% of neonatal deaths occurred in infants with birth weights 1500–2499 g and gestation periods of 32 weeks or longer.

The data show that the overall NMR was 133, the ENMR was 112 and the LNMR 21 per thousand live births (Table 4). Predictably, the NMRs for certain groups were much higher: 78% (NMR = 780 per thousand live births) of very low-birth-weight infants (VLBW, below 1500 g) died in the neonatal period, whereas only 5% of neonates with birth weights 2000–2499 g died in the same period. Also, preterm infants were five times as likely to die as term infants (risk ratio: 4.78; 95% confidence interval 3.14–7.27); indeed, infants born at fewer than 32 weeks of gestation had a NMR comparable to that of VLBW infants (77% died in the neonatal period, Table 4).

Discussion

It may not be possible to generalize the conclusions of this study because the cohort was recruited from a hospital, where service users tend to come from groups with higher socioeconomic status and lower exposure to risk. However, our sample population was poor by any standards, and the maternal demographic and anthropometric features in the cohort were similar to others described in Bangladesh (20, 21), although this may reflect the high level of ambient risk factors in a population homogeneous for deprivation. Alternatively, referral for hospital delivery may select for the more at risk; and the fact that the majority of infant deaths occurred in hospital raises the question of whether the infants would have

Table 1. Socioeconomic and demographic characteristics of cohort families

Variable	Frequency (%)
Maternal education	
None	283 (37)
Primary	389 (50)
Secondary	101 (13)
<i>n</i>	773 (100)
Paternal education	
None	156 (20)
Primary	409 (53)
Secondary	207 (27)
<i>n</i>	772 (100)
Family income (taka per month)^a	
Under 3000	421 (55)
3001–5000	196 (25)
5001–10 000	115 (15)
Over 10 000	40 (5)
<i>n</i>	772 (100)
Paternal occupation	
Day labourer	115 (15)
Unskilled manual worker	245 (32)
Skilled worker	412 (53)
<i>n</i>	772 (100)
Maternal age at marriage (years)	
Under 20	560 (73)
Over 20	211 (27)
<i>n</i>	771 (100)

^a 1000 taka = ca US\$ 22.

Table 2. Contributions of term and preterm deliveries to birth weight bands

Birthweight band	Number of LBW infants (%)	% deliveries preterm	% deliveries at term
< 1500 g	62 (7)	94	6
1500–1999 g	205 (22)	66	34
2000–2499 g	664 (71)	25	75
All LBW infants	931 (100)	39	61

LBW = low birth weight.

been at higher risk of dying if born in the community. Loss to follow-up is also likely to be biased towards social groups at higher risk of mortality, so that late neonatal deaths may be overrepresented in the drop-out group. Thus, even though our ENMR figures for birth weight and gestational bands are consistent with earlier results (22), we advise caution when using our data since the balance of biases may underestimate the ENMR and LNMR in the general population. Support for this idea comes from the observation that LBW prevalence is 30% in Mitford hospital, 10% lower than the national estimate. There may also be a systematic downward bias in the assessment of gestational age, since we relied, of necessity, on the

Table 3. Neonatal mortality by birth weight and gestation period

Birth weight or gestation period	Number of deaths (% of total deaths)
< 1500 g	39 (38)
1500–1999 g	35 (34)
2000–2499 g	29 (28)
Preterm (< 32 weeks)	20 (20)
Preterm (32–36 weeks)	57 (55)
Term	26 (25%)
All LBW infants	103 (100%)

LBW = low birth weight.

Fig. 2. Kaplan–Meier survival plots for a) birth weight divided into categorical bands and b) gestational age divided into categorical bands

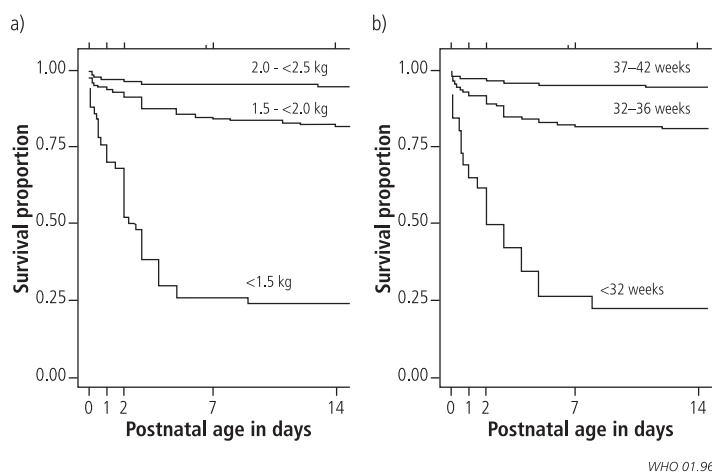


Table 4. Neonatal, early neonatal and late neonatal mortality rates, by birth weight and gestation period

