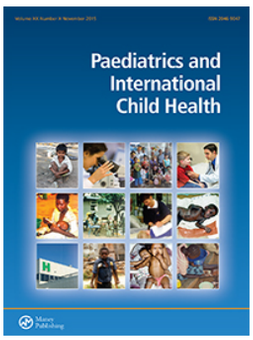

Taylor & Francis
Taylor & Francis Group

Paediatrics and International Child Health

ISSN: 2046-9047 (Print) 2046-9055 (Online) Journal homepage: https://www.tandfonline.com/loi/ypch20

Improving the quality of neonatal data capture and clinical care at a tertiary-care hospital in Uganda through enhanced surveillance, training and mentorship

Jane Achan, Humphrey Wanzira, Arthur Mpimbaza, Daniel Tumwine, Sophie Namasopo, Harriet Nambuya, Asadu Serwanga & Rebecca Nantanda

To cite this article: Jane Achan, Humphrey Wanzira, Arthur Mpimbaza, Daniel Tumwine, Sophie Namasopo, Harriet Nambuya, Asadu Serwanga & Rebecca Nantanda (2019): Improving the quality of neonatal data capture and clinical care at a tertiary-care hospital in Uganda through enhanced surveillance, training and mentorship, Paediatrics and International Child Health, DOI: 10.1080/20469047.2019.1638131

To link to this article: https://doi.org/10.1080/20469047.2019.1638131

PAEDIATRICS AND INTERNATIONAL CHILD HEALTH
https://doi.org/10.1080/20469047.2019.1638131

Improving the quality of neonatal data capture and clinical care at a tertiary-care hospital in Uganda through enhanced surveillance, training and mentorship

Jane Achan[a,b], Humphrey Wanzira[c], Arthur Mpimbaza[d], Daniel Tumwine[a], Sophie Namasopo[e], Harriet Nambuya[e], Asadu Serwanga[a] and Rebecca Nantanda[a,f]

[a]Uganda Paediatric Association, Kampala, Uganda; [b]Disease Control and Elimination Theme, Medical Research Council Unit, Banjul, The Gambia; [c]Pilgrim Africa, Kampala, Uganda; [d]Child Health and Development Centre, College of Health Sciences, Makerere University, Kampala, Uganda; [e]Department of Paediatrics, Jinja Regional Referral Hospital, Jinja, Uganda; [f]Makerere University Lung Institute, Kampala, Uganda

ABSTRACT

Introduction: Accurate documentation of neonatal morbidity and mortality is limited in many countries in sub-Saharan Africa. This project aimed to establish a surveillance system for neonatal conditions as an approach to improving the quality of neonatal care.

Methods: A systematic data capture and surveillance system was established at Jinja Regional Referral Hospital, Uganda using a standardised neonatal medical record form which collected detailed individual patient level data. Additionally, training and mentorship were conducted and basic equipment was provided.

Results: A total of 4178 neonates were hospitalised from July 2014 to December 2016. Median (IQR) age on admission was one day (1–3) and 48.0% (1851/3859) were male. Median (IQR) duration of hospitalisation was 17 days (IQR 10–40) and the longest duration of hospitalisation was 47 days (IQR 41–58). The majority were referrals from government health facilities (54.4%, 2012/3699), though 30.6% (1123/3669) presented as self-referrals. Septicaemia (44.9%, 1962/4371), prematurity (21.0%, 917/4371) and birth asphyxia (19.1%, 833/4371) were the most common diagnoses. The overall mortality was 13.8% (577/4178) and the commonest causes of death included septicaemia (26.9%, 155/577), prematurity (24.3%, 140/577), birth asphyxia (21.0%, 121/577), hypothermia (9.9%, 57/577) and respiratory distress (8.0%, 46/577). The majority of deaths (51.5%, 297/577) occurred within the first 24 h of hospitalisation although a significant proportion of deaths also occurred after 7 days of hospitalisation (24.1%, 139/577). A modest decrease in mortality and improvement in clinical outcome were observed.

Conclusion: Improvement in neonatal data capture and quality of care was observed following establishment of an enhanced surveillance system, training and mentorship.

Abbreviations: aOR: adjusted odds ratio; CHRP: Centre for Health research and Programmes; HC: health centre; HMIS: Health Management Information System; JRRH: Jinja Regional Referral Hospital; NMRF: neonatal medical record form; PMTCT: prevention of mother-to-child transmission of HIV; UPA: Uganda Paediatric Association

ARTICLE HISTORY
Received 1 March 2019
Accepted 25 June 2019

KEYWORDS
Neonates; quality of care; morbidity; mortality; Quality improvement; mentorship; training; surveillance

Introduction

Despite substantial progress in reducing child mortality in the past several decades, improving child survival remains a matter of significant public health concern [1,2]. Children face the highest risk of dying during the neonatal period and there are marked disparities in neonatal mortality between regions and countries. Neonatal mortality is an important indicator of the quality of health-care services for pregnant women during the prenatal and perinatal periods and of the care given to the newborn immediately after birth in the delivery room and neonatal units [3,4]. There was a modest decline in the neonatal mortality rate between 1990 and 2016 but it was slower than the decline in mortality in children aged 1–59 months with the highest rates of neonatal mortality seen in sub-Saharan Africa and Southern Asia [1]. In these settings, a lack of skilled care of mothers and neonates during delivery coupled with inadequate basic care services for neonates at health facilities possibly contribute to these high neonatal mortality rates [5,6].

In Uganda, an estimated 45,000 neonates die each year with the national average neonatal mortality rate estimated to be 21.4/1000 live births [7]. The main causes of death include birth asphyxia, infections and complications of preterm birth, all of which are preventable and treatable [8]. As is the case in many countries in sub-Saharan Africa, consistent and accurate documentation of neonatal morbidity and mortality is limited in Uganda and there are significant information gaps.

CONTACT Jane Achan achanj@yahoo.co.uk
The supplemental data for this article can be accessed here.

Most population-level maternal and neonatal mortality data in Uganda come from demographic health surveys, verbal autopsy studies and perinatal death audits [9–11]. The data are often collected retrospectively, a method known to under-report early neonatal deaths largely owing to the omission of events or dating errors [12]. In addition, retrospective data lead to missed opportunities for early identification of systemic challenges contributing to neonatal deaths which could be addressed to prevent further neonatal mortality if data were collected in real time. The need for more frequent assessment and high-quality data coupled with prospective analysis to develop a more accurate understanding of neonatal mortality is paramount: the general scarcity of high-quality national-level data on neonatal morbidity and mortality data impairs effective planning and programme implementation.

Despite improvement over the past few years, the Health Management Information System (HMIS) designed to capture health facility-level data does not capture sufficient data on neonatal morbidity and mortality [13]. Currently, HMIS captures a narrow scope of neonatal conditions and total admissions with limited information on other related clinical data on neonates. In addition, HMIS does not specifically report on deaths during the first month of life and most neonatal causes of death are combined in one 'perinatal conditions' category and so are not reported by programmatically useful causes of deaths [13]. Such aggregated data are not useful for the purposes of understanding clinical performance and quality improvement approaches. Consequently, there is a paucity of much-needed, high-quality routinely collected data on the magnitude and spectrum of neonatal morbidity and mortality at the health facility level. There is, therefore, an urgent need for regularly updated data on the burden and causes of neonatal illnesses and deaths and better routine collection of neonatal information at health facilities. Such data are vital to better document trends and are useful for facility-level and national-level planning as well as monitoring and evaluation of different interventions for neonatal health.

