Improved Neonatal Mortality at a District Hospital in Aweil, South Sudan

by Johanna Thomson,1,2 Myrto Schaefer,3 Belen Caminoa,3 David Kahindi,4 and Northan Hurtado5

1Me´decins Sans Frontie`res, Paris, 75011, France
2Department of Field Epidemiology and Training, Epicentre, Paris, 75011, France
3Me´decins Sans Frontie`res, Sydney, 2037, Australia
4Medical Co-ordination, Me´decins Sans Frontie`res, Juba, South Sudan
5Me´decins Sans Frontie`res, NY, 10001-5004, USA
Correspondence: Johanna Thomson, Me´decins Sans Frontie`res, Operational Centre Paris, France.
E-mail <johannathomson@hotmail.com>.

ABSTRACT
Neonatal deaths comprise a growing proportion of global under-five mortality. However, data from the highest-burden areas is sparse. This descriptive retrospective study analyses the outcomes of all infants exiting the Médecins sans Frontières-managed neonatal unit in Aweil Hospital, rural South Sudan from 2011 to 2014. A total of 4268 patients were treated over 4 years, with annual admissions increasing from 687 to 1494. Overall mortality was 13.5% ($n = 576$), declining from 18.7% to 11.1% ($p$ for trend $< 0.001$). Newborns weighing $< 2500$ g were at significantly increased mortality risk compared with babies $\geq 2500$ g (odds ratio $= 2.27$, 95% confidence interval $= 1.9–2.71$, $p < 0.001$). Leading causes of death included sepsis (49.7%), tetanus (15.8%), respiratory distress (12.8%) and asphyxia (9.2%). Tetanus had the highest case fatality rate (49.7%), followed by perinatal asphyxia (26.5%), respiratory distress (20.4%) and neonatal sepsis (10.5%). Despite increasing admissions, overall mortality declined, indicating that survival of these especially vulnerable infants can be improved even in a basic-level district hospital programme.

KEYWORDS: newborn, neonatal mortality, developing countries, South Sudan.

BACKGROUND
Of the 135 million babies born every year, 2.9 million do not survive beyond the neonatal period (the first 28 days of life) [1]. Neonatal deaths account for an increasing proportion of under-five mortality (44%), while global childhood mortality declines. Almost all (99%) neonatal deaths occur in low- and middle-income countries where resources and access to health care are lacking; the limited care available is typically in tertiary hospitals, far removed from rural communities.

Epidemiological and research data from these contexts are sparse [2], vital registration is either inadequate or non-existent and factors relating to neonatal survival are usually not recorded. Most estimates of key neonatal health determinants and outcomes in these contexts are extrapolated from high-income countries with reliable vital registration. Of the few existing studies in sub-Saharan Africa, nearly all come from tertiary facilities with intensive care units and relatively better resources. Little literature is available on outcomes from more basic
district-level hospitals, and there are no reports from South Sudan.

South Sudan is one of the poorest countries and has some of the worst health indicators in the world. The neonatal mortality rate is 36 per 1000 live births. The under-five mortality rate is 104 per 1000 live births of which neonatal deaths comprise an estimated 35% [3]. Ongoing insecurity, poor governance, lack of infrastructure, a weak economy, lack of a skilled educated workforce and geographic constraints contribute to high ongoing unmet health needs.

This study seeks to address the critical information gap in neonatal mortality by describing outcomes of a cohort of neonates treated in a Médecins sans Frontières (MSF)-managed newborn facility in a district-level facility in South Sudan and provide recommendations for improving care and decreasing the rates of death and disability.

**METHODS**

**Study setting**

Aweil is located in Northern Bahr el Ghazal (NBeG) near the international border with Sudan and the disputed Abyei region. MSF has been operating a Maternal and Child Health programme at Aweil Civil Hospital since 2008, in collaboration with the Ministry of Health of the Government of South Sudan. The facility in Aweil is the only hospital with dedicated neonatal services in NBeG, with an estimated 1.1 million predominantly rural inhabitants [4]. Free secondary-level neonatal care is provided to patients admitted either from maternity or from the community.

Providing comprehensive care for newborns is a relatively recent development within MSF. Standardized protocols are used for the management of common neonatal problems. Beginning in 2013, admission criteria were adapted to exclude babies weighing <1250 g because of poor prognosis and limited resources. Sick neonates or low birth weight (LBW) babies between 1250 and 2000 g needing supportive care are admitted to the neonatal ward. Table 1 summarizes available human resources, monitoring, investigations and treatment. Patients are discharged from the unit into the community with little structured follow-up.

