Factors associated with mortality and length of stay in hospitalised neonates in Eritrea, Africa: a cross-sectional study

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ABSTRACT

Objective: To determine the factors associated with mortality in a hospitalised cohort of infants in Asmara, Eritrea.

Design: Retrospective cross-sectional review of all 2006 admissions to a specialised neonatal intensive care unit. Data on gestational age (prematurity), age at presentation, birth weight, gender, mode of delivery, Apgar score, maternal age, birth location, admission diagnosis, admission comorbidities, time of admission and outcome were collected.

Setting: Orotta Pediatric Hospital 'Specialised Neonatal Intensive Care Unit' (SNCU) in Orotta National Maternity Referral Hospital, the nation's only tertiary newborn centre.

Primary and secondary outcome

measures: Factors associated with mortality and length of stay via multivariate regression analysis and the combined association of both hypothermia and pneumonia. Other outcome measures were determination of the association of admission hypothermia, time of admission and pneumonia on mortality.

Results: A total of 1502 infants were admitted to the SNCU with an average preterm gestational age of 35.9 weeks. 87 died (mortality 8.2%). In bivariate analysis, the highest mortality rate (10.3%) was seen in patient's admitted <1 h after birth. Patients with hypothermia or pneumonia exhibited higher mortality rates (13.6% and 13.4%, respectively). In multivariate analysis, birth weight <2 kg ($p<0.01$), birth weight between 2.1 and 2.5 kg ($p<0.01$), Apgar score at 1 min ($p<0.01$), small for gestational age ($p<0.01$), hypothermia ($p<0.04$) and pneumonia ($p<0.01$) were associated with mortality.

Conclusion: Hypothermia, pneumonia, younger gestational age, 1 min Apgar score and small size for gestational age are significantly associated with mortality and longer length of stay in the Eritrean SNCU.

INTRODUCTION

Four million neonates will die in the first 28 days of life.¹ This translates to 450 newborns that die worldwide each hour.²⁻³ While under 5-year childhood mortality has

ARTICLE SUMMARY

Article focus

- Limited data exist on the causes of mortality in Eritrea.
- Review of inpatient hospitalisation data in Eritrea's only tertiary care intensive care nursery allows for insight into factors associated with mortality.
- The purpose of the study was to determine factors associated with mortality in a hospitalised cohort of infants in Asmara, Eritrea.

Key messages

- Pneumonia, hypothermia, abnormalities of gestational age, lower Apgar scores, decreased birth weight and younger gestational age are associated with mortality and morbidity (including longer length of stay) in Eritrea and should be a focus area for improving care.
- Increasing attendance of skilled resuscitation personnel at deliveries and improved attention post-delivery may improve mortality by reducing hypothermia, improving Apgar scores and increasing prompt treatment of medical sequelae of small- and large-for-gestational-age neonates.
- Substantial reduction in neonatal mortality with increased attention to these factors may be possible without significant increases in costs and should be an area for future research effects aimed at evaluating the effect of skilled resuscitators on short- and long-term neonatal mortality.

Strengths and limitations of this study

- Information was obtained in 2006 and may not be indicative of real-time annual changes in neonatal mortality rate. Furthermore, information on birth weight, Apgar score and temperature may not be representative of national data as many births occur at home, a commonly encountered problem for research in the developing world. Also potentially confounding is the inclusion of pneumonia versus sepsis as two distinct categories.

steadily declined worldwide, decreasing 50% from 1960 to 1990 alone, neonatal mortality has decreased only 20% in the same time period.⁴⁻⁵ Thus, as a percentage of overall childhood deaths, the proportion

attributable to the first month of life has increase steadily since 1960 and rose from 23% to 38% from 1980 to 2000.^{6 7} Of all known neonatal deaths, 99% occur in low- and middle-income countries, particularly in South East Asia and Africa.⁸ In sub-Saharan Africa, the neonatal mortality rate (NMR) is >45/1000 in 14 of 18 countries and contrasts sharply to that of the 39 wealthiest nations, whose NMR averages 4/1000 (range 1–11/1000).^{9 10}