Given that neonatal health as a global public health issue has gone from being viewed as an invisible and intractable problem to one for which effective interventions exist and are affordable in low-resource settings [14], it is critical that good-quality surveillance data are available to enhance the targeting of interventions and training to specific health facility or national requirements. It is against this background that the neonatal disease surveillance project was implemented with the overall objective of improving neonatal data collection and quality and neonatal health care at a referral hospital in Eastern Uganda.

Methods

The project was undertaken from July 2014 until December 2016 at Jinja Regional Referral Hospital (JRRH) in Eastern Uganda. The hospital serves a catchment area including 10 districts in the Busoga sub-region and two neighbouring districts in the central region of Uganda. The facility offers specialised services for neonatal care and receives patients from surrounding district hospitals, health centre (HC) IVs and HC IIIs. The treatment available for the most common neonatal conditions at the facility included antibiotics (commonly injectable ampicillin, gentamicin, cloxacillin and ceftriaxone), intravenous fluids (including normal saline, Ringer's lactate and 10% dextrose) and other aspects of supportive care including incubators, nasogastric tube feeding, phototherapy, oxygen therapy, blood transfusion services and Kangaroo mother care. HC IVs are sub-district health facilities with services for emergency obstetric care and inpatient and outpatient care manned by one to two general doctors, nurses and midwives, while HC IIIs are smaller health facilities with basic maternity services and general outpatient care. The project was a collaboration between the Uganda Paediatrics Association (UPA), JRRH and the Centre for Health Research and Programmes (CHRP) and was implemented in two phases. The first, between July 2014 and June 2015, was the pilot phase and the second phase, from December 2015 to November 2016, was the actual project implementation period. Using a quality improvement approach, the specific aims were to set up a surveillance system for neonatal mortality and morbidity, support the establishment of functional neonatal care points and provide health worker training and mentorship.

Baseline assessment

Before the project was initiated, baseline assessment of the neonatal care points at JRRH was undertaken using a modified version of the WHO tool for assessing the quality of care of neonates [15]. The assessment aimed to understand the status of neonatal care services in the hospital at baseline with a focus on data capture and reporting systems, training and mentorship processes and needs and equipment and supplies requirements. The information from this assessment was used to identify critical gaps in the stated areas and the interventions implemented addressed these specific areas.

Surveillance system

To improve surveillance of neonatal morbidity and mortality, a systematic data capture and surveillance system was established at the hospital using a standardised neonatal medical record form (NMRF) (Appendix 1).

The NMRF collected detailed individual patient data including demographics, address, referring institute, presenting symptoms and signs, obstetric history, antenatal and perinatal care, laboratory test results, admission and final diagnoses, treatments administered and final outcome on discharge. It also captured information on preventive and health promotion aspects of neonatal health such as immunisation, prevention of mother-to-child transmission of HIV (PMTCT) and feeding practices. The NMRF used check boxes to minimise transcription errors and improve its ease of use. It also incorporated standard terminology provided for in the national neonatal care guidelines, a framework familiar to most clinicians and health-care providers in Uganda. This NMRF was completed by nurses, clinical officers, intern doctors, general doctors and paediatricians. The main diagnoses were made using clinical criteria developed by the hospital staff with support from the project team. These guidelines were available to the different staffs completing the NMRF. Antenatal records including ultrasound scans and laboratory results were not consistently available. There was also limited access to some laboratory tests such as complete blood count, but blood culture and C-reactive protein testing were not available. Data from the NMRF were then entered into a computerised database by a trained data officer. At the end of each month, reports were generated which were shared and discussed with the hospital staff. The overall aim of these discussions was to highlight any improvement in performance and to identify in a timely manner existing gaps, how they could be addressed and any training and mentorship requirements.

Training and mentorship

Training and mentorship were also undertaken and approximately 30 health workers were trained at each session. The frequency of training and mentorship sessions was determined by health facility needs with at least one session per quarter. To ensure holistic team involvement, different cadres of health workers attended for training and included paediatricians, medical officers, intern doctors, records personnel, senior nursing officers, enrolled nurses, nursing assistants, clinical officers and midwives. These sessions targeted all the health workers from the various neonatal care points in the hospital and focused on the common causes of morbidity and mortality and also addressed identified health systems issues. Topics and areas of training were those most relevant for the identified needs of the health facility at different time points based on the data collected. To reinforce lessons from the training sessions, on-site clinical mentorship was also conducted and consisted of direct observations of patient care, coaching and feedback sessions. When necessary, mentors also conducted teaching sessions which usually focussed on any emerging clinical challenges. Mentors also provided additional input on any logistical challenges identified. Training and mentorship were followed up by support supervision visits which were conducted by the project team together with regional and national officials to enhance sustainability. The mentors included senior nurses and medical officers, a data manager, paediatricians and a neonatologist.

Equipment and supplies

Equipment and supplies needs were identified by the baseline assessment and included oxygen supply/concentrators, clinical thermometers and neonatal weighing scales. All these were procured by the project and provided to the neonatal care points to support provision of care at the facility. In addition to providing equipment, infrastructural organisation and staff coverage planning at the neonatal care points were also strengthened by providing additional neonatal beds and mattresses and by discussing optimisation of staff duty rosters.

Quality control

The main objective of the pilot phase of the project was to collect evidence of the feasibility of implementing the NMRF and to document its critical role in directly affecting decisions on the quality of care. The second phase of the project additionally included two lower-level facilities strategically selected to represent facilities with the largest number of neonatal referrals to JRRH, as shown by the data collected in the pilot phase. The main objective of the second phase was to further strengthen the use of a modified version of the NMRF and also improve quality of care at these selected lower-level health facilities since poor-quality referral practices had been highlighted during the pilot phase as contributing to mortality.

This paper presents quantitative data from the surveillance system documenting the temporal trends of neonatal morbidity and mortality over both project implementation periods and describes changes potentially attributable to ongoing interventions. It also reports on the process aspects of the project according to the perceptions and experiences of the health workers.

Data management and analysis

Data were entered into EpiData version 3.1 and then transferred to STATA Version 12.1 for analysis. Any discrepancies were rechecked against medical records. To document the demographic and clinical characteristics of hospitalised neonates, a descriptive analysis was undertaken and the results presented as

frequencies with respective proportions for categorical parameters. Means and standard deviations (SD) were presented for continuous parameters with normal distribution and median and interquartile ranges (IQR) for those that were not normally distributed. Results were presented in graphs to show trends over time, and in the tables and text. The associations between death and independent variables such as gender, gestational age, location of birth, mode of delivery, admission ward and referring institution were assessed using first a univariate logistic regression model to determine the crude odds ratio and 95% confidence interval (CI) and subsequently using a multivariate model adjusting for the effect of each independent variable to obtain the adjusted odds ratio (aOR) and 95% CI. In all analyses, $p < 0.05$ was taken as statistically significant. For the qualitative data from health worker interviews, a thematic content analysis was conducted and data were coded and summarised into emerging themes based on the questions asked. Verbatim quotes were used to illustrate the themes and sub-themes.

Ethics approval and consent to participate

Administrative clearance for the project was obtained from the administration of JRRH and ethics approval was provided by the JRRH ethics committee. No individual consent was obtained as this was considered a routine health services project/audit for which individual consent was not required.

