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ORIGINAL ARTICLE

A prospective study on neonatal mortality and its predictors in a rural area in Burkina Faso: Can MDG-4 be met by 2015?

AH Diallo[1,2], N Meda[1], WT Ouédraogo[1], S Cousens[3] and T Tylleskar[2], For the PROMISE-EBF study group[4]

[1]Centre MURAZ Research Institute, Ministry of Health/Burkina Faso, Bobo-Dioulasso, Burkina Faso; [2]Centre for International Health (CIH), University of Bergen, Arstadveien 21, Bergen, Norway; [3]London School of Hygiene and Tropical Medicine, Infectious Diseases Epidemiology Unit (IDEU), London, United Kingdom

Objective: To measure the neonatal mortality rate (NMR) and investigate its predictors in a rural area of Burkina Faso.

Study Design: A cohort of infants born in 24 villages in Banfora region was followed until the children were 6 months old. We estimated the risk of neonatal death and used logistic regression to identify its predictors.

Result: Among 864 live births followed to day 28, there were 40 neonatal deaths, a NMR of 46.3 per 1000 live births (95% confidence intervals (CI): 22 to 70). Multivariable regression identified twin birth (OR = 11.5, 95%CI: 4.5 to 29.8), having a nulliparous mother (odds ratio (OR) = 4.3, 95% CI: 1.5 to 12.1), and birth into a polygynous household (OR = 2.1, 95% CI: 1.0 to 4.7) as main predictors of neonatal death.

Conclusion: The burden of neonatal mortality in rural Burkina Faso is very high and the observed NMRs in a predominantly rural country suggest that it is unlikely Burkina will meet fourth Millennium Development Goal (MDG-4) by 2015.
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Keywords: Neonatal; mortality; estimates; predictors; rural-Burkina Faso

Introduction

With an estimated annual global burden ranging from 3.1 to 3.6 million deaths, high neonatal mortality remains a challenge for many low-income countries[1,2] and a major threat to the achievement of the fourth Millennium Development Goal (MDG-4) (see ref. 3–5). In 2009, UNICEF reported that the under-5 mortality rate (U5MR) in sub-Saharan Africa had reduced from 184 in 1990 to 144 per 1000 live births in 2008, a reduction of 22%, whereas the neonatal mortality rate (NMR) had gone from 41 in 1995 to 40 in 2004 per 1000, showing almost no reduction.[6]

Correspondence: Dr AH Diallo, Clinical Epidemiologist, Centre MURAZ Research Institute, Ministry of Health/Burkina Faso, 01 PO Box 390, Bobo-Dioulasso, Burkina Faso.
E-mail: hamadial@yahoo.fr
[4]The PROMISE-EBF study group is listed in the appendix.
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Monitoring progress towards MDG-4 and the planning and implementation of efficient and effective health programs require reliable representative data from countries where the mortality burden is high. Several reports have called for improved estimates of NMRs in sub-Saharan Africa.[3,4,7]

In addition to demographic and health surveys (DHS) based on recall, some countries in sub-Saharan Africa have demographical surveillance sites (DSS), which provide prospective data on mortality trends in the absence of vital registration systems with high coverage.[8,9] In Burkina Faso, two DSS were established in the 1990s in the central and north-western parts of the country.[10–12] However, reports from these DSS suggest under-ascertainment of deaths occurring during the neonatal period.[13,14] Other prospective studies that provide some data on neonatal deaths are restricted to urban populations[15,16] or other specific, atypical study populations[17–19] and there is a lack of reliable prospective data on representative rural populations.

The PROMISE-EBF trial (http://www.clinicaltrials.gov NCT00397150) was a prospective community-based study implemented in four Sub-Saharan African countries including Burkina Faso, during which exclusive breastfeeding was promoted through individual peer counselling.[20] This study provided an opportunity to measure the burden of neonatal mortality in a rural area in Burkina Faso and to study its predictors a few years before the 2015 deadline for MDG-4.

Methods

Setting

The study was carried out in Banfora Health District, in the south-west of Burkina Faso. The district covers an area of 15 000 km^2 and consists of three administrative areas, Banfora, Soubakénédougou and Sidéradougou, respectively. The annual rainfall is 950 to 1250 mm.[21] The population was 410 000 in 2006, dominated by the *Gouin, Karaboro* and *Dioula* ethnic groups.[22] Farming and animal husbandry are the two main activities in rural areas, whereas the town of Banfora is a trading centre. The region is,

relatively speaking, one of the wealthiest in the country.[21] The district health care system comprises 60 primary health facilities and one regional hospital in Banfora town.

