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Original Article

Prevalence and Factors Associated with Neonatal Death among Neonates referred to Neonatal Intensive Care Unit from an Urban high-density community of Lusaka, Zambia

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ABSTRACT

Background: The first month of life is the most vulnerable period of child survival. Globally the neonatal period accounted for nearly half (47 per cent) of all under-five deaths that occurred in 2022. Factors associated with neonatal death vary between environments and are essentially not well understood. This study aimed to investigate the prevalence and factors associated with neonatal death among neonates born at Kanyama first level hospital, located in an urban high-density community and referred to University Teaching Hospital (UTH)- Neonatal Intensive Care Unit (NICU).

Methods: A cross-sectional study was conducted in January and February 2023 through data extraction from registers and medical files on prevalence and factors associated with neonatal death. Pearson's Chi square, fisher's exact test and multiple logistic regression were conducted using the STATA version 14.2. 205 medical records were selected for the study using Cochrane (1963) formula to calculate a minimum sample size of 104.

Results: The study population comprised neonates born at Kanyama first level hospital in 2021 and 2022 of which 38.05% were female, 61.95% were male, 60% were born at full term and 40% were born at pre-term. Factors associated with neonatal death were labour complications (AOR: 3.46, p=0.039), conditions requiring special attention such as preeclampsia (AOR: 20.4, p=0.001), concerning Apgar score at one minute (AOR=4.50, p=0.014) and pre-term at birth (AOR=7.50, p<0.0001).

Conclusion: The prevalence of neonatal death was found to be high and the associated factors included; labour complications, condition requiring special attention, Apgar score at one minute and term at birth. Therefore, neonatal survival should be prioritized through pregnancy monitoring, quality antenatal and Emergency Obstetric and Neonatal Care (EmONC) training to improve response interventions in the event of complications.

Keywords: *neonatal mortality, urban high-density community, factors associated, neonatal intensive care unit*

INTRODUCTION

The first month of life is the most vulnerable period of child survival. Globally the neonatal period – first 28 days of life accounted for nearly half (47 per cent) of all under-five deaths that occurred in 2022. Globally neonatal death is estimated at 2.7 million deaths yearly [6, 21]. It is estimated that on average global rate of neonatal mortality rate stands at 17 deaths per 1,000 live births in 2021, in Sub-Saharan Africa the neonatal mortality rate in 2021 stood at 27 deaths per 1000 live births, followed by central and southern Asia with 21 deaths per 1000 live births. In Zambia, as of 2020 the neonatal mortality was at 24 deaths per 1,000 live births. The corresponding figures for many parts of the world which are developed such as Europe, and USA are much lower ranging from 2 to 3% or even less [19].

The global under-five mortality rate has decreased from 76 per 1000 live births in 2000 to 39 in 2018. Despite this progress, 5.3 million children under the age of five died in

2018, with Sub-Saharan Africa accounting for nearly half of these deaths. The literature suggests that the factorsassociated with neonatal mortality vary between environments and are essentially not well understood. Studies have demonstrated that a complex chain of factors are associated with neonatal death, spanning from socioeconomic, biological, and healthcare-related issues[8]. According to a study by Reyes et al. (2018)[15] the conditions associated with neonatal death were gestational age <37 weeks, birth weight ≤ 1500 grams, moderate/severe respiratory distress at 10 minutes, Apgar score <7 and less than 5 antenatal visits.

In Zambia, many interventional strategies have been put in place to help reduce neonatal deaths and improve neonatal survival. The Zambian Ministry of Health and the Clinton Health Access Initiative (CHAI) implemented an integrated Sexual, Reproductive, Maternal, and Newborn Health (SRMNH) program aimed at reducing maternal, neonatal and perinatal mortality by 40%, 40%, and 20%, respectively[7].

Another intervention is Every Newborn Action Plan (ENAP) which was endorsed at the 67th World Health Assembly in 2014, low-resource countries identified as having the highest newborn mortality rates took action to improve maternal and newborn care around the time of birth and to save lives[21]. Further programs such as Emergency Obstetric and Neonatal Care training of health workers (EmONC) have been implemented to help achieve Strategic Development Goal (SDG) target of reducing neonatal mortality rate to 12 per 1000 live birth by 2030 [24]. Although some studies have established factors associated with neonatal death, there is limited evidence on prevalence and factors associated with neonatal death among neonates born from mothers residing in urban high-density communities like Kanyama compound.

Hence this study investigated the factors associated with neonatal death among neonates born from mothers residing in urban high-density communities and admitted to the UTH-NICU with a view to identify pointers to guide policy and as such aid in the reduction of neonatal death to the SDG goal of 12 deaths per 1000 live births by 2030.

METHODS

Study design and setting

The study was a cross-sectional study that used hospital records in the form of registers and patient files of neonates delivered at Kanyama first level hospital and referred to UTH-NICU. The study was conducted at Kanyama first level hospital located in a high-density community of Kanyama compound. It is one of the largest high-density communities in Zambia and is among the hospitals responsible for the highest number of deliveries in Lusaka.

The Mosley and Chen conceptual framework for child survival was used to conceptualize factors associated with neonatal death. The framework is based on the assumption that all social and economic determinants of child mortality exert an impact on mortality via a common set of biological mechanisms, or proximate determinates. The identification of a set of distal, proximate, or intermediate determinants that directly influence the risk of morbidity and mortality is central to the model. To affect child survival, all demographic determinants must pass through these variables. The framework also guided the discussion of the results12.