Results

From July 2014 until December 2016, data on 4178 neonates hospitalised at JRRH were collected. The mean number of neonatal admissions per quarter was 417 with the lowest number of admissions (287) in the last quarter of 2016 and the highest (521) in the third quarter of that year. Data completeness over this 30-month project implementation period, defined as the absence of missing data fields or blank responses in the NMRF, was generally high (>80%). However, whereas assessment of the presence of fever and failure to breastfeed achieved 100% completeness, information on temperature, Apgar score and oxygen saturation were missing for 26.2%, 40.0% and 51.6% of records, respectively. Figure 1 shows the variations in completeness for selected variables over the project implementation period. A general trend of improvement in data quality and completeness of data collection was noted over time; for example, missing data on neonates' weight dropped from 23.0% at the end of the pilot phase to 3.0% by the end of the second phase, and missing data on admission diagnosis fell from 43.0% in the pilot phase to 10.0% in the second phase. Such improvement was specifically noted following training and mentorship sessions in the first quarter of 2015 and after modifications of the form to simplify its use in the second quarter of 2016 (Figure 1). From the data available, the HIV prevalence rate assessed by antenatal testing was 5.8% (191/3092, 95% CI, 5.1–6.7) and the syphilis prevalence rate was 15.4% (149/966, 95% CI 13.3–17.8).

Demographic and clinical characteristics of hospitalized neonates

Median (IQR) age on admission was 1 day (1–3) and a higher proportion of hospitalised neonates were female (52.0%, 2008/3859). Overall, most hospitalised neonates (76.4%, 2104/2754) were delivered at government hospitals (Table 1). The overall

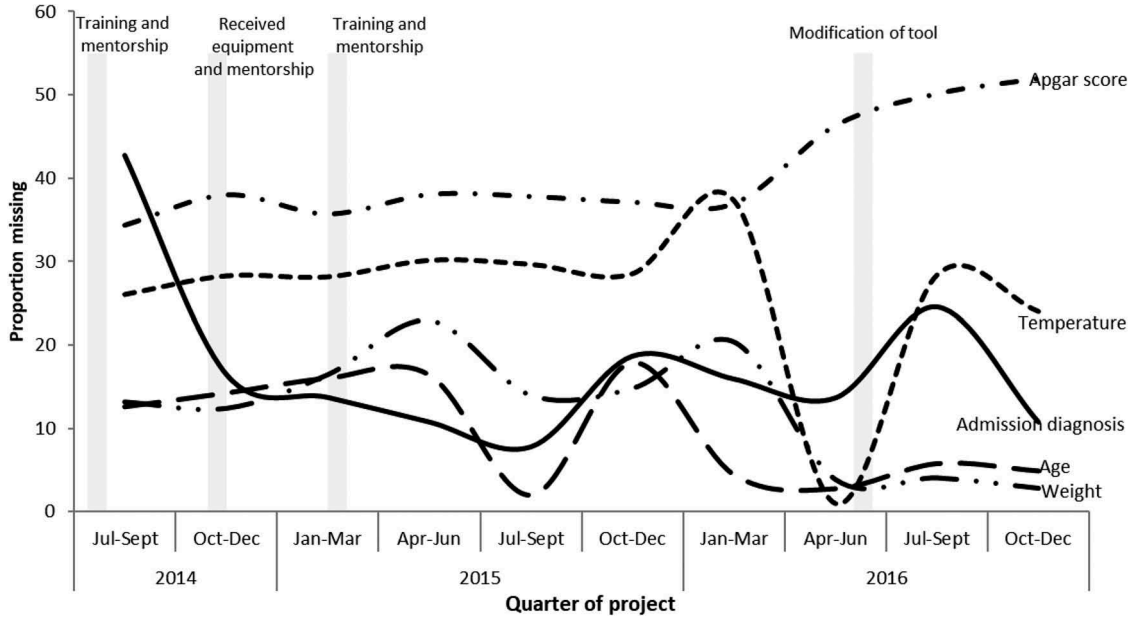

Figure 1. Completeness of neonatal medical record forms for key variables at Jinja Regional Referral Hospital, Eastern Uganda: July 2014 to December 2016.

median (IQR) duration of hospitalisation was 17 days (10–40) and the longest duration was 47 days (41–58) seen in the first year of the project, falling to 12 days (8–44) in the last project year (non-parametric test for trends across years was significant, p= 0.001). Normal vaginal delivery (63.8%, 2420/3796) was the most common mode of delivery, followed by caesarean section (35.0%, 1327/3796) (Table 1). The special care unit was the main admission ward for neonates with 1938 of 3782 (51.2%) admissions and an approximately equal proportion of neonates (48.8%, 1744/3782) were admitted to other wards including the general children's ward (28.3%, 1072/3782) and the postnatal ward (11.2%, 422/3782). Most of the neonates were admitted as referrals from government health facilities (54.4%, 2012/3699) but 30.4% (1123/3669) presented as self-referrals (Table 1).

Morbidity patterns in hospitalised neonates

The most common of the 4371 final diagnoses recorded were septicaemia (44.9%, 1962/4371), prematurity (21.0%, 917/4371) and birth asphyxia (19.1%, 833/4371) (Table 2). In order of decreasing frequency, other conditions for which neonates were admitted included meconium aspiration (4.8%, 208/4371), meningitis (3.6%, 157/4371), hypothermia (3.4%, 150/4371) and respiratory distress (3.3% 144/4371). Septicaemia was consistently the most common reason for admission throughout the 30 months and there was a significant overlap between birth asphyxia and prematurity as the second most common reasons for admission with the latter being the second most common morbidity in the last year of project implementation. There was no significant variation in the distribution of the other causes of morbidity during the 30 months of the project (Figure 2).

Mortality trends in hospitalised neonates

During the project implementation period, 577 deaths were recorded among 4178 neonates admitted, an overall mortality rate of 13.8%. The lowest mortality rate was 5.7% (20/349) and the highest was 17.2% (83/484) in the third and fourth quarters, respectively, of the first project implementation year. The diagnoses most commonly associated with death were septicaemia, contributing to 26.9% (155/577) of deaths, followed by prematurity (24.3%, 140/577), birth asphyxia (21.0%, 121/577), hypothermia (9.9%, 57/577) and respiratory distress (8.0%, 46/577) (Table 2). There was

Table 1. Demographic and clinical characteristics of hospitalised neonates at Jinja Regional Referral Hospital (JRRH): July 2014 to December 2016.

	Evaluation year			
Variable	2014[a]	2015	2016	Overall
Total admissions	835	1670	1673	4178
Median admission time, days (IQR)	47 (41–58)	20 (13–30)	12 (8–44)	17 (10–40)
Median age on admission, days (IQR)	2 (1–4)	1 (1–3)	1 (1–2)	1 (1–3)
Gender[b]				
Male, *n* (%)	335 (45.4)	728 (49.0)	788 (48.2)	1853 (48.0)
Gestation[2]				
Term	623 (75.0)	1305 (78.1)	1321 (79.4)	3250 (78.0)
Pre-term	208 (25.0)	365 (21.9)	343 (20.6)	916 (22.0)
Place of birth[b]				
Government hospital	592 (77.2)	1164 (75.7)	345 (77.2)	2104 (76.4)
Private hospital	18 (2.4)	41 (2.7)	8 (1.8)	67 (2.4)
Private clinic	44 (5.7)	82 (5.3)	15 (3.4)	141 (5.1)
Health centre IV	57 (7.4)	148 (9.6)	50 (11.2)	255 (9.3)
Health centre III	18 (2.4)	30 (2.0)	11 (3.1)	59 (2.1)
Home	32 (4.2)	58 (3.8)	14 (3.1)	104 (3.8)
Other	6 (0.8)	14 (0.9)	4 (0.9)	24 (0.9)
Mode of delivery[b]				
Normal vaginal delivery	472 (64.1)	966 (64.8)	980 (62.6)	2420 (63.8)
Abnormal vaginal delivery	9 (1.2)	17 (1.1)	18 (1.2)	44 (1.2)
Vacuum extraction	0	3 (0.2)	2 (0.1)	5 (0.1)
Caesarian section	255 (34.7)	506 (33.9)	565 (36.1)	1327 (35.0)
Admission ward[b]				
Special care unit	375 (50.3)	803 (57.4)	760 (46.4)	1938 (51.2)
Children's ward	221 (29.7)	402 (28.8)	449 (27.4)	1072 (28.3)
Labour ward/delivery room	38 (5.1)	53 (3.8)	156 (9.5)	147 (6.5)
Postnatal ward	91 (12.2)	84 (6.0)	247 (27.4)	422 (11.2)
Other wards	20 (2.7)	56 (4.0)	27 (1.7)	103 (2.7)
Referring institution[b]				
Self-referral	287 (40.7)	477 (32.3)	359 (23.7)	1123 (30.4)
Health centre IV	82 (11.6)	157 (10.6)	111 (7.3)	350 (9.5)
Government hospital	286 (40.6)	778 (52.6)	948 (62.6)	2012 (54.4)
Private hospital	50 (7.1)	67 (4.5)	43 (2.8)	160 (4.3)
Private clinic	0	0	31 (2.1)	31 (0.8)
Other health facility	0	0	23 (1.5)	23 (0.6)