Study design
The PROMISE-EBF trial was a community-based cluster randomised trial performed in 24 villages from Banfora Health District and is described elsewhere.[23] Children born to pregnant women enrolled into the trial were followed prospectively until they were 6 months old.

Sample size
On the basis of the previous estimates of NMR in Burkina Faso (32 per 1000),[24] and for a confidence level of 95%, we estimated that a sample of 826 newborns would allow us to measure the NMR with a precision of ± 1.2%. This sample size was achieved in the PROMISE-EBF trial.[23]

Recruitment, follow-up, data collection and main variables
In each study village two to five female 'recruiters' were selected and trained to identify all pregnant women through weekly household visits and to record information on pregnancy outcomes. Each month, up to four pregnant women were randomly selected from each village and invited to participate in this study. Women were eligible for the study, if they planned to live in the village for the next 12 months, were 7 months pregnant, intended to breastfeed their child, had no severe illness or known psychiatric disorder and gave written informed consent. Recruitment of pregnant women lasted 1 year from June 2006 to May 2007.

Five data collectors who spoke the main local dialects (*Dioula* and *Gouin/Karaboro*) were recruited and trained. They lived in the study area and received monthly supervisory visits. Home visits were performed by data collectors at recruitment and after birth, at day 7, weeks 3, 6, 12 and 24 (± 7 days for each visit). Mothers who were not at home on scheduled visit days were revisited. Data were collected on handheld computers (PDAs) using electronic questionnaires with the Epihandy software (http://www.openXdata.org). For quality control purposes, 10 to 20% of the mothers were re-interviewed by the supervisors.

Information recorded at recruitment included the baseline characteristics of the mother. During follow-up, data on pregnancy outcomes, newborn characteristics, infant feeding and child growth were collected. Maternal height and the newborn's birth weight were taken from the antenatal care (ANC) card when available. Data collectors recorded dates of birth and death during weekly visits to each cluster. Infant weight was recorded in kg to the nearest 0.10 kg using Seca 872 scales and recumbent length was measured in cm to the nearest 0.5 cm using a Seca210 infantometer (http://www.seca.com). For multiple births, no data were collected on feeding patterns and growth.

The WHO standard neonatal verbal autopsy questionnaire[25] was administered to the mother in the event of infant death, 4 to 6 weeks after the death to respect the mourning period in the area. The probable causes of death were assigned by two independent physicians using a hierarchical grouping adapted both from the Child Health Epidemiology Reference Group Classification[26] and ICD-10 (see ref. 27). Multiple causes of death were allowed, although only the primary cause is reported here. The opinion of a senior pediatrician was sought in cases of disagreement between the two physicians.

Definitions
The WHO's standard definition of neonatal death (that is, the death of any live born infant within 28 days of his/her birth) and exclusive breastfeeding (that is, the child is given nothing other than breast milk, with minerals, vitamins and medicines allowed) were used.[27,28] Exclusive breastfeeding (EBF) status was based on 'since birth' dietary recall. Delivery with a skilled birth attendant refers to births attended by a nurse, a midwife or a doctor.

Anthropometric status was assessed using WHO's standards (http://www.who.int/childgrowth/en/). Children were classified as wasted, stunted or underweight, if their relevant z-score was below −2.

Data analysis
Data analysis was performed using Stata SE 11.0 (StataCorp LP, College Station, TX 77845, USA). All live births with known vital status at day 28 were included in the analyses.

We generated a relative wealth index as a proxy for socio-economic status based on data collected at recruitment on housing material (walls, floor, windows and roof) and household assets, such as possession of the following items: car/truck, motorcycle/scooter, bicycle, mobile phone/telephone, plough and chart. The index was constructed using principal component analysis.[29]

Summary statistics for the main outcomes were computed as proportions or means with 95% confidence intervals (CIs) based on robust standard errors to account for the cluster sampling of the PROMISE-EBF trial. Pearson chi-squared tests, correcting for the cluster sampling design, were used for between-group comparisons. The NMR per 1000 live births was calculated as the number of neonatal deaths, divided by the number of live births, multiplied by 1000. We assessed the between-cluster variation in NMR using random-effects logistic regression.

