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RESEARCH ARTICLE

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Birthweight and gestational age-specific neonatal mortality rate in tertiary care facilities in Eastern Central Uganda

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Abstract

Background: An estimated 2.8 million neonatal deaths occur each year globally, which accounts for at least 45% of deaths in children aged less than 5 years. Birthweight and gestational age-specific mortality estimates are limited in low-resource countries like Uganda. A deeper analysis of mortality by birthweight and gestational age is critical in identifying the cause and potential solutions to decrease neonatal mortality.

Objectives: We studied mortality before discharge in relation to birthweight and gestational age using a large sample size from selected tertiary care facilities in Uganda.

Methods: We used secondary data from the East Africa Preterm Birth Initiative study conducted in six tertiary care facilities. Birth records of infants born between October 2016 and March 2019 with a gestational age greater than or equal to 24 weeks and/or birthweight greater than or equal to 500 g were reviewed for inclusion in the analysis. Newborn death before discharge was the outcome variable of interest. Multivariable Poisson regression modeling was used to explore birthweight and gestational age-specific mortality rate.

Results: We analysed 50 278 birth records. Among these 95.3% (47 913) were live births and 4.8% (2365) were stillbirths. Of the 47 913 live births, 50% (24 147) were males. Overall, pre-discharge mortality was 13.0 per 1000 live births. For each 1 kg increase in birthweight, mortality before discharge decreased by −0.016. As birthweight increases, the mortality before discharge decreased from 336 per 1000 live births among infants born between 500 and 999 g, to 4.7 per 1000 live births among infants born weighing 3500 to 3999 g, and increased again to 11.2 per 1000 live births among infants weighing more than 4500 g.

Conclusions: Our study highlights the need for further research to understand newborn survival across different birthweight and gestational categories.

KEYWORDS
birthweight, gestational age, mortality before discharge, neonatal mortality

1 | INTRODUCTION

An estimated 2.8 million neonatal deaths occur each year globally, which accounts for at least 45% of deaths in children aged less than 5 years.[1] Birthweight and gestational age-specific mortality estimates are limited in low-resource countries like Uganda. Due to an increase in the rate of mothers delivering in health care facilities from 58% to 74% in Uganda[2] and stagnant neonatal mortality at 27 deaths per 1000 live births over the last decade, a deeper analysis of mortality by birthweight and gestational age is critical in identifying the cause and potential solutions to decrease neonatal mortality.

Uganda is among the countries in Sub-Saharan Africa with a high neonatal mortality rate despite the availability of evidence-based and low-cost interventions to reduce these deaths.[3,4] Studies by Narayanan et al and Macarayan et al suggest that for low- and middle-income countries to address neonatal mortality effectively, there is a need to improve facility readiness to provide comprehensive and high-quality care for newborns born at both health facilities and in the community.[5,6]

In the sustainable development goals (SDG) era, for Uganda to achieve Target 3.2 of reducing neonatal mortality to 12 per 1000 live births by 2030, it is not enough to understand the cause of neonatal deaths. Information about birthweight and gestational age is increasingly critical to guide interventions to decrease neonatal morbidity, mortality, and developmental delay.[7-9] Most studies of birthweight and gestational age risk for neonatal and perinatal deaths have been conducted in Europe and the United States[10-12]; however, 98% of all newborn deaths occur in low- and middle-income countries.[13,14] and the results of these studies have limited applicability to these contexts. We studied mortality before discharge in relation to birthweight and gestational age using a large sample size from selected tertiary care facilities in Uganda inorder to inform precision health care innovations. Mortality before discharge was defined as death before a newborn was discharged from the health facility that he or she was born in.

2 | METHODS

We used secondary data from the East Africa Preterm Birth Initiative study, a cluster randomized controlled trial, on strengthening intrapartum and immediate newborn care[15,16] conducted in six selected hospitals in the Busoga region of east-central Uganda—one regional referral hospital, two private not for-profit hospitals, and three district hospitals and Migori County in Western Kenya. The study data were abstracted monthly from maternity ward birth registers by trained record officers attached to these hospitals. All births were recorded in the maternity register. Before study intervention, data strengthening efforts were conducted to improve accuracy and completeness of birth records as part of the PTBi trial. Particular attention was placed on accurate estimation of gestational age and included the provision of pregnancy wheels to calculate estimated date of delivery from last normal menstrual period, tape measures to assess fundal height, and digital scales to capture birthweight. These efforts also included monthly training and mentorship of health workers on standard indicator definitions, data recording and reporting, as well as monthly feedback on completeness of birth registers. Data strengthening efforts are described elsewhere.[17] The six hospitals serve a catchment population of about 3.8 million people[18] and provide comprehensive obstetric and neonatal care services including over 20 000 deliveries each year. The neonatal care services provided include resuscitation with positive pressure ventilation, Kangaroo mother care, phototherapy, supplemental oxygen, continuous positive airway pressure (CPAP), and treatment of infections. Neonatal mortality in this region is estimated at 28/1000 live births[2] which is similar to the national rate of 27/1000 live births.