[a]Data collected from July to December 2014.
[b]Total missing overall: gender 315, gestation 8, location of birth 298, mode of delivery 378, admission ward 392, referring institution 475.

Table 2. Main causes of morbidity and mortality in hospitalised neonates at JRRH: July 2014 to December 2016.

	Morbidity Total = 4371[a]		Mortality Total = 577	
Diagnosis	*n* (%)	Rank	*n* (%)	Rank
Septicaemia	1962 (44.9)	1	155 (26.9)	1
Prematurity	917 (21.0)	2	140 (24.3)	2
Birth asphyxia	833 (19.1)	3	121 (21.0)	3
Meconium aspiration	208 (4.8)	4	24 (4.2)	7
Meningitis	157 (3.6)	5	34 (5.9)	6
Hypothermia	150 (3.4)	6	57 (9.9)	4
Respiratory distress	144 (3.3)	7	46 (8.0)	5

[a]Total number of diagnoses recorded.

a gradual decline in mortality from the last quarter of 2014 to the third quarter of 2016, from 18.0% to 10.0%, with a subsequent slight increase thereafter in the last quarter of 2016 (Figure 3).

The following trend patterns in cause-specific mortality were observed. Mortality owing to prematurity increased significantly over time from 10.0% in 2014 to a peak of 44.0% ($p < 0.0001$) in the second and third quarters of 2016. A similar pattern was observed in mortality owing to birth asphyxia, increasing from 10% in 2014 to 36.0% ($p < 0.0001$) in the second quarter of 2016. Mortality owing to hypothermia declined significantly from 23.0% to 4.0%, $p < 0.0001$ in the third and fourth quarters of 2015 and remained low thereafter. Mortality owing to the other conditions showed a non-specific undulating pattern with transient increases and declines. The largest proportion of neonatal deaths (45.8%, 264/577) was recorded in the special care unit which is the designated unit for sick neonates. A further significant

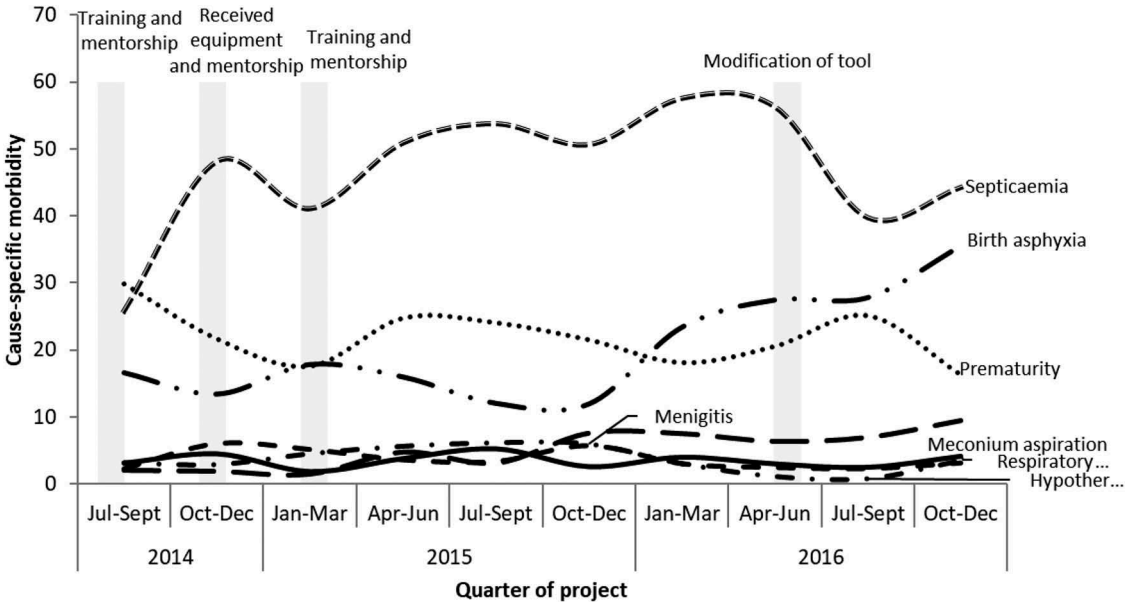

Figure 2. Temporal trends in morbidity of hospitalised neonates: July 2014 to December 2016.

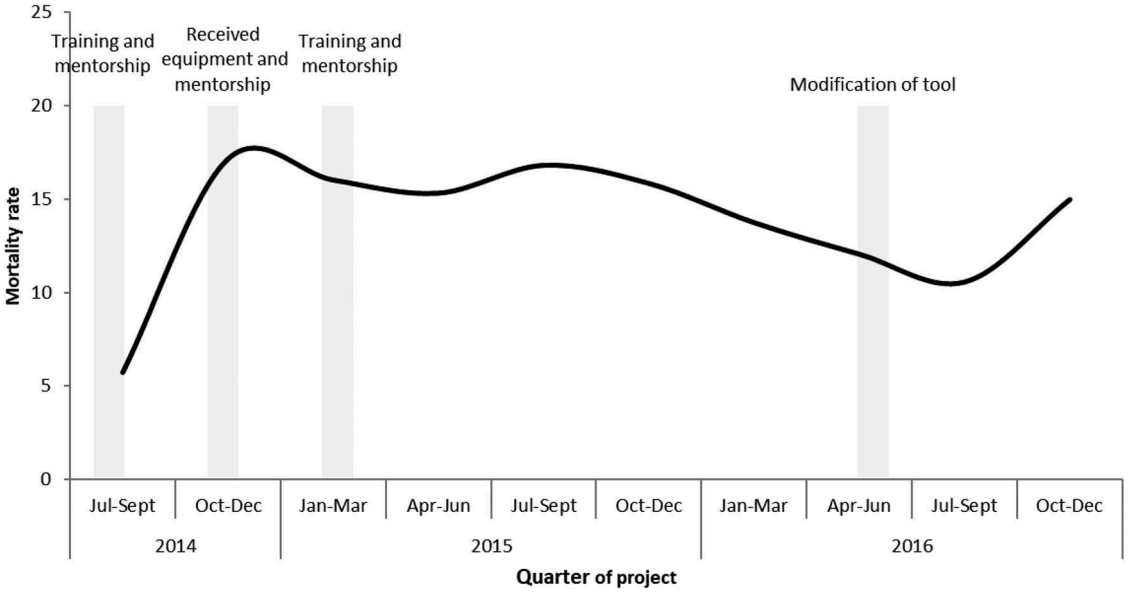

Figure 3. Temporal trends in mortality in hospitalised neonates: July 2014 to December 2016.

proportion of neonatal deaths (31.2%, 180/577) occurred in the children's ward which is the designated unit for all sick children in the hospital. However, 12.0% (69/577) of neonatal deaths occurred in other wards which are not usually designated areas for neonatal hospitalisation. Mortality in the special care unit declined significantly from 55.0% at commencement of the project to 30.2% in the last project quarter ($p < 0.0001$).