Predictors of neonatal death were screened through univariable random-effects logistic regression. Crude odds ratios (ORs) and their 95% CIs were obtained. To reduce the potential for reverse causality, the analysis of feeding covariates was restricted to singleton births, who survived either the first 24 h (for colostrum and time to initiation of breastfeeding) or the first 7 days (for the EBF status).

Multivariable analyses to identify predictors of neonatal deaths were developed following the model from Mosley and Chen.[30]

Only covariates that were associated with the outcome ($P<0.05$) after potential confounders were taken into account were retained. We paid particular attention to the potential association with feeding patterns based on reports from a previous study.[31]

Ethical and administrative clearances

This study was approved by the Institutional Review Board of Centre MURAZ (N°013/2005/CE-CM) and the Western Regional Committee for Medical and Health Research Ethics in Norway (Sak nr 05/8197). The study was authorised by the Ministry of Health of Burkina Faso.

Results

Study profile

Over 1 year, 1162 pregnant women were identified 21 of whom (1.8%) declined study participation upon initial contact. A total of 900 women were then randomly selected for data collection of whom 895 were eligible; all were enrolled and followed until delivery. These pregnancies resulted in 49 stillbirths and 866 live births, including 20 pairs of twins (2.3%). Vital status at 28 days of age was known for 864 newborns. One pair of twins was lost to follow-up after the first week and was excluded from the analyses.

Maternal and infant baseline characteristics

The mean age of the women was 26 years. Few women were nulliparous (16%) or literate (20%). Almost half of women (49%) lived in polygynous households and polygyny was associated with higher odds of multiparity (OR = 5.7, 95% CI: 3.5 to 9.2), with a higher odds of belonging to the least poor two quintiles (OR = 1.7, 95% CI: 1.3 to 2.3) and with a higher odds of an unskilled attendant at birth (OR = 1.4, 95%CI: 1.1 to 1.9).

A total of 609 women attended at least one antenatal consultation of whom 365 (60%) had their height measured and 480 (79%) had a fundal height recorded. However, only 50 (8%) had the date of their last menstrual period recorded in their ANC card. Only 18% of women completed more than two ANC visits and 38% delivered with a skilled birth attendant (Table 1).

The proportion of women without any ANC visit varied within the study area, by season and by parity (Table 2). There was strong evidence that being of low parity and living near a facility were associated with a higher probability of a facility delivery. There was weaker evidence that living in a monogamous household and increasing maternal education were also associated with facility delivery. However, there was no evidence that socio-economic status, as assessed by asset ownership, was associated with facility delivery.

Birth weight was available for 295 newborns. In this subsample the mean birth weight (s.d.) was 2971 (527) g and 14% had a birth weight <2500 g. Two villages (Karfiguéla and Nafona1) showed a higher odds of low birth weight (OR = 3.6, 95% CI: 2.0 to 6.3), but also had a higher odds of twin birth (OR = 5.1, 95% CI: 2.0 to 12.8) as compared with other villages. Birth weight was positively correlated with parity (Spearman's coefficient = 0.29, $P<0.001$) in this subsample.

Table 1 Maternal, newborns baseline, NMR and factors associated with increased odds of neonatal death in a cohort of 864 newborns in Banfora (Burkina Faso)