The study was approved by Makerere University Higher Degree Research Ethics committee (MUSPH HDREC 395), the Uganda National Council for Science and Technology ethics committee and the University of California San Francisco IRB (Study # 16-19 162).

2.1 | Mortality before discharge

Birth records of infants born between October 2016 and March 2019 with a gestational age greater than or equal to 24 weeks and/or birthweight greater than or equal to 500 g were reviewed for inclusion in the analysis. A birth record was included if one of the following indices was recorded: (a) birthweight, (b) Apgar score at 1-minute, (c) infant sex, or (d) infant discharge status. We excluded all births where both birthweight and gestational age were not recorded. We further, excluded birth records with extreme values of birthweight by gestational age. Extreme values were computed using the median and interquartile range of birthweight by different gestational age (Alexandria's criteria), data that were greater than the median ± 2 IQR[19] were excluded. We excluded birth records missing birthweight. Live birth was categorized as a birth record with an Apgar score greater than zero or else it was referred to as a stillbirth. Ninety-seven percent of all birth records had an Apgar score recorded. Stillbirths were excluded in the analysis. Newborn death at discharge was determined using the recorded discharge status of the infant. Figure 1 illustrates the inclusion and exclusion criteria of birth records in our analysis.

2.2 | Statistical analysis

Newborn death before discharge was the outcome variable of interest. Birthweight and gestational age were the independent variables. Birthweight was categorised using increments of 500 g (500-999 and 1000-1499). Mortality rate before discharge was computed as the number of newborn deaths before discharge divided by number of infants born alive in each birthweight category for gestational age. Multivariable Poisson regression modelling was used to explore birthweight and gestational age-specific mortality rate. We used the

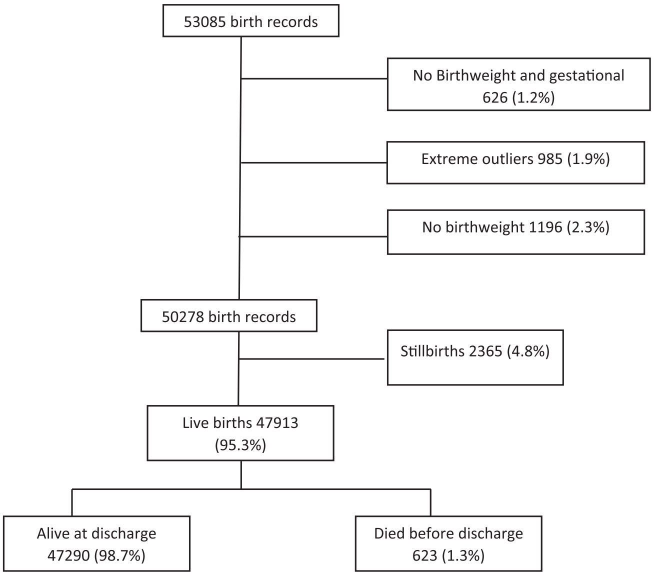

FIGURE 1 Exclusion criteria of birth records

logarithm of a rate as the weighted sum of the independent variables as below;

$$\text{Log}\,(\text{newborn death before discharge rate}) = \beta_0 + \beta_1\,\text{gestational age} + \beta_2\,\text{birth weight} \quad (1)$$

Maternal and infant characteristics including sex of the infant, type of birth, birthweight, gestational age and mode of delivery are described using frequencies and percentages. All statistical analyses were performed using STATA 15.1.[20]

To ensure accuracy of our gestational age and birthweight data, we assumed that the recorded birthweight was accurate. Using Intergrowth-21 reference cut off value at 3rd and 97th percentile of birthweight at every gestational age,[9] all infants with a reported gestational age less than third or greater than the 97th percentile cut off values were considered to have incorrect gestational age and their gestational age was considered as missing. In total, 12.4% (5930) birth records were assumed to have incorrect gestational age.

2.3 | Missing data

The proportion of infants with missing data was 26.2%. No method of imputing missing data was used since missing data was considered to be missing not at random.