**Study design and population**

This is a descriptive study involving retrospective review of routinely collected facility data of all neonates exiting from the neonatal unit (owing to discharge, death or removal by caregiver) during the 4-year period from January 2011 to December 2014.

**Data collection**

A Microsoft Excel-based data monitoring system implemented in 2010 provided the data source for this study. Patient outcome (discharge, death, defaulter, referral) and discharge diagnosis stratified by admission weight were entered weekly into the database. Weight refers to admission weight and is not necessarily equal to birth weight. Gestational age assessment is not routinely performed. Details regarding timing of admission, socio-demographic information and maternal and birth risk exposures were not available. Admission referral location (outpatient department or maternity) was recorded in a manual logbook by the clinical officer as patients entered the hospital.

Case definitions lacked detail (see Table 2) and a single diagnosis was assigned in a defined order of priority. Consequently, a high proportion of neonates diagnosed with sepsis may have had another diagnosis (e.g. birth asphyxia), which will not be accounted for using this classification system. There was no category for ‘prematurity/LBW’ as a primary diagnosis. ‘Hypoglycaemia’ and ‘risk of sepsis’ were only added as diagnostic categories from 2013.

**Data analysis**

Discharge diagnoses were grouped into six categories: neonatal sepsis, asphyxia, respiratory distress, tetanus, hypoglycaemia (2013–14 only) and other. Descriptive statistics including frequencies and proportions were calculated. The association between admission weight (<2500 g or ≥2500 g) and mortality was investigated using a chi-squared test at 5% significance level. Trend analysis over 4 years was performed using the Cochrane-Armitage test for trend in proportions at a 5% significance level.
All statistical analyses were performed using the statistical package R (version 0.98.1091) [5].

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting of observational studies [6]. This retrospective study used routinely collected anonymized programme data only and is exempt from the requirement for ethical approval according to MSF ethics review board rules and confirmed by the Deputy Medical Director of MSF France.

**RESULTS**

A total of 4186 neonates were admitted to the unit over 4 years (2011–14); two-thirds were referred from the community (n = 2792), the remainder were transferred from maternity (n = 1397). Over the same time, 4268 patients were discharged: 3601 (84.4%) were discharged home, 72 (1.7%) were removed by their caretaker (against medical advice) and 19 (0.4%) were referred to other facilities. There were 576 deaths, yielding an overall mortality of 13.5% (Fig. 1).

**Analysis by admission weight**

Of the 4268 discharged patients, 62.2% weighed ≥2500 g (n = 2659) and 37.7% (n = 1609) were <2500 g. Babies weighing <2500 g were at significantly higher risk of death compared with babies weighing ≥2500 g (19.7%, n = 317 versus 9.8%, n = 259) (odds ratio = 2.27, 95% confidence interval = 1.9–2.71, p < 0.001), and these babies comprised more than half of all deaths (55%, n = 317).

---

**Table 1. Neonatal care provided in Aweil Civil Hospital**

| 26-bed capacity | 13 regular (semi-NICU) |
|-----------------|-----------------------|
|                 | 9 premature/LBW (KMC unit) |
|                 | 4 neonatal tetanus |

| Staff            | Day | Night |
|------------------|-----|-------|
| National staff supervisor | 1   | –     |
| Nurse assistants  | 2   | –     |
| National staff nurses | 2  | 1     |
| Medical assistant | 1   | 1     |
| Expatriate neonatal nurse | 1 | –     |
| Expatriate paediatrician | 1 | doctor on call |

| Protocols          |
|--------------------|
| Resuscitation area (BMV and resuscitation drugs) |
| Radiant overhead heaters |
| Oxygen concentrators |
| Intravenous fluids |
| Intravenous antibiotics (ampicillin, gentamicin, cefotaxime, cloxacillin, metronidazole, amikacin) |
| Medications (caffeine, oral ferrous sulphate, phenobarbitone, phenytoin, diazepam) |
| Nasogastric tube feeding or alternative feeding methods |
| Basic x-ray |

| Equipment          |
|--------------------|
| Oxygen pulse oximetry |
| Glucometer |

| Laboratory         |
|--------------------|
| Haemoglobin testing |
| Rapid diagnostic testing for malaria |
| Blood transfusion |

*No incubators, mechanical or non-invasive ventilation, phototherapy, limited radiological facilities. Laboratory performs basic tests; blood culture, CRP, bilirubin, electrolytes and blood gas analysis not performed.*
The leading single cause of morbidity was neonatal sepsis (63.7%; n = 2716) (Fig. 2). Other diagnoses included respiratory distress (8.5%; n = 363), birth asphyxia (4.7%; n = 200) and neonatal tetanus (4.3%; n = 183). Hypoglycaemia, included as a diagnostic criterion only in 2013–14, accounted for 3% (n = 131). Neonates with ‘other’ diagnoses (15.8%, n = 675) included soft tissue infections, jaundice, spina bifida, congenital heart defects and other congenital abnormalities.