The fourth generation of the Millennium Development Goals (MDG-4) aims to reduce under 5-year mortality by 2/3 from 1990 to 2015.¹¹ Given the increased percentage of childhood mortality in the first month of life, achievement of MDG-4 requires reductions in neonatal mortality, particularly in India and Africa. In these areas, preterm birth, asphyxia and infections (sepsis/pneumonia) account for 75% of all neonatal mortality.^{9 12 13} Increasing poverty in sub-Saharan Africa, decreased global investment in child health stemming from a worldwide economic recession and competing public health challenges such as tuberculosis and HIV/AIDS have been cited as significant impediments towards achieving MDG-4.^{14–16} Eritrea, a 124 000 km² country of 4 million bordered by Ethiopia, Sudan and the Red Sea, is one African country considered capable of reaching MDG-4 by targeting neonatal mortality.⁵ Independent of <2 decades, the country introduced a 'Specialised Neonatal Care Unit' (SNCU) in 2003. The SNCU is the national referral centre for all critically ill newborns and is located in the nation's only paediatric hospital. In a nation of four paediatricians, introduction of the SNCU reduced mortality for hospitalised newborns from 10.8% to 7.8% over 2 years.⁵ Mortality for preterm infants in the SNCU was reduced by 10% over the same time span. In 2008, 3032 neonatal deaths were reported in Eritrea, and since the 1970s, the area has seen a reduction in under 5-year mortality from 232/1000 to 78.2/1000.^{17 18}

However, because many infant deaths in this region are unrecorded, or occur at home, there is a lack of direct health information originating from a patient's medical record related to factors associated with neonatal mortality. Epidemiological research has almost exclusively focused on the 1% of newborn deaths occurring in wealthy nations where ample data are recorded.^{6 19} Current information in resource-poor regions is based on smaller studies and dependent on statistical modelling rather than source data.⁹ Use of local birth registries at individual healthcare facilities has been proposed to bridge this epidemiological gap in information.²⁰ Using such a registry, the objective of this study was to determine factors associated with mortality in a hospitalised cohort of infants in Asmara, Eritrea, thereby aiming to reduce gaps in source data and improve estimates of neonatal mortality in this region of the world.

METHODS

Study location

Eritrea's SNCU is located at Orotta National Maternity Referral Hospital, the nation's tertiary care centre and

only dedicated paediatric hospital. The unit admits approximately 1100 patients annually up to 1 month of age at presentation. The affiliated maternal hospital on the same campus averages 8000 deliveries per year. However, 70% of the nation's deliveries take place at home.⁵ At the time of data collection, hospital deliveries were not routinely attended by paediatric healthcare workers certified by the American Academy of Pediatrics' Neonatal Resuscitation Program. The SNCU was attended to by two physicians, one registered nurse and 14 nurse assistants. Designed for an average daily census of 40, the facility provided a centralised oxygen supply, infusion pumps and incubators, three radiant warmers and phototherapy equipment. Bubble Continuous Positive Airway Pressure was the primary means of assisted ventilation.⁵

Data collection

In 2006, data on all admitted infants to the SNCU were collected by one physician (ZO). Information on gestational age, length of stay (days), mode of delivery (spontaneous vaginal delivery, cesarian section (C-section), breech presentation or forceps use), location of delivery Maternal Child Hospital (MCH) or extramural, birth weight (grams), Apgar scores, primary diagnosis, comorbid conditions (ie, hypothermia, sepsis, pneumonia), birth size (appropriate, small for gestational age (SGA) or large for gestational age), maternal age (years) and mortality was obtained. Gestational age was based on physical examination by the neonatal director upon SNCU presentation taking into account the mother's known last menstrual period and infant's chronological age. Apgar scores were recorded by physicians or rural health workers present at delivery but were unavailable for 35 infants in the cohort. SGA was defined as having a first recorded weight (either by an outside rural health facility or upon SNCU admission) of less than the 10th percentile for gestational age based on WHO Infant Growth Charts. Large for gestational age was defined as an admission weight greater than the 90th percentile. Timing of mortality was based on presentation to the SNCU, which was considered 'time 0' and equivalent to admission in this context.