3 | RESULTS

We analysed 50 278 birth records. Amongst these 95.3% (47913) were live births and 4.8% (2365) were stillbirths. Stillbirths were excluded from the final analysis (Figure 1). Of the 47 913 live births, 50% (24 147) were males and 47.3% (22 643) were females (Table 1). Nearly 73% of the babies were delivered by spontaneous vaginal delivery. About 5% were multiple deliveries. The majority (86%) of the infants weighed between 2500 and 4000 g. The incidence of low birthweight and preterm birth was 9.9% and 6.2%, respectively.

TABLE 1 Selected characteristics of births included in the analysis

Characteristics	Frequency	Percent
Total birth records	50 278	-
Live births	47 913	95.3
Stillbirths	2365	4.7
Sex		
Male	24 147	50.4
Female	22 643	47.3
Not recorded	1123	2.3
Type of birth		
Singleton	45 619	95.2
Multiples	2294	4.8
Birthweight category		
500-999 g	57	0.1
1000-1499 g	389	0.8
1500-1999 g	1134	2.4
2000-2499 g	3167	6.6
2500-2999 g	11 729	24.5
3000-3499 g	18 550	38.7
3500-3999 g	10 868	22.7
4000-4499 g	1930	4.0
4500+ g	89	0.2
Low birthweight (<2500 g)	4747	9.9
Preterm (GA <37 weeks)	2981	6.2
Gestational age		
<28 weeks	30	0.1
28-31 weeks	324	0.7
32-34 weeks	873	1.8
35-36 weeks	1754	3.7
≥37 weeks	31 136	65.0
Not recorded	13 796	28.8
Mode of delivery		
Normal vaginal delivery	34 778	72.6
Caesarean section	12 555	26.2
Others	580	1.2

Table 2 depicts the association of birthweight and gestational age on mortality. For each 1 kg increase in birthweight, mortality before discharge decreased by −0.016. The gestational age-specific and birthweight specific neonatal mortality rate is presented in Figure 2. As birthweight increased, the mortality before discharge decreased from 336 per 1000 live births among infants born between 500 and 999 g, to 4.7 per 1000 live births among infants born weighing 3500 to 3999 g, and increased again to 11.2 per 1000 live births among infants weighing more than 4500 g. Of note, of 57 infants born weighing 500 to 1000 g, 32 survived to discharge. The mortality rate by gestational age showed a similar pattern. The mortality rate among infants born at 24 weeks of gestation was 500 per 1000 live births and decreased to 4 per 1000 live births at 40 weeks of gestation, and increased to 11.5 per 1000 live births at 42 weeks of gestation. Among infants born at less than 34 weeks of gestation, the mortality ranged from 500 to 23 per 1000 live births, while for late preterm births (34-36 weeks of gestation), mortality ranged from 27.3 to 12.3 per 1000 live births.

Table 3 depicts birthweight and gestational age-specific mortality before discharge. Infants born between 24 and 28 weeks of gestation who had a birthweight less than 1000 g, had a mortality rate of 500 per 1000 live births. The mortality rate ranged from 19.4 to 100 per 1000 live birth among infants born between 29 and 36 weeks of gestation and birthweight between 1500 and 1999 g. Overall, mortality before discharge was estimated at 13.0/1000 live births.

TABLE 2 Poisson regression model for in-hospital mortality rates

Variables	Coef	SE
Intercept	5.76	0.064
Gestational age	0.002	0.0001
Birthweight	−0.016	0.0001

4 | DISCUSSION

In our study of six large hospitals in Uganda, we found that, although the mortality before discharge is close to the SDG neonatal mortality goal of 12 per 10 000, in-hospital neonatal mortality, particularly among infants with the lowest birthweight and most preterm infants, is still high. As expected, mortality was highest among extremely low birthweight (<1000 g) and extremely preterm (<28 weeks) infants, however, mortality was also high among infants weighing 4000 kg and above or gestational age greater than 40 weeks.