Variables	*Number of live births (%) n = 864*	*Number of deaths (NMR) n = 40*	*Unadjusted[a] OR (95% CI)*	*Adjusted[b] OR (95% CI) n = 864*
Study arm				
Control	429 (50)	15 (35.0)	1.00	
Intervention	435 (50)	25 (57.5)	1.7 (0.6–4.3)	
Maternal age				
<20	133 (16)	8 (60.2)	1.3 (0.6–3.1)	
20–35	642 (74)	28 (43.6)	1.00	
>35	89 (10)	4 (44.9)	1.0 (0.3–3.1)	
Parity				
0	139 (16)	9 (64.7)	1.9 (0.8–4.8)	4.3 (1.5–12.1)
1	141 (16)	6 (42.6)	1.3 (0.5–3.6)	1.6 (0.5–4.8)
2–4	404 (47)	14 (34.7)	1.00	1.00
5+	180 (21)	11 (61.1)	1.8 (0.8–4.2)	2.3 (0.9–5.6)
Polygynous household				
Yes	420 (49)	24 (57.1)	1.7 (0.9–3.4)	2.1 (1.0–4.7)
No	444 (51)	16 (36.0)	1.00	1.00
Maternal education				
None	682 (80)	29 (41.9)	1.0 (0.2–4.4)	
Literate/primary school	120 (14)	9 (75.0)	1.7 (0.3–8.8)	
Secondary school	52 (06)	2 (38.5)	1.00	
Distance to nearest health facility				
⩽5 km	417 (48)	27 (64.7)	2.1 (0.8–5.3)	
>5 km	447 (52)	13 (29.1)	1.00	
Mothers got ANC visit				
Yes	626 (72)	28 (44.7)	1.00	
No	238 (28)	12 (50.4)	1.1 (0.5–2.4)	
Birth attendants				
Skilled attendant	324 (38)	10 (30.9)	1.00	1.00
TBA/Family/ other	540 (62)	30 (55.6)	2.3 (1.1–5.1)	2.1 (0.9–4.7)
Twins				
Yes	38 (04)	11 (289.5)	9.7 (4.1–23.1)	11.5 (4.5–29.8)
No	826 (96)	29 (35.1)	1.00	1.00
Time to initiation of breastfeeding[c]				
⩽24 h	639 (84)	19 (29.7)	1.00	
>24 h	124 (16)	4 (32.3)	1.1 (0.4–3.2)	
Received colostrum[c]				
Yes	683 (90)	19 (27.8)	1.00	
No	80 (10)	4 (50.0)	1.8 (0.6–5.5)	

Abbreviations: ANC, antenatal care; NMR, neonatal mortality rate; TBA, traditional birth attendant.
All logistic regressions were based on random-effects models.
The multivariable analyses identified twins' birth, nulliparous mothers and polygynous households as the major predictors of neonatal death in this cohort (Wald chi-2, $P<0.0001$). There was weak evidence that high multiparae ($P=0.07$) and unskilled attendant at birth ($P=0.08$) were both associated with increased odds of neonatal death in the adjusted model.
[a]Univariable analyses were adjusted for clustering to account for the design of the PROMISE-EBF trial.
[b]Adjusted for clustering and for parity, polygynous status, attendant at birth and twinship.
[c]Restricted to singleton births who survived the first 24 h ($N=763$).

Table 2 Levels of usage of health services by maternal, and local characteristics of the cohort in Banfora Health District

Variables n = 846	*No ANC visit* N *(%)*	P-*values*	*Delivered in a health facility,* N *(%)*	P-*values*
Study arm				
Control	122 (29)	0.86	151 (36)	0.70
Intervention	115 (27)		168 (40)	
Study area				
Banfora	114 (27)		190 (45)	
Soubakénédougou	24 (11)	0.003	63 (30)	0.37
Sidéradougou	99 (45)		66 (30)	
Season				
Dry season (Nov–April)	137 (34)	0.0001	140 (37)	0.87
Rainy season (May–Oct)	100 (22)		170 (38)	
Distance to the nearest health facility				
<5 km	96 (24)	0.32	226 (56)	0.0001
⩾5 km	141 (32)		93 (21)	
Parity				
0	23 (17)	0.0005	70 (51)	0.001
1	31 (23)		56 (41)	
2–4	115 (29)		142 (36)	
⩾5	68 (38)		51 (29)	
Polygynous household				
Yes	123 (30)	0.32	137 (33)	0.024
No	114 (26)		182 (42)	
Maternal education				
None	190 (28)		239 (35)	
Literate/primary school	31 (27)	0.81	55 (47)	0.086
Secondary school	16 (31)		25 (48)	
Assets ownership (household)				
Q1 (most poor)	59 (32)		67 (37)	
Q2	51 (33)		65 (42)	
Q3	49 (27)	0.32	57 (32)	0.45
Q4	34 (20)		70 (42)	
Q5 (least poor)	44 (27)		60 (37)	

Abbreviation: ANC, antenatal care.
The probability of not having ANC visit and that of having a health facility delivery were found to vary significantly with maternal socio-economic variables (parity, polygynous status and education) and also with local characteristics such as the study area, the season and the distance to the nearest health facility.

Neonatal mortality outcomes

A total of 40 newborns had died by day 28, a NMR of 46.3 per 1000 (95% CI: 22 to 70). In all, 23 of these deaths (57%) occurred during the first week of life, an early NMR of 26.6 per 1000 (95% CI: 9 to 44). Six of the deaths occurred on the day of birth (15%), 8 (20%) occurred within 24 h. Moreover, 11 deaths (28%) were among twins, giving a NMR of 289 for twins compared with 35 for singleton births ($P = 0.0001$).