Overall, most deaths (51.5%, 297/577) occurred within the first 24 h of hospitalisation although a significant proportion also occurred after day 7 of hospitalisation (24.1%, 139/577). Of the 523 deaths for which time of death was recorded, a significantly higher proportion occurred during the day than at night 58.7% (307/523) *vs* 41.3% (216/523) respectively ($p < 0.05$).

Factors associated with mortality in hospitalised neonates

Overall, there were no gender-based or gestational age-related differences in mortality (Table 3). Of the different places of birth, home delivery was associated with a higher risk of mortality than delivery at government hospitals (aOR 1.77, 95% CI 1.12–2.81, $p= 0.0015$). Delivery at a private hospital was associated with a significantly lower risk of mortality (aOR 0.50, 95% CI 0.37–0.69, $p= 0.001$). Admission to wards other than the special care unit or the children's ward was associated with significantly higher mortality (aOR 10.11, 95% CI 6.00–17.07, $p= 0.001$). Mortality was also significantly higher in neonates referred from HC IVs than in those referred from government hospitals (aOR 1.53, 96% CI 1.06–2.20, $p= 0.02$) (Table 3).

Other related clinical outcomes of hospitalisation

In addition to mortality, data were also collected on other relevant clinical outcomes of hospitalisation, including whether the neonate improved without disability, improved with a disability, absconded or was referred to another health facility. These were considered to be additional indicators of the quality of care. Clinical outcomes including disability were assessed at discharge. Determination of whether or not an infant had a disability was based on clinical assessment by the clinicians and included assessment of mainly motor function but also sensory function as appropriate at discharge. Overall, the proportion of neonates who improved with a disability or were referred remained

Table 3. Factors associated with mortality in hospitalised neonates at a referral hospital in Eastern Uganda: July 2014 to December 2016.

Variable	Survived *n*=3597	Died *n*=577	Crude OR (95% CI)	Adjusted OR (95% CI)	χ^2 *p*-value
Gender					
Male	1585 (47.6)	266 (50.2)	1	1	
Female	1744 (52.4)	264 (49.8)	0.90 (0.75–1.08)	0.93 (0.75–1.16)	0.52
Gestation					
Term	777 (21.7)	438 (75.9)	1	1	
Pre-term	2812 (78.3)	139 (24.1)	0.87(0.71–1.07)	0.84 (0.64–1.09)	0.19
Place of birth					
Government hospital	1816 (54.1)	290 (55.7)	1	1	
Private hospital	821 (24.5)	72 (13.8)	0.55 (0.42–0.72)	0.50 (0.37–0.69)	**0.001**
Private clinic	139 (4.1)	22 (4.2)	0.99 (0.62–1.58)	0.99 (0.56–1.74)	0.96
Health centre IV	294 (8.8)	60 (11.5)	1.28 (0.94–1.73)	1.11 (0.77–1.62)	0.57
Health centre III	77 (2.3)	23 (4.4)	1.87 (1.16–3.02)	1.65 (0.88–2.81)	0.12
Home	146 (4.3)	41 (7.9)	1.76 (1.22–2.54)	1.77 (1.12–2.81)	**0.01**
Other	62 (1.9)	13 (2.5)	1.31 (0.71–2.42)	1.33 (0.65–2.74)	0.43
Mode of delivery					
Normal vaginal delivery	2071(63.2)	349 (67.5)	1	1	
Abnormal vaginal delivery	35 (1.1)	9 (1.7)	1.53 (0.73–3.20)	1.22 (0.51–2.94)	0.66
Vacuum extraction	4 (0.1)	1 (0.2)	1.48 (0.17–13.31)	1.58 (0.08–29.06)	0.76
Caesarian section	1169 (35.6)	158 (30.6)	0.80 (0.66–0.98)	1.03 (0.77–1.43)	0.83
Admission ward					
SCU	1676 (52.3)	262 (45.4)	1	1	
Children's ward	892 (27.8)	180 (31.2)	1.29 (1.05–1.59)	1.05 (0.77–1.43)	0.77
Delivery room/labour ward	228 (7.1)	19 (3.3)	0.53 (0.33–0.87)	0.65 (0.37–1.14)	0.13
Postnatal wards	374 (11.7)	48 (8.3)	0.82 (0.59–1.14)	0.95 (0.65–1.38)	0.77
Other wards	35 (1.1)	68 (11.8)	12.43 (8.10–19.07)	10.11 (6.00–17.07)	**0.001**
Referring institution					
Government hospital	1768 (55.5)	244 (47.6)	1	1	
Health Center IV	289 (9.1)	61 (11.9)	1.53 (1.13–2.07)	1.53 (1.06–2.20)	**0.02**
Self-referral	944 (29.6)	179 (34.9)	1.37 (1.12–1.69)	1.14 (0.32–1.15)	0.39
Private hospital	142 (4.5)	18 (3.5)	0.92 (0.55–1.53)	0.60 (0.32–1.15)	0.12
Private clinic	27 (0.8)	4 (0.8)	1.07 (0.37–3.09)	0.35 (0.78–1.56)	0.16
Other	16 (0.5)	7 (1.4)	3.17 (1.29–7.78)	1.85 (0.62–5.56)	0.27

p-values in bold type are statistically significant.

very low (≤2.0%) throughout the project implementation period (Figure 4). On the other hand, the proportion of neonates who improved with no disability increased significantly from 14.0% to 70.0% ($p < 0.0001$) over the first three-quarters of the project implementation period and remained above 60.0% throughout the other project quarters. In addition, the proportion of abscondments from the hospital decreased markedly over the first three quarters of project implementation from 78.0% to 9.0% ($p < 0.0001$), remained <15.0% in the second year of project implementation and was 20.0% in the last project year (Figure 4).

Health worker perspectives on the value of the project and of the data collected

The health workers received training and mentorship on common neonatal conditions with a focus on the practical skills required to identify, manage and prevent them. The choice of training topics was determined by morbidity and mortality trends in the monthly surveillance reports and were discussed and agreed upon by the health facility staff. Following these training and mentorship sessions, health workers reported that they felt more empowered and confident to care for neonates and provide better-quality care. This was also evident in some quotes from the qualitative interviews conducted. In response to what they thought about the project, one health worker said: 'Ok, so it was a good initiative and we hope it is not ending. The system of giving us feedback was also very beneficial because people would then reflect on what they are providing in terms of quality of care.'

The provision of medical equipment was also a motivator to health workers with one stating: 'Knowing what to do when appropriate equipment is not available can be frustrating. Having the basic equipment makes a big difference.'