Our results confirm previous findings of infants born less than 2500 g have a high risk of deaths compared to the 2500 g and above. However, infants born weighing less than 1000 g in our setting have a 50% chance of survival before discharge, this consistent with the global action report on Preterm Births that state that 75% of preterm deaths can be prevented without intensive care ([21]) and also using low-cost interventions including Kangaroo Mother Care, appropriate use of antenatal corticosteroids, exclusive breast-feeding support, improved usage of antibiotics and aminophylline.[1,22,23]

The survival of infants <1000 g was improved due to setting up of functional neonatal units which were equipped by low cost equipment's to support babies with respiratory complications like bubble CPAP. Introduction and use of low cost bubble CPAP causes a marked reduction in mortality. Previous studies conducted in low resource

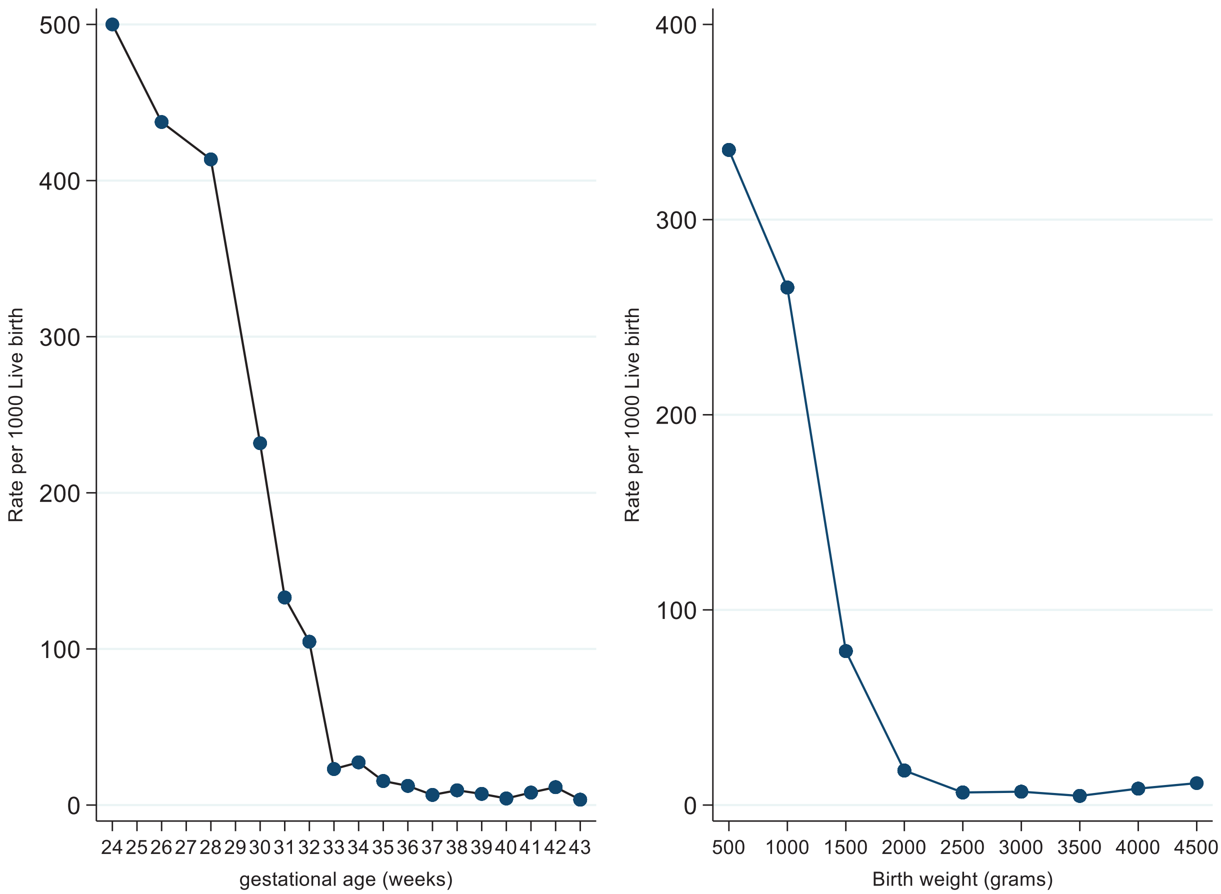

FIGURE 2 Gestational age and birthweight specific pre-discharge neonatal mortality rate