Primary diagnosis was defined as the patient's most acute medical problem on admission, while secondary diagnoses were those considered to be comorbid or complicating conditions. Thus, it is possible that some diagnoses could be either primary or secondary based on the infant's presentation. Neonatal pneumonia was a clinical diagnosis informed by the presence of radiographic infiltrate(s) or focally decreased breath sounds on examination with clinical evidence of increased work of breathing, laboratory leucocytosis and/or bandemia. The definition of hypoxic-ischaemic encephalopathy was clinical but based on National Neonatal Perinatal Database Information for the developing world and defined as an Apgar score of 0–3 at 1 min of life and synonymous with perinatal asphyxia.²¹ Hypothermia was defined as a temperature of <36.5°C rectally at the time of first

medical presentation. As many babies, particularly from areas outside the Asmara region, would first present to rural health workers or local clinics, the temperature obtained at those outlying facilities was used if known. If not, then the first recorded temperature on admission to the SNCU was used. The binary outcome for length of stay analysis was >10 days.

Data analysis

Data were entered into a Microsoft Access Database (Microsoft, Inc., Redmond, Washington, USA). Descriptive statistics for admitting diagnosis, time of admission, presence of hypothermia and pneumonia were calculated as a percentage of all admissions and compared using the χ^2 test. Continuous variables of days of life on admission and length of stay were analysed using the non-parametric Wilcoxon rank-sum test. *t* Tests were used for gestational age, maternal age, birth weight and Apgar scores. Multivariate logistic regression was performed using the SAS Systems Version 9.2 (SAS Institute, Inc, Cary, NC) to identify characteristics associated with mortality. For the purpose of regression analysis, birth weight was divided into four categories (≤ 2 , >2 to ≤ 2.5 , >2.5 to ≤ 3.0 and >3 kg). To determine factors associated with increased length of stay, logarithmic transformation was used. Length of stay analysis excluded newborns that died.

Ethics: This work was reviewed by the Stony Brook University Institutional Review Board.

RESULTS

General

Data were available for 1053 patients admitted between 1 January 2006 and 31 December 2006. Characteristics of the entire patient cohort are seen in table 1. On average, patients presented at 4 days of life (reflecting the high percentage of outborns—infants not born at the regional centre, but either at home or in a community medical setting) with an average gestational age of 35.9 ± 2.7 weeks. Mean birth weight was 2.7 ± 0.8 kg. Mortality was 87/1053 (8.2%), and 220/1053 (20.9%) of all infants were SGA. The mean maternal age was 26.7 years, and 47% of the infants were women. Overall, the C-section rate was 22.5% (237 patients), and 816 patients were born via vaginal delivery (759 required no supplemental instrumentation with vertex presentation). Thirteen and 17 patients were born via breech or forceps delivery (1.2% and 1.7%, respectively) and 27 infants (2.6%) were born via other means such as vacuum extraction. Data on episiotomy were not collected.

Admission diagnosis

Primary admission diagnosis for all patients in the cohort is depicted in figure 1. The most common primary diagnosis was pneumonia, affecting 306 (29%) of the infants. Sepsis (culture proven or suspected) was diagnosed in 181 (17%) of patients. Dehydration and primary hypothermia were seen in 164 (16%) and 100 (10%) of patients', respectively. These four conditions

Table 1 General characteristics of Specialised Neonatal Intensive Care Unit patients, 2006

	Mean $\pm$ SD	No of patients (total no. of infants in register 1053)
Gestation age (weeks)	35.9 ± 2.7	1051
Birth weight (kg)	2.7 ± 0.8	1043
Days of life at hospital admission	4.1 ± 1.3	1052
Apgar score (1 min)	3.6 ± 3.1	1014
Apgar score (5 min)	4.8 ± 3.6	1018
Hospital length of stay (days)	5.5 ± 3.5	1051
Maternal age (years)	26.7 ± 5.7	1041
	Percentage of cohort	
Female	47.1	1053
Cesarian section	22.5	1053
Large for gestational age	6.8	1053
Small for gestational age	20.9	1053
Birth at maternal hospital	60.7	1053
Hypothermia	23	1053
Pneumonia	29.1	1053

Average gestational age for patients was 35.9 weeks with a birth weight of 2.7 kg. One-fifth of the population was small for gestational age and only 60% of infants were hospital born.

constituted >70% of 2006 SNCU admissions in Eritrea. Of note, respiratory distress syndrome (RDS) was seen in only 1% of the population and hypoxic-ischaemic encephalopathy/asphyxia in 6%.