There was evidence that the NMR varied between villages (LR test, $P = 0.001$). NMRs ordered by village reveal two villages, Karfiguéla and Nafona1 with very high-observed NMRs (214 and 250 per 1000, respectively). Both villages house a health facility.

Of the newborns who died, 5 (12%) were taken to the local health facility before death, 2 (5%) were taken to a local healer and 33 (83%) were either treated at home (8 received self-prescribed drugs) or did not receive any care before death (25 infants). In all, 36 (90%) of the deaths occurred at home, 3 (8%) in a health facility and 1 in a local healer's home.

The probable primary causes of neonatal death were birth asphyxia (1 case), complications of pre-term birth (17 cases), infections (7 cases), haemorrhage (1 case) and acute intestinal occlusion syndrome (2 cases). Cause of death could not be identified for 12 neonates.

Infant feeding patterns and anthropometric status at 3 weeks of age

The analysis of the early feeding behaviour in this cohort showed that 684 (90%) of the 764 singletons newborns who survived the first 24 h received colostrum. Five singleton newborns died before initiation of breastfeeding and four of these deaths occurred within 24 h of birth. Only 32 mothers of singletons (4%) initiated breastfeeding within 1 h of birth, whereas a further 371 (49%) did so within 12 h of birth. The proportion of singleton births reported to be EBF by 3 weeks of age was 54% (95% CI: 38 to 69).

Anthropometric data were only available for three of the neonates who died and therefore no useful comparison could be carried out with the survivors. The mean (95% CI) z-scores among newborns with anthropometric data at 3 weeks of age ($n = 715$) were: WLZ = −0.88 (−1.1 to −0.7); LAZ = −0.64 (−0.77 to −0.52); WAZ = −0.96 (−1.07 to −0.85). The corresponding proportions of wasted, stunted and underweight newborns were 17% (95% CI: 13 to 22), 11% (95% CI: 9 to 13) and 16% (95% CI: 13 to 20), respectively.

Predictors of neonatal death

In univariable analyses, twin births had almost 10-fold increased (OR = 9.7) odds of neonatal death (Table 1). Having an unskilled attendant at birth was associated with doubling (OR = 2.3) in the odds of neonatal death. Living within 5 km of a health facility was unexpectedly associated with doubling in the odds of neonatal death (OR = 2.1), although this was not significant ($P = 0.09$). Nulliparous and high multiparae mothers had increased odds of neonatal death with ORs of 2.0 (95% CI: 0.8 to 4.8) and 1.8 (95% CI: 0.8 to 4.2), respectively, although the association was not

statistically significant ($P = 0.15$). No other variables examined, including maternal age, newborn's gender, time to initiation of breastfeeding, receiving colostrum, reported EBF-status by 3 weeks, had ORs of <0.5 or >2.0.

In multivariable regression, having a nulliparous mother (OR = 4.3), being born in a polygynous household (OR = 2.1), and being a twin (OR = 11.5) were the factors associated with an increased odds of neonatal death (Table 1). Neither birth attendant (OR = 2.1, 95% CI: 0.9 to 4.7), nor distance to health facility (OR = 2.1, 95% CI: 0.9 to 4.8) after controlling for other factors, showed evidence that either of these variables were 'significantly' associated with the odds of neonatal death. Inclusion of the feeding covariates in a multivariable model did not provide any evidence that time to initiation of breastfeeding or administration of colostrum was associated with the odds of neonatal death (data not shown). Similar analyses using a Cox regression model were also performed and produced results similar to those obtained with the logistic model (data not shown).

Discussion

Estimates of neonatal mortality

We observed a high burden of neonatal mortality in this rural area in Burkina Faso. The NMR of 46.3 per 1000 is one of the highest ever reported from the country.

Our study is a rarity in Burkina Faso, being a community-based, prospective cohort study, which measured the burden of neonatal mortality in a rural area. The study participants were a random sample of pregnant women from 24 villages in the study area. The recruitment lasted exactly 1 year to capture any seasonal variation in maternal and newborn characteristics. The collaboration of local 'recruiters' with trained data collectors, the weekly household visits and the regular supervision of data collection and the low proportion of refusals (1.8%) should have resulted in data of high quality from a representative sample of eligible mothers.