### Cause-specific mortality

Sepsis was the leading cause of death contributing to almost half the mortality (49.7%; n = 286) (Fig. 2). Neonatal tetanus was the second highest cause of mortality (15.8%; n = 91), followed by respiratory distress (12.8%; n = 74) and asphyxia (9.2%; n = 53). ‘Other’ deaths (10.8%; n = 62) were mainly owing to severe congenital defects, jaundice and surgical conditions.

### Cause-specific mortality

**Table 2. Neonatal case definitions**

| Condition                        | Definition                                                                                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Neonatal sepsis (clinical or high risk) | Clinical Sepsis: Clinical signs of sepsis [includes a diagnosis of meningitis, bacterial pneumonia or necrotizing enterocolitis (NEC)]. Risk of sepsis: Risk factors according to clinical guidelines \(^{25}\) without clinical symptoms or signs of sepsis. |
| Asphyxia                         | APGAR score at < 6 at 5 min of life and no antibiotics received \(\text{Resuscitation at birth: Received resuscitation and no other diagnosis above}\) |
| Respiratory distress, NOS        | Clinical signs of tetanus, regardless of any other diagnosis. \(\text{Resuscitation at birth: Received resuscitation and no other diagnosis above}\) |
| Tetanus                          | Clinical signs of tetanus, regardless of any other diagnosis. \(\text{Resuscitation at birth: Received resuscitation and no other diagnosis above}\) |
| Hypoglycaemia                    | Hypoglycaemia \((<45 \text{ mg/ml or } < 2.5 \text{ mmol/ml})\) without receiving antibiotics. \(\text{Risk of hypoglycaemia: healthy newborns with abnormal birth weight (}\leq2500 \text{ g or } \geq4000 \text{ g})\), prematurity, signs of hypoglycaemia (including hypothermia), maternal diabetes or poor feeding |
| Other                            | All newborns not corresponding to discharge diagnoses above (e.g. surveillance for maternal reasons, jaundice, failure to thrive/feeding problems, congenital malformations, gastro-intestinal obstruction, congenital or neonatal malaria, birth trauma, gastroenteritis). |
observed for asphyxia (26.5%) and respiratory distress (20.4%). Neonates diagnosed with sepsis (10.4%) and hypoglycaemia (7.6%) had lower CFRs.

Mortality trends
Over the 4-year period, patient admissions increased steadily, more than doubling from 687 (2011) to 1494 (2014). Overall mortality decreased from 18.7% to 11.1% ($p$ for trend $<0.001$) and this trend was seen both in babies weighing $\geq 2500$ g and in those $<2500$ g ($p$ for trend $<0.001$) (Fig. 3). When babies $<1250$ g were removed from analysis (before the restriction of admission criteria in 2013), this trend was sustained (18.0% to 11.1%), as these babies made up a small proportion of overall admissions. Cases classified as neonatal sepsis increased over the study period, from 410 to 1121 ($p$ for trend $<0.001$). CFR for tetanus decreased from 64.8% in 2011 to 35.2% in 2014. No clear patterns emerged for other diagnostic categories.

DISCUSSION
To our knowledge, this is the first publication to report facility-based neonatal outcomes in South Sudan. It is also one of the few to report such data from a district-level facility in sub-Saharan Africa. Our demonstration of reduced mortality shows that improvement is possible in low-resource settings, and provides baseline information on ways to improve care and survival further.

One-third of neonates were inborn, while the remaining two-thirds were admitted from the community. These data do not allow assessment of the impact of referral location and outcome. However, previous studies have shown that the prognosis for out-born infants is significantly worse than inborn babies [7–9]. A high proportion of babies were $<2500$ g (37.7%), slightly higher than reported elsewhere [7, 8, 10, 11]. These babies had a mortality more than double that of babies $\geq 2500$ g (19.7% vs. 9.8%). The impact of LBW and mortality is reiterated in several other studies reporting an inverse relationship between birth weight and survival [9–13]. Given that $>80\%$ of neonatal deaths in sub-Saharan Africa are associated with LBW and that prematurity/LBW is increasing disproportionately as a cause of childhood death, facility-based interventions focussing on the care of small babies is critical for reducing child mortality [1].