Mortality

Figure 2 illustrates the causes of death for the 87 patients who expired in 2006. Pneumonia contributed to 49% of all mortality, with RDS and sepsis contributing 16% and 14%, respectively, of total mortality. These diagnoses

Figure 1 Admission diagnosis for Eritrean neonates treated at the Specialised Neonatal Intensive Care Unit in 2006. Pneumonia, sepsis, hypothermia and dehydration were the three most common primary diagnoses in this cohort, accounting for 79% of all admissions. RDS, respiratory distress syndrome; URI, upper respiratory infection.

Figure 2 Causes of mortality for 87 Eritrean neonates in 2006. Pneumonia and sepsis were responsible for the greatest percentage of overall mortality, accounting for 59% of deaths in the Specialised Neonatal Care Unit. MAS, meconium aspiration syndrome; RDS, respiratory distress syndrome.

caused >85% of all neonatal deaths in Eritrea's SNCU. Disease-specific mortality is seen in figure 3. Meconium aspiration syndrome was uniformly fatal for all diagnosed patients. Ninety-three per cent of patients with RDS died, a factor that may be attributed to the lack of mechanical ventilation and the unavailability of exogenous surfactant. The percentage mortality for all patients with pneumonia was 12% and for sepsis 6.6%. Compared individually to each of the other mortalities, meconium aspiration and RDS were associated with significantly greater mortality ($p<0.05$, χ^2).

As seen in table 2, using bivariate analysis, patients who died were of lower gestational age (33.2 ± 4.7 vs 36.2 ± 2.3 weeks, $p<0.001$) and lower birth weight (2.1 ± 1 vs 2.7 ± 0.8 kg, $p<0.001$). Patients who died also had lower 1 and 5 min Apgar scores and were more likely to have pneumonia (49.4% vs 27.3%, $p<0.01$) or be hypothermic (39.8% vs 21.5%, $p<0.01$). These infants were also more likely to be large for gestational age (12% vs

6.4%, $p<0.05$) and be delivered by C-section (23.5% vs 10.8%, $p<0.01$).

Comparison of mortality for the cohort of 414 patients born outside the hospital is shown in table 3. Out-of-hospital-born patients who died had lower birth weights (2.4 ± 0.8 vs 2.8 ± 0.8 kg, $p<0.01$) and were more likely to be diagnosed with pneumonia (25% vs 11.9%, $p<0.05$) or be hypothermic (32.1% vs 16.1%, $p<0.03$).

Table 4 shows bivariate analysis results for mortality from the 639 patients born at the hospital. Hospital-born patients who died were of lower gestational age (32.2 ± 5 vs 36.1 ± 2.5 weeks, $p<0.01$), lower birth weight (1.9 ± 1 vs 2.7 ± 0.8 kg, $p<0.01$) and exhibited lower 1 and 5 min Apgar scores. The patients were less likely to be born by C-section (16.4% vs 33.6%, $p<0.01$) and had younger mothers (24.7 ± 5.8 vs 27 ± 5.6 years). Hospital-born patients who died also exhibited higher rates of hypothermia (43.6% vs 25.5%, $p<0.01$) and pneumonia (61.8% vs 37.5%, $p<0.01$).

For 1037 patients for whom data were available, factors associated with mortality were calculated using multivariate regression as shown in table 5. Younger gestational age, lower 1 min Apgar score, hypothermia at presentation, diagnosis of pneumonia and SGA were associated with higher mortality. The interaction of hypothermia and pneumonia (patients with both conditions) was not associated with higher mortality ($p<0.06$, OR 2.42, 95% CI 0.93 to 6.27). Day of SNCU presentation, birth weight, female gender, maternal age and hospital birth were not associated with higher mortality.

Timing of mortality

Mortality was not evenly distributed across the range of hospital length of stay for the 1052 patients for whom data were available (figure 4). Twenty-nine patients of

Figure 3 Disease-specific mortality for Eritrean neonates in 2006. Meconium aspiration syndrome (MAS) was uniformly fatal (100% mortality, $p<0.05$, χ^2 compared individually to sepsis, pneumonia, hypothermia and congenital malformations). Respiratory distress syndrome (RDS) carried a poor prognosis with >90% mortality ($p<0.05$, χ^2 compared individually to sepsis, pneumonia, hypothermia and congenital malformations).