However, a limitation of our study was its relatively small sample size, resulting in low power to detect risk factors associated with small increases in neonatal mortality risk. The high proportion of home deliveries meant few babies had birth weight measured and recorded. Most deaths occurred before 14 days, so that no anthropometric comparison of children who died with survivors at 3 weeks was possible. The possibility that some early neonatal deaths were misclassified as stillbirths cannot be excluded, with circumstantial evidence for such misclassification provided by the high stillbirth: early neonatal death ratio,[23] the low proportion of neonatal deaths on day 0 (15%) and the fact that only one neonatal death out of 40 was attributed to birth asphyxia. If some of the stillbirths were actually live births who died shortly after delivery, then our estimate of NMR is an underestimate. Several studies have shown that for cultural and economic reasons, some early neonatal deaths may be reported as stillbirths.[32,33]

In our study, the probable causes of deaths were dominated by complications of pre-term birth (42%) and infections (18%), differing from a Ghanaian study[34] where infections (40.3%), birth asphyxia (33.2%) and pre-maturity (19.7%) were the major causes of neonatal deaths, and a recent meta-analysis showing that in sub-Saharan Africa, infections, pre-term birth complications and birth asphyxia are in decreasing order the main causes of neonatal deaths.[1] Again the potential for misclassification and the proportion of deaths with undetermined causes (30%) could explain the observed difference.

One explanation for the high NMR observed in this study is likely to be the weak health system, with health facilities geographically inaccessible, poorly equipped where they exist, and offering a generally poor quality of health care[35–37] In our study, only six villages (25%) had their own primary health facility and the one regional hospital that provides round-the-clock emergency obstetric care serves a population of over 400 000. The proportion of women delivering in a facility was higher in villages located within 5 km of the nearest health facility (56%). Surprisingly, the two villages with the highest observed NMRs both had a health facility (Karfiguéla and Nafona1), and had a higher proportion of facility deliveries than the average in this cohort. The high proportion of twin births and possibly the low birth weights in these two villages may partly explain their high NMRs. Nonetheless, another explanation could be the poor quality of health care offered in the health centres in general. In a recent study conducted in another rural district of Burkina Faso, the authors reported on the poor quality of antenatal and childbirth services.[38] Understaffing, de-motivated health personnel and the attitude of health workers in the context of low literacy in rural areas are among the factors contributing to the poor quality in health services.[38] Moreover, in rural settings, a proportion of deliveries classified as facility-based may actually have started at home and only been taken to the clinic when progress was slow, masking the expected benefits of delivering in a facility.[24]

The 2003-DHS reported that neonatal mortality was slightly higher in rural areas of Burkina Faso (NMR = 39 per 1000) than in urban settings (NMR = 35 per 1000), and a NMR of 50 per 1000 was reported in the region of Banfora, consistent with our results.[24] The few longitudinal studies conducted in rural areas of Burkina report NMRs ranging from 94 to 350 per 1000 person-years, all in the DSS of Nouna.[14,39] These estimates are below ours when converted to neonatal deaths per 1000 live births. However, given the low proportion of neonatal deaths in one of the studies (6% of all child deaths), it seems they failed to identify many neonatal deaths.[14] Another study conducted in Houndé region reported a somewhat lower NMR of 14.6 per 1000, but this was in the context of a randomised trial of micronutrient supplementation during pregnancy.[40]

Recent reports on overall child mortality trends in Burkina Faso[5,41] estimated the U5MR to be of 169 per 1000 in 2008 with a target of 68 in 2015. The average annual reduction rate for U5MR between 1990 and 2008 was of 1% (see ref. 5), and the authors concluded that this was insufficient to reach MDG-4 by 2015. Given that Banfora is among the wealthiest regions in Burkina and the high proportion of child deaths, which are neonatal (40%), achieving MDG-4 seems unlikely for Burkina based on our observation of a very high NMR in a rural area, of a largely rural population (>75%) (see ref. 22). A recent publication estimated the national NMR at 32 per 1000 in 2010 (see ref. 2) in Burkina. Our data collected in field up to August 2008 suggest that NMRs may be much higher than this in rural areas where 77% of the Burkina population lives.[22] High NMRs have also been reported in Benin and Mali, both neighbours of Burkina Faso.[42]

Predictors of neonatal death

The multivariable analyses identified that nulliparous mothers, polygynous households and twin births are associated with increased odds of neonatal death.