Overall mortality (13.5%) is lower than that reported elsewhere [7, 11, 14, 15]. However, most other studies were conducted in tertiary facilities with different patient populations compared with district-level hospitals. Mortality showed a downward trend from 18.5% (2011) to 11.1% (2014). This can partly be attributed to a change in admission criteria implemented in 2013, limiting admission to babies...
weighing $\geq 1250$ g, although the direct effect was small. It also reflects interventions prioritizing neonatal care and improvements in resources and training. Improvements in structure of the unit included creation of a dedicated resuscitation area and separation of LBW neonates for improved monitoring. Other improvements included the use of syringe drivers for intravenous fluids, medications such as caffeine, administration of prophylactic antibiotics to babies with risk factors for sepsis and trialling innovations for hypothermia (such as plastic boxes). A full-time expatriate neonatal nurse was added in mid-2013, and training of national staff on neonatal resuscitation and care was expanded.

Neonatal sepsis was the leading cause of mortality; however, this is likely an over-representation owing to single-diagnosis coding, prioritizing sepsis as a diagnosis. A high number of patients were treated for neonatal tetanus, consistent with low rates of antenatal care (only 17% of women in South Sudan receive the minimum of four antenatal visits recommended by World Health Organization) [16] and low rates of tetanus vaccination coverage during pregnancy. Tetanus had the highest CFR (49.7%), consistent with rates reported in similar settings [8, 17]. The CFR for sepsis was 10%, lower than that reported in Nigeria (20.3%) and Kenya [8, 15] (16.5%) and higher than Tanzania (7.5%), which included only inborn patients [11].

Other technologies aimed at reducing neonatal mortality should be considered. Phototherapy is a simple measure, which may reduce morbidity and mortality from jaundice, a common complication among LBW babies [18]. Respiratory technologies such as continuous positive airway pressure systems have been introduced in resource-limited settings with promising results [19–23].

**Strengths and limitations**

All neonates exiting the unit over 4 years are included, so the patient population is large. This also accounts for seasonal variation in mortality that can be a problem in studies of shorter duration. There was a low defaulter rate, allowing an accurate measure of in-hospital mortality.

Nonetheless, this study has many limitations and presents several potential areas for improvement in data collection, management and analysis. Limited clinical information is captured in the database and minimal inferences can be drawn from maternal, perinatal and postnatal factors. Gestational age is not routinely assessed and weight is assigned on admission. Birth weight is often unknown for the high proportion of out-born patients. There was no way to examine the effect of referral location, an important prognostic factor, on outcome. An updated database linking specific exposures with patient outcomes would allow more detailed inferential analysis of determinants of neonatal morbidity and mortality.

Given the limitations of the study setting, assignment of clinical diagnosis is inconsistent. Internationally recognized standard case definitions should be developed. There is no diagnostic category for prematurity/LBW—an important consideration, as other studies in sub-Saharan Africa have reported that complications arising from prematurity account for approximately 35% of diagnoses [24]. Improving diagnostic accuracy could better identify programme needs and highlight priorities for intervention.

### Table 3. Case fatality rates

| Diagnosis            | Number of cases (N) | Number of deaths (n) | Case fatality rate (%) |
|----------------------|---------------------|----------------------|------------------------|
| Sepsis               | 2716                | 286                  | 10.5                   |
| Respiratory distress | 363                 | 74                   | 20.4                   |
| Asphyxia             | 200                 | 53                   | 26.5                   |
| Tetanus              | 183                 | 91                   | 49.7                   |
| Hypoglycaemia*       | 131                 | 10                   | 7.6                    |
| Other                | 675                 | 62                   | 9.2                    |

*Included as diagnostic category in 2013–14.
This study describes outcomes of neonates treated in a hospital setting and represents a specific group of neonates whose families had sufficient means to present to hospital. The results are not generalizable to the general community nor do they provide population-based mortality estimates for the region.

Finally, lack of patient review after hospital discharge means that long-term mortality and neurodevelopmental outcomes are unknown. Structured follow-up of newborns is required to better understand outcomes and identify vulnerable groups. Prospective follow-up studies are crucial to assess mid- to long-term outcomes, evaluate advances in neonatal care and guide operational decision-making.