Table 2 Bivariate analysis of mortality for 1053 hospitalised neonates in Eritrea, 2006

	Alive		Died		p Value
	N	Mean $\pm$ SD	N	Mean $\pm$ SD	
Gestation age (weeks)	968	36.2 $\pm$ 2.3	83	33.2 $\pm$ 4.7	<0.01*
Birth weight (kg)	961	2.7 $\pm$ 0.8	82	2.1 $\pm$ 1	<0.01*
Days of life (days)	969	4.3 $\pm$ 7.5	83	2.8 $\pm$ 5.5	0.07
Apgar score 1	631	6 $\pm$ 2	54	3.3 $\pm$ 1.9	<0.01*
Apgar score 5	636	7 $\pm$ 2	60	4.9 $\pm$ 1.8	<0.01*
Maternal age	958	26.8 $\pm$ 5.6	83	25.7 $\pm$ 6.2	0.15
Female, %	970	47.1	83	47	0.98
Cesarian section, %	970	23.5	83	10.8	0.01*
Large for gestational age, %	970	6.4	83	12	0.05*
Small for gestational age, %	970	20.6	83	24.1	0.45
Birth at the Maternal Child Hospital, %	970	60.2	83	66.3	0.28
Hypothermia, %	970	21.5	83	39.8	<0.01*
Pneumonia, %	970	27.3	83	49.4	<0.01*

Mortality was associated with lower gestational age, lower birth weight and lower Apgar scores at 1 and 5 min. Deceased patients exhibited a lower rate of delivery via cesarian section, despite a higher incidence of large-for-gestational-age neonates. Rates of hypothermia and pneumonia were higher in patients who did not survive (* p <0.05, significant).

the 280 (10.4%) who presented within the first hours of SNCU admission died compared with 8.1% (29/355) between hours 2 and 24 of presentation. After the first day, SNCU mortality decreased to 6% (25/417). This decrease was statistically significant compared with mortality within the first hour of life (p <0.05, χ^2). No difference in mortality was seen between the first hour and the remaining day of admission. Mortality for patients with pneumonia was greater than overall mortality (13.4% vs 8.2%, p <0.05, χ^2) in bivariate analysis.

Hypothermia

Hypothermia, defined as an initial temperature <36.5°C, was the primary diagnosis for 100 of 1053 patients (9.4%). However, hypothermia was a contributing diagnosis for 242 (22.9%) of patients. Fewer hypothermic babies were born by C-section (15.3% vs 24%, χ^2). Characteristics of hypothermic patients are seen in

table 6. Using bivariate analysis, patients with hypothermia were more likely to be of younger gestational age (34 $\pm$ 3.9 vs 36 $\pm$ 1.9 weeks, p <0.001, t test). These patients also were of smaller birth weight (p <0.01, t test) and more often SGA (p <0.01, χ^2). Apgar scores at 1 and 5 min were lower for hypothermic patients (p <0.01, for both, t test) as was increased length of stay (p <0.01, non-parametric Wilcoxon rank-sum test). Hypothermic patients presented to the SNCU earlier in life (p <0.0, non-parametric Wilcoxon rank-sum test) and were more likely to be born in the maternal-child hospital (p <0.01, χ^2), which may reflect earlier and more accurate temperature reading.

Length of stay

Factors associated with increased length of stay in the SNCU for 953 neonates were analysed via non-parametric linear regression after logarithmic transformation as shown in table 7. Length of stay analysis excluded

Table 3 Bivariate analysis of mortality for 414 out-of-hospital-born neonates in Eritrea, 2006

	Alive (outborn)		Died (outborn)		p Value
	N	Mean $\pm$ SD	N	Mean $\pm$ SD	
Gestation age (weeks)	384	36.3 $\pm$ 2	28	35.1 $\pm$ 3.5	0.08
Birth weight (kg)	377	2.8 $\pm$ 0.8	27	2.4 $\pm$ 0.8	0.01*
Days of life (days)	385	9.9 $\pm$ 8.8	28	8.3 $\pm$ 6.7	0.5
Apgar score (1 min)	81	6 $\pm$ 2.3	6	5.8 $\pm$ 1.8	0.65
Apgar score (5 min)	82	7.3 $\pm$ 2.2	6	7 $\pm$ 1.9	0.57
Maternal age (years)	375	26.3 $\pm$ 5.6	28	27.8 $\pm$ 6.5	0.27
Female, %	386	51.3	28	46.4	0.62
Cesarian section, %	386	0.1	28	0	0.11
Large for gestational age, %	386	4.9	28	7.1	0.61
Small for gestational age, %	386	16.8	28	28.6	0.12
Hypothermia, %	386	16.1	28	32.1	0.03*
Pneumonia, %	386	11.9	28	25	0.05*

For patients born outside of the hospital setting, lower birth weight, hypothermia and pneumonia were associated with mortality (* p <0.05, significant).