Birth weight or gestation period	NMR (CI) ^a	ENMR (CI)	LNMR (CI)
< 1500 g	780 (640–885)	740 (597–854)	40 (5–14)
1500–1999 g	204 (147–273)	152 (102–215)	52 (24–98)
2000–2499 g	52 (35–74)	43 (28–64)	9 (3–21)
Preterm (< 32 weeks)	769 (563–910)	731 (522–884)	38 (1–196)
Preterm (32–36 weeks)	210 (163–264)	173 (130–224)	37 (18–67)
Term	54 (36–78)	44 (27–66)	10 (3–24)
All LBW infants	133 (110–159)	112 (91–136)	21 (12–33)

^a Neonatal mortality rates are expressed as deaths per thousand live births. CI: 95% binomial exact confidence interval.

NMR = neonatal mortality rates.

CI = confidence interval.

ENMR = early neonatal mortality rates.

LNMR = late neonatal mortality rates.

method of Capurro (18). The group of preterm neonates would thus be overascribed, since infants with intrauterine growth retardation (IUGR) may achieve lower scores on such profiles.

Our findings show that several factors influence the NMR, which need to be addressed if neonatal survival is to be improved. The most obvious factor is LBW. The cohort consisted entirely of LBW infants, and the NMR was 133 deaths per thousand live births, roughly double the figures for unselected South Asian populations, which range from 50 to 97 deaths per thousand live births (11, 17, 23, 24). The next most striking finding is that 84% (95% confidence interval: 76–91%) of cohort deaths occurred in the first week of extrauterine life, half within the first 48 hours. This is generally consistent with previous findings from Bangladesh indicating that 21% of neonates die within the first three days (25); comparable results have been reported for Brazil (26). By contrast, a study in the Gambia (NMR = 39 deaths per thousand livebirths) suggested that early and late neonatal deaths were roughly equal (27), although early deaths may have been underreported. The data also show that VLBW is strongly associated with high mortality. VLBW infants made up only 7% of the LBW total, but accounted for a third of infant deaths and had a mortality rate of 780 per thousand live births. Like VLBW, lower gestational age at birth also carries a high mortality risk (769 per thousand live births at less than 32 weeks). More interesting, perhaps, is that 75% of all deaths occurred in preterm infants, even though they constituted only a third of all LBW infants.

The majority of LBW infants in developing countries are small-for-dates rather than preterm (28), and the high prevalence of LBW can be explained mainly on the basis of IUGR. For this reason, IUGR has become a focus for potential interventions, two assumptions being that: (i) intrauterine growth may be more tractable to interventions than preterm labour (although the degree of tractability remains questionable and there are overlaps in etiology between the two areas); and (ii) its numerical dominance in the etiology of LBW means that interventions to reduce IUGR will pay dividends in terms of outcome (29). This second assumption may be valid in the context of later morbidity, since IUGR may have effects on childhood growth, cognitive development and subsequent diseases in adulthood (30, 31). However, our study suggests that IUGR should not be emphasized alone, if neonatal mortality is to be reduced. Previous work suggests that preterm infants have a perinatal mortality rate 13 times higher than that of term infants of comparable birth weight, and twice that of infants with IUGR (32). This conclusion is supported by the results presented in this study, showing that 75% of all deaths in the LBW group were accounted for by preterm infants.

Sixty-one per cent of cohort deaths occurred to infants whose birth weights were 1500 g or more and

whose gestation periods were 32 weeks or more. This is a group where an emphasis on essential newborn care may have large effects (33). It has been suggested that two-thirds of all first-week deaths can be prevented by simple practices (22, 34, 35), and an emphasis on the care of infants at high risk of dying may pay greater dividends in the short term than attempts to prevent the birth of LBW infants. Given the difficulties inherent in preventing IUGR and preterm delivery, there is a strong case for shifting the focus of current discourse towards community-based care of the newborn. We do not propose a

cessation of programmatic interventions and advocacy aimed at improving women's health, nutrition over the life cycle and gender equity. Instead, programmatic agendas should include both the prevention of preterm delivery and the prevention and reduction of IUGR. We also advocate an emphasis on essential care of the newborn infant at community level, since the short-term effects of this may be substantial. ■

Conflicts of interest: none declared.

Résumé

Mortalité néonatale chez les nourrissons de faible poids de naissance au Bangladesh

Objectif Évaluer le rôle du faible poids de naissance dans la mortalité néonatale dans un secteur périurbain du Bangladesh.