ACKNOWLEDGEMENTS
We wish to thank Patricia Kahn, Medical Editor at Médecins sans Frontières, for her assistance in preparing this document for publication.

FUNDING
No external funding, apart from the support of the authors’ institution, was available for this study.

REFERENCES
1. Lawn JE, Blencowe H, Oza S, et al. Every newborn: progress, priorities, and potential beyond survival. Lancet 2014;384:189–205.
2. Mason E, McDougall L, Lawn JE, et al. From evidence to action to deliver a healthy start for the next generation. Lancet 2014;384:455–67.
3. World Health Organization; United National Children’s Fund. Fulfilling the Health Agenda for Women and Children: The 2014 Report. Geneva, Switzerland: WHO, 2014.
4. International Organization for Migration. Village assessment survey county profiles. Northern Bahr El Ghazal, IOM, 2013.
5. R Development Core Team. R: A language and environment for statistical computing [computer program]. Vienna, Austria: R Foundation for Statistical Computing, 2012.
6. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Prev Med 2007;45:247–51.
7. Mukhtar-Yola M, Illyasu Z. A review of neonatal morbidity and mortality in Aminu Kano Teaching Hospital, Northern Nigeria. Trop Doct 2007;37:130–2.
8. Omoigberal A, Sadoh W, Nwaneri D. A 4 year review of neonatal outcome at the University of Benin Teaching Hospital, Benin city. Niger J Clin Pract 2010;13:321–5.
9. Hedstrom A, Ryman T, Otai C, et al. Demographics, clinical characteristics and neonatal outcomes in a rural Ugandan NICU. BMC Pregnancy Childbirth 2014;14:327.
10. Okechukwu A, Achonwa A. Morbidity and mortality patterns of admissions into the special care baby unit of University of Abuja Teaching Hospital, Gwagwalada, Nigeria. Niger J Clin Pract 2009;12:389–94.
11. Mmbaga BT, Lie RT, Olomi R, et al. Cause-specific neonatal mortality in a neonatal care unit in Northern Tanzania: a registry based cohort study. BMC Pediatr 2012;12:116.
12. Zuniga I, Van den Bergh R, Ndelema B, et al. Characteristics and mortality of neonates in an emergency obstetric and neonatal care facility, rural Burundi. Public Health Action 2013;3:276–81.
13. Ndelema B, Van den Bergh R, Manzi M, et al. Low-tech, high impact: care for premature neonates in a district hospital in Burundi. A way forward to decrease neonatal mortality. BMC Res Notes 2016;9:28.
14. Klingenberg C, Olomi R, Onoko M, et al. Neonatal morbidity and mortality in a Tanzanian tertiary care referral hospital. Ann Trop Paediatr 2003;23:293–9.
15. Mwaniki MK, Gatakaa HW, Mturi FN, et al. An increase in the burden of neonatal admissions to a rural district hospital in Kenya over 19 years. BMC Public Health 2010;10:591.
16. World Health Organization. South Sudan: WHO Statistical profile. 2015. Available at: http://www.who.int/countries/ssd/en/.
17. Mwaniki MK, Atieno M, Lawn JE, Newton CR. Long-term neurodevelopmental outcomes after intrauterine and neonatal insults: a systematic review. Lancet 2012;379:445–52.
18. Gordon AL, English M, Tumaini Dzombo J, et al. Neurological and developmental outcome of neonatal jaundice and sepsis in rural Kenya. Trop Med Int Health 2005;10:1114–20.
19. Van Den Heuvel M, Blencowe H, Mittermayer K, et al. Introduction of bubble CPAP in a teaching hospital in Malawi. Ann Trop Paediatr 2011;31:59–65.
20. Koyamaibo L, Kado J, Qovu JD, et al. An evaluation of bubble-CPAP in a neonatal unit in a developing country: effective respiratory support that can be applied by nurses. J Trop Pediatr 2006;52:249–53.
21. Pieper C, Smith J, Maree D, Pohl F. Is nCPAP of value in extreme preterms with no access to neonatal intensive care? J Trop Pediatr 2003;49:148–52.
22. McAdams RM, Hedstrom AB, DiBlasi RM, et al. Implementation of bubble CPAP in a rural Ugandan neonatal ICU. Respir Care. 2015;60:437–45.
23. Duke T. CPAP: a guide for clinicians in developing countries. Paediatr Int Child Health 2014;34:3–11.
24. United Nation’s Children’s Fund (UNICEF). Committing to Child Survival: A Promise Renewed. New York, NY: UNICEF, 2014.