Table 4 Bivariate analysis of mortality for 639 hospital-born neonates in Eritrea, 2006

	Alive (inborn)		Died (inborn)		p Value
	N	Mean $\pm$ SD	N	Mean $\pm$ SD	
Gestation age (weeks)	584	36.1 $\pm$ 2.5	55	32.2 $\pm$ 5	<0.01*
Birth weight (kg)	584	2.7 $\pm$ 0.8	55	1.9 $\pm$ 1	<0.01*
Days of life (days)	584	0.5 $\pm$ 2.4	55	0.1 $\pm$ 0.3	0.21
Apgar score (1 min)	550	5.4 $\pm$ 2.1	48	3 $\pm$ 1.6	<0.01*
Apgar score (5 min)	554	7.1 $\pm$ 1.7	54	4.6 $\pm$ 1.7	<0.01*
Maternal age (years)	583	27 $\pm$ 5.6	55	24.7 $\pm$ 5.8	<0.01*
Female, %	584	44.3	55	47.3	0.68
Cesarian section, %	584	33.6	55	16.4	0.01*
Large for gestational age, %	584	7.4	55	14.5	0.06
Small for gestational age, %	584	23.1	55	21.8	0.83
Hypothermia, %	584	25.2	55	43.6	<0.01*
Pneumonia, %	584	37.5	55	61.8	<0.01*

Mortality was associated with lower gestational age, lower birth weight and lower Apgar scores at 1 and 5 min. Deceased patients had a lower rate of delivery by cesarian section. Patients who died had younger mothers. These infants had higher rates of pneumonia and hypothermia than survivors (*p<0.05, significant).

newborns that died. Lower gestational age, birth weight <2.0 kg, SGA and pneumonia were associated with a prolonged length of stay. In this analysis, hypothermia was not associated with prolonged length of stay (p<0.31). Age at presentation, birth weight >2.0 kg, female gender, Apgar scores at 1 and 5 min, birth at the maternal-child hospital, younger maternal age and delivery via C-section were also not significant.

DISCUSSION

Achievement of MDG-4 requires increased focus on neonatal mortality. Improved data collection and analysis from countries in which infant mortality is high are necessary to develop cost-effective and successful programmes aimed at neonatal health.¹³ Impeding progress in addressing these issues is the lack of local

data from many countries regarding neonatal deaths, which may provide raw material from which broader-scale intervention studies can be based.

These data further provide specific information on neonatal mortality from a region where information on cause of death and neonatal treatment is not well characterised.

Pneumonia and sepsis constituted 46% of all admission diagnoses and was associated with 59% of overall mortality compared with 26% internationally.¹⁶ Hypothermia contributed to 22.9% of patient morbidity—within the range of worldwide estimates of prevalence in the developing world.²² Diarrhoea causes 3% of worldwide neonatal deaths but did not account for Eritrean mortality, despite being frequently encountered as the primary diagnosis for 15.5% of patients. Congenital

Table 5 Multivariate regression analysis for mortality for 1037 hospitalised neonates in Eritrea, 2006

	OR	SE	95% CI	p Value
Gestation age (weeks)	0.70	0.05	0.6 to 0.82	<0.01*
Days of life at admission	1.00	0.02	0.95 to 1.05	0.96
Birth weight (kg)				
≤2	0.29	0.24	0.06 to 1.48	0.14
>2 to ≤2.5	0.60	0.44	0.15 to 2.51	0.49
>2.5 to ≤3.0	1.17	0.59	0.43 to 3.17	0.76
>3	0.91	0.45	0.34 to 2.42	0.86
Apgar score (1 min)	0.34	0.11	0.18 to 0.66	<0.01*
Female gender	0.93	0.24	0.56 to 1.52	0.77
Cesarian section	0.49	0.19	0.23 to 1.05	0.07
Small for gestational age	3.22	1.91	1.0 to 10.3	0.04*
Maternal age	0.97	0.22	0.93 to 1.0	0.35
Hospital birth	1.06	0.36	0.55 to 2.1	0.85
Hypothermia	2.10	0.85	1.0 to 4.7	0.04*
Pneumonia	4.50	1.52	2.3 to 8.7	<0.01*
Hypothermia and pneumonia	2.42	1.17	0.93 to 6.27	0.06