Regarding the usefulness of data collected, the administration and health workers were able to clearly understand the burden of neonatal morbidity and mortality in general and disease-specific morbidity and mortality trends through the monthly feedback reports. Using these reports, the units were able to identify priority areas to target with existing available resources. For example, upon discovering that septicaemia was a major cause of morbidity and mortality, infection control measures were strengthened through training and practice. The surveillance data also guided forecasting for drugs and supplies. For example, the requisitions to the pharmacy and stores were easier to make and justify because of the availability of supportive information. Some local process changes were also made to facilitate improved patient care and flow. For example, the transfer of neonates from the labour and delivery room and the children's ward to the special care unit was streamlined, thus reducing transfer times and delays in access to care. In response to whether they thought the data had been helpful, one health worker responded as follows: 'At my level yes, because now we know the reasons for presentation to the hospital, the scope of challenges in terms of disease patterns of the babies but also we now can plan with the little information we have on how we should be ready for sick neonates. We also can now plan in terms of competencies for the health workers, we can also now plan in terms of follow-up or even now from public health aspects we can plan

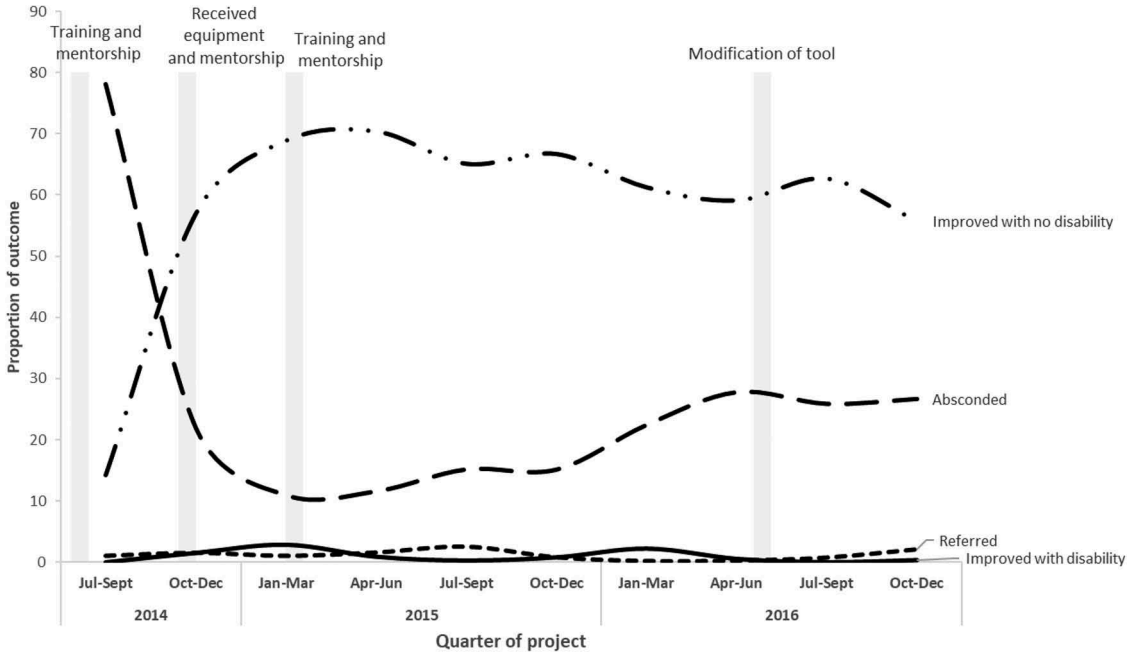

Figure 4. Other related clinical outcomes of hospitalised neonates: July 2014 to December 2016.

to prevent the very conditions that are bringing them because 80–90% of these conditions are avoidable because we would be able to package a message that would help mothers that have not yet delivered so that we considerably reduce these conditions, hence contribute to the reduction of morbidity and mortality.'

Discussion

The lack of good quality data on neonatal morbidity and mortality in sub-Saharan Africa contributes to the difficulty of estimating country-specific trends [16]. This project aimed to improve assessment of hospitalised neonates, data capture and data utilisation by enhanced surveillance of neonatal illnesses. The results provide evidence of the feasibility of implementing simple tools and actions to enhance surveillance of neonatal morbidity and mortality at a tertiary level of health care.

Central to the surveillance system was the neonatal medical record form (NMRF) which facilitated timely, consistent and comprehensive assessment of neonates, and the subsequent capture of data in an electronic database. The NMRF ensured a holistic approach to hospital care of neonates and was easy to use by health-care workers. Using the NMRF improved data collection, and the better data quality and completeness were sustained with training, mentorship and support supervision. The surveillance system also enhanced the compilation of data and analysis of trends in a timely manner and promoted regular feedback to health workers and the administration. The data were available for audit purposes and for planning at the unit/department level and at the health facility level. They became a vital instrument to support changes in practise through audits and feedback sessions, both of which have been shown to be effective in improving professional practice [17] and also contribute significantly to improving quality of health care in resource-limited settings [18–20]. The monthly data summaries were also a source of consumption data which were useful for quantifying needs and contributed to better forecasting of medicines and supplies and a consequent reduction of absences of stock. The results, therefore, highlight the importance of standardised forms for neonatal clinical assessment in documenting neonatal morbidity and mortality and triggering relevant actions for improvement.

In addition to establishing the neonatal surveillance system, the project approach to improving quality of care of neonates also included evidence-based training, mentorship, support supervision and provision of equipment. Studies in resource-limited settings indicate that sub-standard care, inadequate training, poor staff competence and a lack of resources such as equipment and medication contribute to neonatal death [21–24]. Addressing these issues is therefore vital to achieving a better quality of care. Indeed, it has been shown that clinical training improves health worker skills and competence [25] and also has a positive impact on the quality of neonatal care [26,27]. To promote a more responsive approach to training and mentorship, the innovative approach of this project was that training was mainly needs-directed, with training and mentorship requirements driven by the monthly data summaries and discussions with onsite health workers. This promoted effective discussion and generation of home-based or in-house solutions to the challenges identified. Equipment requirements identified by the baseline situation assessment ensured that equipment provided was relevant to need such as thermometers, weighing scales and oxygen concentrators. The surveillance system enabled formal tracking of the impact of these interventions on the multiple clinical parameters which cause specific morbidity and mortality over time, an observation often lacking in similar studies [25]. Overall, this approach to improving the quality of neonatal care at JRRH incorporated multiple dimensions of the WHO quality-of-care improvement framework. These included the provision-of-care dimension which was addressed with evidence-based interventions to enhance routine and emergency care and improvement in the information systems with the enhanced surveillance which allowed for review and auditing [28]. Additional areas of the framework addressed included enhancing staff competence and the provision of physical resources/equipment. Following these sessions, the health workers reported that they felt more empowered and confident to care for the neonates as well as provide a better quality of care.

The surveillance system identified the true neonatal disease burden and related trends. The main causes of hospitalisation were septicaemia, prematurity and birth asphyxia which have continued to cause significant morbidity and mortality in sub-Saharan Africa despite many interventions at various levels [29,30]. Although the proportion of neonates with multiple diagnoses is not specifically reported, previous studies show that considerable overlap in these three conditions is common [31]. Such overlap is associated with a considerable increase in the risk of mortality which should be addressed by effective clinical assessment and holistic management. Most neonates were hospitalised very early in life with a median age of 1 day at hospitalisation. Birth and the first day of life are the times of greatest risk to mothers and their neonates with hospitalisations in the first 24 h of life often resulting from intrapartum complications. As most neonatal problems present within the first day of life, early detection and intervention during this time are crucial. To ensure optimal care of neonates, it is vital that any risk factors be identified early during the prenatal and intrapartum periods, with the effective early communication to the neonatal care teams of any potentially adverse risk factors during the delivery process to ensure prompt

treatment. The health-seeking behaviour of this population might also have contributed to the early hospitalisations observed as about 30.0% of the neonates were admitted as self-referrals. It is important, though, to understand the reasons for these many self-referrals, especially if these neonates were inadequately assessed before discharge after delivery or whether they were mostly home deliveries. Timely and adequate care-seeking is critical to the appropriate care of neonates at the onset of illness and to the avoidance of delays that could lead to adverse outcomes. Care-seeking for neonatal illnesses in resource-limited settings appears to be low in general and remains a key challenge to improving neonatal mortality [32]. Among hospitalised neonates, the median 17 days of hospitalisation was quite long. Among others, known risk factors associated with increased length of hospital stay include gestational age <37 weeks and birth weight <1500 g [33,34]. Prolonged hospitalisation increases the risk of adverse events such as nosocomial infections and also increases the cost of health care. Therefore, approaches and strategies to reduce the duration of hospital stay are needed. These could include strengthening links between the hospital and community and promoting safe discharge practices, especially for preterm infants.