Méthodes Des nouveau-nés de faible poids de naissance ont été recrutés de façon prospective et suivis à l'âge d'un mois. Les nouveau-nés de la cohorte ont été inclus dans l'étude après leur naissance dans un hôpital de Dhaka (Bangladesh) et 776 d'entre eux ont pu être suivis à domicile ou, en cas de décès précoce, à l'hôpital.

Résultats Pour ces nourrissons, le taux de mortalité néonatale était de 133 pour 1000 naissances vivantes (intervalle de confiance à 95 % : 110-159). Les taux correspondants (et leurs intervalles de confiance) pour les décès néonataux précoces et tardifs étaient respectivement de 112 (91-136) et 21 (12-33) pour 1000 naissances vivantes. Le taux de mortalité néonatale pour les nourrissons nés après moins de 32 semaines de grossesse était de 769 (563-910) pour 1000 naissances

vivantes et il était de 780 (640-885) pour 1000 naissances vivantes chez ceux dont le poids de naissance était inférieur à 1500 g. Parmi les décès néonataux, 84 % survenaient au cours des 7 premiers jours et la moitié dans les 48 heures suivant la naissance. L'accouchement prématuré était impliqué dans les trois quarts des décès néonataux, mais n'était associé qu'au tiers des insuffisances pondérales à la naissance.

Conclusion Plusieurs observations sont intéressantes du point de vue des politiques de santé : le faible poids de naissance double pratiquement le taux de mortalité néonatale dans un secteur périurbain du Bangladesh ; les décès néonataux tendent à être précoces ; l'accouchement prématuré est le facteur qui contribue le plus au taux de mortalité néonatale. Le groupe de nourrissons qui devrait tirer le plus grand bénéfice d'une amélioration des soins de base peu coûteux destinés aux nouveau-nés représentait près de 61 % des décès néonataux dans la cohorte examinée.

Resumen

Mortalidad neonatal entre lactantes de bajo peso al nacer en Bangladesh

Objetivo Determinar la contribución del bajo peso al nacer (BPN) a la mortalidad neonatal en una zona periurbana de Bangladesh.

Métodos Se reclutó prospectivamente a recién nacidos con BPN para su posterior seguimiento a la edad de un mes. Los neonatos de la cohorte habían nacido en un hospital de Dhaka (Bangladesh), y en 776 casos se logró seguir su evolución ya fuera en el hogar o, entre los que fallecieron prematuramente, en el hospital.

Resultados La Tasa de Mortalidad Neonatal (TMN) de esos lactantes fue de 133 por 1000 nacidos vivos (IC95%: 110-159). Las TMN (e intervalos de confianza) correspondientes a los neonatos precoces y tardíos fueron de 112 (91-136) y 21 (12-33) por mil nacidos vivos, respectivamente. La TMN para los lactantes nacidos con menos de 32 semanas de gestación fue de 769 (563-910); y para los lactantes con menos de

1500 g al nacer la tasa fue de 780 (640-885). El 84% de las defunciones neonatales se produjeron durante los primeros siete días, y la mitad dentro de las primeras 48 horas. El antecedente de un nacimiento prematuro se asociaba a las tres cuartas partes de las defunciones neonatales, pero sólo a la tercera parte de los recién nacidos con BPN.

Conclusión Con miras a la elaboración de políticas, revisten interés los siguientes datos: el BPN conlleva aproximadamente una duplicación de la TMN en un entorno periurbano de Bangladesh; las defunciones neonatales suelen producirse tempranamente, y el nacimiento prematuro es el factor que más contribuye a la TMN. El grupo de lactantes que más puede beneficiarse de una mejora de la atención básica de bajo costo para el recién nacido representó casi el 61% de la mortalidad neonatal de la cohorte.