Regression analysis demonstrated that lower gestational age, lower first minute Apgar score, small for gestational age at birth and the presence of hypothermia or pneumonia were associated with an increased likelihood of death (*p≤0.05, significant).

Figure 4 Timing of mortality for neonates admitted to the Specialised Neonatal Intensive Care Unit (SNCU) in 2006 in Asmara, Eritrea. The greatest observed mortality occurred within the first hour of presentation to the SNCU (10.4%). The lowest mortality occurred after admission to the SNCU for >1 day (6.0%). Mortality was significantly higher in the first hour of life compared with that after the first day of hospitalisation ($p < 0.05$, χ^2).

anomalies caused 7% of deaths in the SNCU and are estimated at 7% worldwide. Malformations often require specialised surgical correction, a degree of technology not available widely in the developing world.

Worldwide, 25%–45% of neonatal deaths occur in the first 24 h of life. This international trend was lower than our unit's experience where the number was almost 70% (58/87), though not all these data were based on time of presentation, which may differ from actual age given delays in care-seeking.^{1 10 23} Given that over 50%–90% of births take place outside medical facilities (in Eritrea

this number is 40%–72%), introduction of skilled nursing care at birth by community health workers may reduce early neonatal morbidity.^{2 3}

Similar to other developing nations, hypothermia remains significantly associated with morbidity and mortality in the developing world.²⁴ Hypothermia is an independent associative factor for mortality in our logistic regression model and may play a role in the increased morbidity in patients with pneumonia.^{25–27} In Eritrea, hypothermic patients were of lower gestational age and birth weight. Low birth weight has been commonly cited in all countries as a risk factor for hypothermia at birth.^{28–32} The incidence of obtaining temperature in home births in an Indian cohort was only 11% in 189 neonates.³³ However, our data support the notion that throughout the developing world, cold stress is a major factor associated with neonatal outcome.³⁴

One-fifth of our birth cohort was SGA, a potent risk factor for both mortality and increased length of stay. While being SGA increases susceptibility to death by other means, the Child Health Epidemiologic Research Group estimates that 2% of all worldwide deaths are directly attributable to in utero growth restriction.³⁵ Interventions to reduce SGA births are costly and face several barriers. Increased prenatal surveillance of mothers with an emphasis on safe pregnancy initiatives and nutrition reduce the number of SGA infants.¹³

Information for cause-of-death analysis is unavailable for 97% of neonatal deaths. Thus, estimates are the only source of data on the 3.8 million babies who die in the first 28 days of life. This study sought to determine patterns of morbidity and mortality in a centralised SNCU in Eritrea and contribute relevant region-specific data in an area where information is lacking.^{2 3} Improved epidemiological data are essential, and Eritrea

Table 6 Comparison of characteristics of hypothermic versus normothermic neonates in Eritrea, 2006

	Hypothermia Mean $\pm$ SD	Normothermic Mean $\pm$ SD	p Value
Patients (N)	242	811	
Gestation age (weeks)	34 $\pm$ 3.9	36.5 $\pm$ 1.9	<0.01*
Birth weight (kg)	2 $\pm$ 0.7	2.9 $\pm$ 0.8	<0.01*
Days of life at admission	1.2 $\pm$ 3.8	5 $\pm$ 7.9	0.01†
Apgar score (1 min)	5.0 $\pm$ 2	5.5 $\pm$ 2	0.01*
Apgar score (5 min)	6.7 $\pm$ 1	7.1 $\pm$ 2	0.01*
Length of stay (days)	8.6 $\pm$ 10.1	4.6 $\pm$ 5.1	<0.01†
Maternal age (years)	26.1 $\pm$ 5.5	26.8 $\pm$ 5.7	0.06
Female, %	49.2	46.5	0.46
Cesarian section, %	15.3	24.7	<0.01‡
Large for gestational age, %	7.4	6.7	0.67
Small for gestational age, %	37.6	15.9	<0.01‡
Birth at maternal hospital, %	70.7	57.7	<0.01‡
Pneumonia, %	32.6	28	0.16

Compared with normothermic patients, hypothermic patients were of significantly lower gestational age, birth weight and age of admission. Hypothermic patients presented with lower 1 and 5 min Apgar scores, had longer lengths of stay, were more likely born by vaginal delivery at the hospital and small for gestational age ($p \leq 0.05$ considered significant).