Nulliparous mothers are at a higher risk of neonatal death because of the higher risk both of complicated and pre-term births in this group, the latter being a result of their higher vulnerability to certain infections such as malaria.[43,44]

Our finding of increased risk of neonatal death in polygynous households is consistent with that of two previous studies.[45,46] In our study, polygyny was associated with higher odds of multiparity and of an unskilled attendant at birth, both of which were associated, albeit, weakly with increased odds of neonatal death. Previous studies have hypothesised polygyny may be associated with increased risk of death through resource constraints, lack of paternal investment and selectivity of the husband.[47,48]

Multiple births including twins have been reported in several studies as being at a higher risk of neonatal death.[3,4,34,49] The high probability of pre-term birth and low birth weight are among the factors suggested to contribute to this poor outcome. The small proportion of babies with measured birth weights and the lack of reliable gestational age data are limitations, which preclude an investigation of the role of gestational age and intra-uterine growth retardation in this study.

We found some weak evidence that having an unskilled attendant at birth was associated with increased odds of neonatal death. Home delivery with an unskilled attendant may increase the risk of neonatal death through increased risk of birth asphyxia at birth and risk of sepsis during the neonatal period.[3,4,34]

We did not find any evidence of an association between the time to initiation of breastfeeding and risk of neonatal death in this study, although our cohort size means that we cannot exclude such an association. A larger study found an increased risk of infection-related neonatal death with delayed initiation of breastfeeding.[31] The difference may also be due to the predominantly higher proportion of non-infectious causes of deaths found in our cohort.

The surprising, albeit weak, association of a shorter distance to the nearest health facility with increased odds of neonatal death was mainly because of the two villages with the highest NMRs, as confirmed by analyses that excluded these two clusters (data not shown). However, this observation may also reflect the poor quality of care provided in facilities and underlines that the presence of a health facility itself may not be enough, especially given the recurrent absences of the health personnel. Our findings oppose to that reported in a previous study in Burkina, in which the outcome was rather infant death,[50] and show the need of further understanding of the concept of distance.[51]

Conclusion

The burden of neonatal mortality is high in this rural area of Burkina Faso. With such high NMRs and the high proportion of population living in those areas and the current progress in the reduction of overall child deaths, it is unlikely that Burkina Faso will meet the MDG-4 by 2015. Our findings call for increased health facility access and improved quality of care in childbirth services in rural areas of this country. Primigravidae and mothers of multiple births may require greater attention in the peripartum, and further studies are needed to understand the social determinants of neonatal deaths.

Conflict of interest

The authors declare no conflict of interest.

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Authors' Contributions

AHD, NM and TT have designed the study. AHD conducted the study, performed data analyses and drafted the manuscript. WTO contributed to data collection. SC supervised the overall data analyses. SC, NM, WTO and TT contributed to interpretation of the findings.

All authors read and approved the final manuscript.

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Appendix

The Promise-EBF study group
List of members for the PROMISE-EBF study Group
Steering Committee:
Thorkild Tylleskär, Philippe Van de Perre, Eva-Charlotte Ekström, Nicolas Meda, James K. Tumwine, Chipepo Kankasa, Debra Jackson.
Participating countries and investigators:
Norway: Thorkild Tylleskär, Ingunn MS Engebretsen, Lars Thore Fadnes, Eli Fjeld, Knut Fylkesnes, Jørn Klungsøyr, Anne Nordrehaug-Åstrøm, Øystein Evjen Olsen, Bjarne Robberstad, Halvor Sommerfelt
France: Philippe Van de Perre
Sweden: Eva-Charlotte Ekström, Barni Nor
Burkina Faso: Nicolas Meda, Abdoulaye Hama Diallo, Thomas W. Ouédraogo, Jeremi Rouamba, Bernadette Traoré, Germain Traoré, Emmanuel Zabsonré
Uganda: James K. Tumwine, Caleb Bwengye, Charles Karamagi, Victoria Nankabirwa, Jolly Nankunda, Grace Ndeezi, Margaret Wandera
Zambia: Chipepo Kankasa, Mary Katepa-Bwalya, Chafye Siuluta, Seter Siziya
South Africa: Debra Jackson, Mickey Chopra, Mark Colvin, Tanya Doherty, Ameena E Goga, Lungiswa Nkonki, David Sanders, Wesley Solomons Wanga Zembe.