Overall mortality was 13.8% which is consistent with findings in some other low- and middle-income countries [35,36] but higher than has been reported elsewhere [37]. As neonates admitted to such tertiary health facilities are an important subgroup with a high risk of mortality, these deaths may be related to the severity of illness at the time of admission or delays in provision of care or care-seeking. The most common causes of death were similar to those in previous reports [38,39] and included septicaemia, prematurity and birth asphyxia. Most deaths occurred in the first 24 h of admission but an important proportion occurred after 7 days of admission. The first day and first week of life are critical as approximately three-quarters of all neonatal deaths occur in the first week of life and nearly half in the first 24 h [39,40]. This period, therefore, needs to be targeted with effective interventions at facility and community level to improve outcome in this group [40]. There are effective interventions to prevent neonatal death from infections and complications of prematurity, but it is more difficult to address intrapartum complications and it requires improvement at all levels of the complete continuum of care.

The case fatality rate in neonatal care units in resource-limited settings varies greatly and might relate to socio-cultural factors which influence treatment-seeking, or health system factors which affect the timeliness of referral, disease burden and quality of care [41]. At this tertiary-care facility, neonatal mortality was significant in those delivered at home which might indicate inadequate resuscitation and care immediately after birth or unhygienic delivery. Promotion of hospital delivery or skilled attendants could prevent such mortality [42]. Similarly, referral from HC IVs was associated with a higher mortality, probably owing to inadequate pre-referral treatment or delayed referral decisions. These findings highlight the need to further understand and improve the quality of care at these lower levels as well as strengthening referral systems and improving pre-referral treatment in these settings. Admission to any hospital ward other than the special care unit or children's ward was associated with significantly greater mortality. These deaths may have resulted from poor thermal regulation, sub-optimal observation, inadequate respiratory support or higher risk of infections in these non-specialised units. Surprisingly, almost 49.0% of all neonates were not hospitalised in the special care unit which is the designated unit for neonates. Reasons for this might relate to a lack of beds or other hospital policies. Optimal inpatient neonatal care requires dedicated ward space and staff with specialist training and skills [43]. Given that these specialised neonatal care points are vital in such health facilities, functional units should be made available and promoted in these settings.

Overall, there was a modest decline in mortality during the project implementation period. Although various approaches were used to enhance neonatal care at JRRH, the limited impact on mortality might be because the package of interventions did not cover the complete continuum of care including the antenatal and intrapartum periods. For better coverage of these different risk periods, early identification of risk factors antenatally and during the intrapartum period should aid optimal planning and management of neonates post-partum.

The strength of this project was that data were collected prospectively and thus provided real-time information on the morbidity and mortality trends requiring action. However, the approach also had some limitations. Firstly, the data focussed only on neonates admitted to the hospital and, although this is vital, a better understanding of the whole continuum of care is critical for optimal targeting of interventions. Therefore, inclusion of the prenatal and immediate perinatal periods could have further enriched the data. Secondly, certain important data on the neonatal period were also not captured including total number of births at the health facility and immediate delivery outcomes such as stillbirth that are an important component of the neonatal period. Despite these limitations, the data do provide information which is valuable for planning and monitoring purposes.

Improved data collection and analysis in settings where neonatal mortality is high are necessary for the development of cost-effective and successful programmes to improve neonatal health care. These findings provide evidence of the feasibility of establishing a system for surveillance of neonatal morbidity and mortality and of the potential usefulness of such data

for improving neonatal care. Through this system, real-time data on morbidity, mortality and outcome in neonates admitted to a tertiary hospital were collected prospectively. The results demonstrate that routinely collected clinical data at a tertiary-care facility can be useful in identifying important trends in neonatal demographics and can indicate areas requiring quality improvement. The potential role of such enhanced surveillance in improving neonatal care and pre-referral practises in lower-level facilities requires further study. Furthermore, focussing on the whole continuum of care could further enhance the quality of care and improve overall neonatal outcome.

Acknowledgments

We are grateful to the staff and administration of JRRH for their cooperation and support for the project and the administrative staff of the Uganda Paediatric Association for logistical support and coordination.

Availability of data and materials

The dataset analysed for this manuscript are available from the corresponding author on reasonable request. The NMRF used as the main data collection tool has been submitted as a supplementary information file.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The project was funded by PORTICUS which played no role in the design of the study, the collection, analysis and interpretation of the data or in writing the manuscript.

Notes on contributors

Jane Achan: Is the immediate Past President of Uganda Paediatric Association. She's a paediatrician and clinical researcher of record with extensive experience in training and development of clinical management, training and clinical audit manuals for both in-service and pre-service training. She's currently the coordinator of malaria research at the MRC unit in The Gambia.

Humphrey Wanzira: Is a medical doctor and epidemiologist with Pilgrim Africa, Uganda. He is also a clinical researcher with expertise in implementation research, large scale field studies and statistical analysis.

Arthur Mpimbaza: Is a paediatrician and lecturer at the Child Health and Development Centre, Makerere University College of Health sciences. He's also a clinical researcher with extensive expertise in the establishment of surveillance systems at health facility level.

Daniel Tumwine: Is a paediatrician and the current Executive Director of Uganda Paediatric Association. He is actively involved in clinical care and has been involved in several quality improvement interventions for different aspects of child health.

Sophie Namasopo: Is a paediatrician and clinical practitioner in Uganda. She was the Director of Jinja Regional referral hospital during the project implementation. She is actively involved in clinical care and implementation of different public health interventions to improve child health outcomes.

Harriet Nambuya: Is a paediatrician/neonatologist and is the current head of the Paediatrics department at Jinja Regional Referral hospital. She is actively involved in clinical care, training and mentorship for neonatal health in the country.

Asadu Serwanga: Is a medical doctor and public health practitioner. He has been involved in the establishment and supervision of surveillance systems at health facility level and is also involved in clinical research.

Rebecca Nantanda: the current President of Uganda Paediatric Association is a paediatrician, a quality improvement mentor and a trainer on several programmes. She currently works as a Research fellow at Makerere University Lung Institute.

ORCID

Humphrey Wanzira http://orcid.org/0000-0003-1074-5340
Sophie Namasopo http://orcid.org/0000-0002-8895-0144

Authors' contributions

AJ, AS, RN AM and DT conceived and designed the study and supervised data collection. SN, HN were involved in data collection and supervision of data collection. AJ and HW were responsible for data analysis and interpretation and wrote the initial draft of the manuscript. All authors read and approved the final manuscript.