TABLE 3 Pre-discharge neonatal mortality rate per 1000 live births

		Birthweight (g)									
Gestational age	#Live births (#death)	500-999	1000–1499	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	4000-4499	4500+	Mortality rate
24	2 (1)	500.0									500.0
25	2 (0)	0.0									0.0
26	14 (6)	500.0	375.0								437.5
27	12 (3)	0.0	375.0								187.5
28	82 (26)	545.5	281.7								413.6
29	35 (4)		120.0	100.0							110.0
30	146 (32)		293.1	170.4							231.8
31	61 (9)		250.0	148.9	0.0						133.0
32	199 (17)		181.8	117.6	14.5						104.6
33	161 (5)			36.4	33.0						23.1
34	513 (16)			19.4	43.8	18.9					27.4
35	378 (4)			40.0	16.7	5.0	0.0				15.4
36	1376 (20)			0.0	39.2	10.0	8.9				12.3
37	3314 (24)				4.9	8.0	7.3	5.9			6.5
38	13 199 (115)				11.8	7.7	8.8	9.5			9.5
39	8056 (76)				0.0	10.0	8.9	9.8	0.0		7.2
40	4309 (24)					7.1	7.6	2.3	0.0	0.0	4.3
41	1053 (6)					4.6	6.1	3.5	17.9	0.0	8.0
42	1007 (7)					5.4	6.4	6.3	27.8	0.0	11.5
43	148 (1)					0.0	13.9	0.0	0.0	0.0	3.5
44	50 (0)					0.0	0.0	0.0	0.0	0.0	0.0
Missing	13 796 (227)	468.7	245.0	77.3	22.2	7.3	7.6	5.0	4.9	11.2	94.4
Mortality rate		335.7	265.2	78.9	17.7	6.5	6.9	4.7	8.4	11.2	13.0

settings have found use of bubble CPAP reduces preterm mortality including, in Eastern Uganda a study that demonstrated reduced mortality by 44%,[24] a study in Tanzania documented reduced risk of death by 52%,[25] and a study in Malawi document survival of VLBW infants was 65.5% compared to 15.4% of the controls.[26] In addition, health workers were trainied on skills and knowledge of care of preterm using simulation based approach "PRONTO". Details of PRONTO training approach has been described in the main PTBi trial.[16]

The fact that infants born at such low gestational ages and birthweight do survive in these settings demonstrates that it is possible and that more can and should be done. Further, these smallest and least developed infants have the highest rates of mortality, thus bringing down overall neonatal mortality rates requires some attention. The birthweight gestational chart provides areas where interventions are still largely needed and improvement using already proven interventions.

From our findings, 32 infants less than 28 weeks of gestation or less than 1000 g were able to survive and yet WHO recommends that survival of infants in this gestational age category is not feasible due to limited facility resources to support life in this baby. Our findings are similar to other studies done in sub-Saharan Africa and USA.[27-29] Survival of these babies could have been possible due to increased awareness among health workers because of the ongoing trial on preterm birth by PTBI and improved quality of care for preterm. Because of this, we recommend further studies to establish if these infants can survive in resource-limited settings and hence not be referred to as abortions.

Overall, the neonatal mortality rate before the discharge of 13 per 1000 live births observed in this study is lower than in a previous study of women living in the catchment area of these six hospitals (34 per 1000 live births).[30] The earlier study included both facility and home births which is not the case with our study. Over the last decade, worldwide efforts recommended by WHO have focused on efforts to increase institutional deliveries and skilled birth attendance. This has increased the proportion of women delivering in facilities; however, we need to demonstrate evidence if institutional deliveries translate in reduced facility neonatal mortality. Evidence shows there has been a slower improvement in intrapartum and newborn care which have contributed in a slowed reduction in neonatal mortality.[22,31,32]

4.1 | Our study has several limitations

Some birthweight and gestational age measurements were likely inaccurate and some data were incomplete or missing. Some infants, particularly the smallest, could have been incorrectly classified as livebirth, stillbirth, or abortion based on providers conflicting motivations such as the infant's chance for survival or the providers' obligation to complete a neonatal death review. Despite these limitations, a range of statistical techniques including missing at random analysis, comparison with standardised WHO Intergrowth curves were to address the study limitations.

4.2 | Strengths of our study

Among the strengths of our study is the large number of infants included in from six large hospitals. This provided a large enough sample size of infants in each weight and gestational age category to assess in relation to mortality. Previous studies have demonstrated neonatal mortality risk using population-based vital registries.[13,21-23] Although household surveys can give fairly accurate estimates of population-based stillbirth and neonatal mortality they cannot disaggregate this data by birthweight or gestational age, indicators which are routinely collected in maternity registers. This type of analysis is important to follow trends in survival and to identify windows of opportunity for intervention. This one of the few studies that have documented neonatal mortality stratified by birthweight and gestational age.

5 | CONCLUSION

In this study, the facility-based pre-discharge mortality was 13 per 1000 live births, and our gestational age and birthweight mortality chart present mortality rates. Our study highlights the need for further research to understand the survival of newborns in their different birthweight and gestational categories.

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All authors reviewed and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

TRANSPARENCY STATEMENT

Paul Mubiri affirms that the manuscript is an honest, accurate, and transparent account of the secondary data analysis and study being reported; that no important aspects of the study have been omitted and discrepancies from the study have been explained.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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