References

1. **Costello A.** Perinatal health in developing countries. *Transactions of the Royal Society for Tropical Medicine and Hygiene*, 1993, **87**: 1–2.
2. **Faroque A.** Infant mortality in Bangladesh: a review of recent evidence. *Journal of Biological Science*, 1991, **23**: 327–336.
3. *1995 Statistical Yearbook of Bangladesh*. Dhaka, Bangladesh Bureau of Statistics, 1995.
4. *The state of the world's children 1998*. Oxford and New York, United Nations Children's Fund, 1998.
5. **Costello AM, Singh ME.** Recent developments for neonatal health in developing countries. *Seminars in Neonatology*, 1999, **4**: 131–140.
6. *Perinatal mortality: a listing of available information*. Geneva, World Health Organization, 1996 (unpublished document WHO/FRH/MSM/96.7).
7. **Fauveau V et al.** Perinatal mortality in Matlab, Bangladesh: a community-based study. *International Journal of Epidemiology*, 1990, **19**: 606–612.
8. *Demographic and health survey 1993–1994*. Dhaka, Bangladesh, Mitra and Associates and Macro International Inc., 1994.
9. **McCormick MC.** The contribution of low birth weight to infant mortality and childhood morbidity. *New England Journal of Medicine*, 1985, **312**: 82–90.
10. **McIntire D et al.** Birth weight in relation to morbidity and mortality among newborn infants. *New England Journal of Medicine*, 1999, **340**: 1234–1238.
11. *Atlas of South Asian women and children*. Kathmandu, United Nations Children's Fund, 1996.
12. *The progress of nations*. New York, United Nations Children's Fund, 1997.
13. **Nahar N.** Recent trends in perinatal health in South Asia: Bangladesh. In: Costello A, Manandhar D, eds. *Improving newborn infant health in developing countries*. London, Imperial College Press, 1999.
14. *Bangladesh country statistics (2001)* (UNICEF website: www.unicef.org).
15. **Nahar S, Costello A.** The hidden cost of "free" maternity care in Dhaka, Bangladesh. *Health Policy and Planning*, 1998, **13**: 417–422.
16. **Rahman M et al.** Impact of environmental sanitation and crowding on infant mortality in rural Bangladesh. *Lancet*, 1985, **2**: 28–31.
17. **Rahman S, Nessa F.** Neonatal mortality patterns in rural Bangladesh. *Journal of Tropical Pediatrics*, 1989, **35**: 199–202.
18. **Capurro H et al.** A simplified method for diagnosis of gestational age in the newborn infant. *The Journal of Pediatrics*, 1978, **93**: 120–122.
19. **Bang A et al.** Diagnosis of causes of childhood deaths in developing countries by verbal autopsy: suggested criteria. *Bulletin of the World Health Organization*, 1992, **70**: 499–507.
20. **Rawshan N.** Effect of maternal nutrition and socio-economic factors on birth weight of babies in Bangladesh. *Bangladesh Medical Research Council Bulletin*, 1978, **1**: 1–9.
21. **Canosa A.** Intrauterine growth retardation in India and Bangladesh. *Nestle Nutrition Workshop Series*, 1989, **18**: 183–204.
22. **Shah U, Pratinidhi A, Bhatlawande P.** Perinatal mortality in rural India: intervention through primary health care. II Neonatal mortality. *Journal of Epidemiology and Community Health*, 1984, **38**: 138–142.
23. **Nessa S, Arco E, Kabir I.** Birth kits for safe motherhood in Bangladesh. *World Health Forum*, 1992, **13**: 66–69.
24. **Misra P et al.** Perinatal mortality in rural India with special reference to high risk pregnancies. *Journal of Tropical Pediatrics*, 1993, **39**: 41–44.
25. **Salway S, Nasim S.** Levels, trends and causes of mortality in children below 5 years of age in Bangladesh: findings from a national survey. *Journal of Diarrhoeal Disease Research*, 1994, **12**: 187–193.
26. **Victora C et al.** Birthweight and infant mortality: a longitudinal study of 5914 Brazilian children. *International Journal of Epidemiology*, 1987, **16**: 239–245.
27. **Leach A et al.** Neonatal mortality in a rural area of The Gambia. *Annals of Tropical Paediatrics*, 1999, **19**: 33–43.
28. **Villar J, Belizan J.** The relative contribution of prematurity and fetal growth retardation to low birth weight in developing and developed countries. *American Journal of Obstetrics and Gynecology*, 1982, **143**: 793–798.
29. **Villar J et al.** A health priority for developing countries: the prevention of chronic fetal malnutrition. *Bulletin of the World Health Organization*, 1986, **64**: 847–851.
30. **Barker DJP.** Fetal origins of coronary heart disease. *British Medical Journal*, 1995, **311**: 171–174.
31. **Lucas A.** Role of nutritional programming in determining adult morbidity. *Archives of Disease in Childhood*, 1994, **71**: 288–290.
32. **Barros F et al.** Comparison of the causes and consequences of prematurity and intrauterine growth retardation: a longitudinal study in southern Brazil. *Pediatrics*, 1992, **90**: 238–244.
33. **Costello A, Manandhar D.** Current status of newborn care in developing countries. In: Costello A, Manandhar D, eds. *Improving newborn infant health in developing countries*. London, Imperial College Press, 1999.
34. **Ghosh S, Daga S.** Comparison of gestational age and weight as standards of prematurity. *Journal of Pediatrics*, 1967, **71**: 173–175.
35. **Mavalankar D, Trivedi C, Gray R.** Levels and risk factors for perinatal mortality in Ahmedabad, India. *Bulletin of the World Health Organization*, 1991, **69**: 435–442.