References

[1] UNICEF. Levels and Trends in Child Mortality Report 2017. Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation. 2017. Available from: https://www.unicef.org/publications/files/Child_Mortality_Report_2017.pdf
[2] World Health Organization. Neonatal and perinatal mortality: country, regional and global estimates. Geneva: WHO; 2006. [cited 2018 July 4]. Available from: http://www.who.int/iris/handle/10665/43444
[3] World Health Organization. Consultation on improving measurement of the quality of maternal, newborn and child care in health facilities Geneva: WHO; 2014 [cited 2018 Jul 4]. Available from: http://apps.who.int/iris/bitstream/10665/128206/1/9789241507417_eng.pdf
[4] Madaj B, Smith H, Mathai M, et al. Developing global indicators for quality of maternal and newborn care: a feasibility assessment. Bull WHO. 2017;95:445–452I.
[5] Waiswa P, Peterson S, Tomson G, et al. Poor newborn care practices – a population based survey in eastern Uganda. BMC Pregnancy Childbirth. 2010;10:9.
[6] Ministry of Health, Government of Uganda. Situation analysis of new-born health in Uganda: current status

and opportunities to improve care and survival; 2008. [cited 2018 July 15]. Available from: https://www.healthynewbornnetwork.org/hnn-content/uploads/Situation-Analysis-of-Newborn-health-in-Uganda.pdf
[7] World Health Organization. World health statistics data visualizations dashboard. Neonatal mortality;2017 [cited 2018 Jun 5]. Available from: http://apps.who.int/gho/data/node.sdg.3-2-viz-3?lang=en
[8] Liu L, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151–2161.
[9] Nakibuuka VK, Okong P, Waiswa P, et al. Perinatal death audits in a peri-urban hospital in Kampala, Uganda. Afr Health Sci. 2012;12:435–442.
[10] Waiswa P, Kallander K, Peterson S, et al. Using the three delays model to understand why newborn babies die in eastern Uganda. Trop Med Int Health. 2010;15:964–972.
[11] Uganda Demographic and Health Survey. Uganda Bureau of Statistics, 2016 [cited 2018 Jun 15]. Available from: https://dhsprogram.com/pubs/pdf/FR333/FR333.pdf
[12] Mathers C, Boerma T. Mortality measurement matters: improving data collection and estimation methods for child and adult mortality. PLoS Med. 2010;7:e1000265.
[13] Mbonye AK, Sentongo M, Mukasa GK, et al. Newborn survival in Uganda: a decade of change and future implications. Health Policy Plan. 2012;27(Suppl 3):iii104–iii117.
[14] Shiffman J. Issue attention in global health: the case of newborn survival. Lancet. 2010;375:2045–2049.
[15] World Health Organization. Hospital care for mothers and newborn babies: quality assessment and improvement tool. 2nd. Denmark: WHO Regional Office for Europe; 2014. Available from http://www.euro.who.int/__data/assets/pdf_file/0004/244831/Hospital-care-for-mothers-and-newborn-babies-quality-assessment-and-improvement-tool.pdf
[16] Baiden F, Hodgson A, Adjuik M, et al. Trend and causes of neonatal mortality in the Kassena-Nankana district of northern Ghana, 1995–2002. Trop Med Int Health. 2006;11:532–539.
[17] Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev. 2012;13:CD000259.
[18] Wilkinson D. Reducing perinatal mortality in developing countries. Health Policy Plan. 1997;12:161–165.
[19] Pattinson R, Kerber K, Waiswa P, et al. Perinatal mortality audit: counting, accountability, and overcoming challenges in scaling up in low- and middle-income countries. Int J Gynaecol Obstet. 2009;107(Suppl 1):S113–S121,S121–S122.
[20] Le Grand Rogers R, Narvaez Y, Venkatesh AK, et al. Improving emergency physician performance using audit and feedback: a systematic review. Am J Emerg Med. 2015;33:1505–1514.
[21] Lawn JE, Kerber K, Enweronu-Laryea C, et al. Newborn survival in low resource settings – are we delivering? BJOG. 2009;116(Suppl 1):49–59.
[22] Lawn JE, Lee AC, Kinney M, et al. Two million intrapartum-related stillbirths and neonatal deaths: where, why, and what can be done? Int J Gynaecol Obstet. 2009;107(Suppl 1):S5–S18, S19.
[23] Ekirapa-Kiracho E, Waiswa P, Rahman MH, et al. Increasing access to institutional deliveries using demand and supply side incentives: early results from a quasi-experimental study. BMC Int Health Hum Rights. 2011;11(Suppl 1):S11.
[24] Uganda Demographic and Health Survey. Uganda: bureau of statistics, 2011 [cited 2018 Jun 16]. Available from: www.ubos.org/onlinefiles/uploads/ubos/UDHS/UDHS2011
[25] Brantuo MN, Cristofalo E, Mehes MM, et al. Evidence-based training and mentorship combined with enhanced outcomes surveillance to address the leading causes of neonatal mortality at the district hospital level in Ghana. Trop Med Int Health. 2014;19:417–426.
[26] Bookman L, Engmann C, Srofenyoh E, et al. Educational impact of a hospital-based neonatal resuscitation program in Ghana. Resuscitation. 2010;81:1180–1182.
[27] Singhal N, Lockyer J, Fidler H, et al. Helping Babies Breathe: global neonatal resuscitation program development and formative educational evaluation. Resuscitation. 2012;83:90–96.
[28] World Health Organization. Standards for improving quality of maternal and new born care in health facilities. Geneva: WHO; 2016. [cited 2018 July 15]. Available from: http://www.who.int/maternal_child_adolescent/documents/improving-maternal-newborn-care-quality/en/
[29] Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? Lancet. 2014;384:347–370.
[30] World Health Organization. The partnership for maternal, newborn and child health. A global review of the key interventions related to reproductive, maternal, newborn and child health. Geneva: WHO; 2011. [cited 2018 June 11]. Available from: www.who.int/pmnch/topics/part.../PMNCH_Report_2011_-_29_09_2011_full.pdf
[31] Aluvaala J, Nyamai R, Were F, et al. Assessment of neonatal care in clinical training facilities in Kenya. Arch Dis Child. 2015;100:42–47.
[32] Herbert HK, Lee AC, Chandran A, et al. Care seeking for neonatal illness in low- and middle-income countries: a systematic review. PLoS Med. 2012;9:e1001183.
[33] Lee HC, Bennett MV, Schulman J, et al. Accounting for variation in length of NICU stay for extremely low birth weight infants. J Perinatol. 2013;33:872–876.
[34] Eken MK, Tüten A, Ozkaya E, et al. Evaluation of the maternal and fetal risk factors associated with neonatal care unit hospitalization time. J Matern Fetal Neonatal Med. 2016;29:3553–3557.
[35] Rahim F, Jan A, Mohummad J, et al. Pattern and outcome of admissions to neonatal unit of Khyber Teaching Hospital, Peshawar. Pak J Med Sci. 2007;23:249–253.
[36] Hoque M, Haaq S, Islam R. Causes of neonatal admissions and deaths at a rural hospital in KwaZulu-Natal, South Africa. S Afr J Epidemiol Infect. 2011;26:26–29.
[37] Shah S, Zemichael O, Meng HD. Factors associated with mortality and length of stay in hospitalised neonates in Eritrea, Africa: a cross-sectional study. BMJ Open. 2012;2:e000792. PubMed PMID: 22983873; PubMed Central PMCID: PMCPMC3467653.

[38] Liu L, Oza S, Hogan D, et al. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet. 2015;385:430–440.
[39] Lawn JE, Blencowe H, Oza S, et al. Every newborn: progress, priorities, and potential beyond survival. Lancet. 2014;384:189–205.
[40] Lawn JE, Cousens S, Zupan J, et al. 4 million neonatal deaths: when? where? why? Lancet. 2005;365: 891–900.
[41] Blencowe H, Cousens S. Addressing the challenge of neonatal mortality. Trop Med Int Health. 2013;18: 303–312.
[42] Koblinsky M, Moyer CA, Calvert C, et al. Quality maternity care for every woman, everywhere: a call to action. Lancet. 2016;388:2307–2320.
[43] Moxon SG, Lawn JE, Dickson KE, et al. Inpatient care of small and sick newborns: a multi-country analysis of health system bottlenecks and potential solutions. BMC Pregnancy Childbirth. 2015;15 (Suppl 2):S7.