*t Test for comparison.

†Non-parametric Wilcoxon rank-sum test.

‡ χ^2 Test.

Table 7 Multivariate regression with logarithmic transformation for length of stay for 953 hospitalised neonates in Eritrea, 2006

	Coefficient	SE	95% CI	p Value
Gestation age (weeks)	−0.10	0.03	−0.15 to 0.04	<0.01*
Days of life at admission	−0.005	0.006	−0.016 to 0.007	0.73
Birth weight (kg)				
≤2	0.79	0.22	0.36 to 1.23	<0.01*
>2 to ≤2.5	0.31	0.19	−0.07 to 0.69	0.11
>2.5 to ≤3.0	0.12	0.10	−0.08 to 0.32	0.26
>3	−0.06	0.09	−0.25 to 0.12	0.51
Apgar score (1 min)	0.04	0.09	−0.15 to 0.2	0.70
Apgar score (5 min)	0.15	0.09	−0.04 to 0.33	0.11
Female gender	−0.03	0.06	−0.15 to 0.09	0.60
Cesarian section	0.11	0.08	−0.04 to 0.27	0.15
Small for gestational age	0.16	0.18	−0.54 to 0.08	<0.01*
Maternal age	0.007	0.005	−0.003 to 0.018	0.19
Hospital birth	−0.09	0.09	−0.28 to 0.09	0.31
Hypothermia	0.09	0.09	−0.08 to 0.271	0.33
Pneumonia	0.49	0.08	0.33 to 0.65	<0.01*

Regression analysis demonstrated that lower gestational age, lower birth weight (<2.0 kg), small for gestational age and pneumonia were associated with increased duration of hospitalisation. Younger maternal age, Apgar scores, hospital birth, female gender, cesarian section and hypothermia were not also associated with prolonged hospitalisation (*p≤0.05, significant).

provides a rich source of data which may inform programme development for the region.

Systematic analysis of neonatal mortality is hampered by limitations. As the only regional neonatal referral centre, these data are based on the small percentage of newborns born in Eritrea who needed care and presented to medical attention in this urban hospital. Thus, they may not be representative of the national population. Rates of home deliveries were lower than the national average, potentially skewing cause-of-death information and explaining our observed differences from national findings. Also, the mean day of presentation to hospital care was 4 days, thus, home-born infants who die in the first 24 h of life escape analysis.⁹

Information was obtained in 2006 and may not be indicative of real-time annual changes in NMR. However, it should be noted the latest WHO Estimates of Global Mortality in Children were published in 2005 and represented the first update since 1995.¹⁶ In that context, a 3–5-year delay in data analysis may be acceptable. Furthermore, information on birth weight, Apgar score and temperature must always be viewed through the experience of an area where many home births occur, a commonly encountered problem for research in the developing world.³⁶ Particularly difficult is the inclusion of pneumonia versus sepsis as two distinct categories. While one neonatologist determined the diagnosis for all patients, creating consistency in case definition, WHO combines sepsis and pneumonia into a single category, owing to the similarity of clinical presentation in neonates.

Our data suggest the impact of skilled neonatal resuscitators may merit future study. Theoretically, use of skilled resuscitators would improve Apgar scores, reduce peripartum hypothermia and may lead to prompt diagnosis of pneumonia, improving care and potentially increasing survival. Improvements in prenatal care may

lead to delivery at an older gestational age, alter C-section rates and improve birth weights.

Achieving substantial reductions in neonatal mortality is possible without significant increases in costs. Greater attention to home birth attendance, avoidance of hypothermia and improved access to postnatal care should play a large role in further reducing Eritrean neonatal mortality.

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Patient consent Exempted from review per the State University of New York Institutional Review Board.

Ethics approval Ethics approval was provided by the State University of Stony Brook Institutional Review Board.

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