Study population

The study population comprised neonates born at Kanyama first level hospital in the years 2021 and 2022 and referred to University Teaching Hospital (UTH). We defined a neonate as a newborn infant less than 28 days of life. A neonate was included in the study if a neonate's mother resided in Kanyama compound and delivered at Kanyama first level hospital in 2021 and 2022. A neonate whose medical record was complete with all variables of interest. Any neonate who was born at Kanyama first level but whose medical records was not complete were not included in the study.

Sample size

A total of 205 files of neonates admitted at the NICU in the period 2021 – 2022 were used. The study used the sample size formula developed by Cochrane (1963) to estimate the sample size. The calculation was based on the 95% confidence interval, an estimated prevalence of neonatal death of 6.04% for Lusaka province in 2021 25 and a margin error (precision) of 0.05. The minimum sample was 104 with the size power of 80%, however a total of 205 files was used to improve substantial power to above 80%. The fulfilment of the sample size was a challenge as some registers and medical files were partial with missing pages and missing records.

Data Sources

The source of the data were medical files, registers and reports at Kanyama first level hospital labour ward and Neonatal Intensive Care Unit department at UTH. The data was obtained in a process that began at Kanyama first level hospital were the variables of interest were extracted from the mother's files and delivery registers. The neonate was then followed up to the UTH-NICU to record the outcome. Data was coded and stored in Microsoft excel then exported to Stata for analysis. To Ensure validity and reliability data from the medical files and registers both admissions and discharges were compared. The data extracted was used to identify key characteristics of all the neonates used as participants in this study. Data was then coded entered and stored in Microsoft excel then exported to Stata for analysis.

Data management and statistical methods

An extraction tool was developed to gather all the necessary information. Data was initially stored in Excel, then cleaned and exported to Stata. The data was then checked for completeness and accuracy by ensuring that, the information answers and addresses all the questions in the data extraction tool. The data was analyzed using Stata version 14.2 (StataCorp, College Station, Texas, USA). The characteristics of study participants were summarized using descriptive statistics i.e., reporting proportions and percentages.

The prevalence of neonatal death was estimated using

World Health Organisation (WHO) prevalence calculation, i.e., the number of deaths divided by the total number of neonates admitted to UTH-NICU that were referred from Kanyama first level hospital. Pearson chi-square and Fisher's exact test was used to test relationships between neonatal death and categorical variables. The cut-off point for statistical significance was set at a p-value less than 0.05.

An investigator led - multivariable logistic regression were done to describe the relationship between the dependent variable 'neonatal death' with the selected predictor variables with the adjusted odds ratios (AOR) at 95% confidence interval (CI). Sensitivity and specificity as well as Receiver Operating Curve (ROC) were used to check model performance while likelihood-ratio test was used to find the best fit model.

Ethical consideration

Ethics clearance was sought from the University of Zambia Biomedical Research Ethics Committee (UNZABREC) (Ref No: 3456-2022). Permission to proceed with the study was as well obtained from the National Health Research Authority (NHRA) (Ref No: NHRAR-R-1229/14/10/2022), the Provincial Health Office, Kanyama first level hospital and University Teaching Hospital – Women and Newborn hospital. Confidentiality was upheld in that data collected was identified by unique identifiers, patient names were not used.

RESULTS

In the study it was found that the prevalence of neonatal death was 33% (67/205). Out of the 205 neonatal records reviewed, mother's ages ranged from 15 to 42. The majority of the mothers, 74% (152/205), were married while 26% (53/205) were unmarried. The majority 43% (89/205) of the mothers were multiparous (Table 1a).

Male neonates made up 62% (127/205) and at birth, 60% (123/205) were full term. Majority of the neonates 56% (114/205) were born with normal birth weight. On the other hand, 41% (84/205), presented with a moderately abnormal Apgar score at 1 minute. It was found that the majority 51% (104/205) presented with a concerning Apgar score at 5 minutes. Lastly it was found that majority of the neonates 70% (144/205) were delivered vaginally (Table 1b).

Outcome Data

Neonatal death prevalence among neonates admitted to NICU from Kanyama first level hospital

The overall percentage of neonatal death among neonates admitted to UTH-NICU from Kanyama first level hospital for the study population from 2021 to 2022 was data was 33% (Table 2).

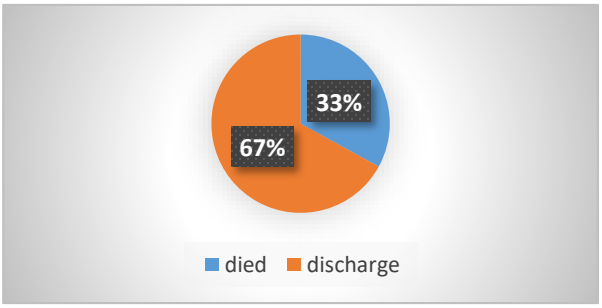

Figure 1. Neonatal death prevalence among neonates admitted at UTH-NICU

The chi-square test of association showed that, seven variables turned out to be associated with neonatal death at 5% level of significance and that included: Blood pressure, Labour complications, Condition requiring special attention, Apgar score at 1 minute, Apgar score at 5 minutes, term at birth and Weight of baby at birth (Table 1a &b).

Table 1a. Comparison of background and clinical characteristics with Neonatal death

Background Characteristics			Neonatal outcome (died)		
Categorical Variable	**Total (n=205)**	**Percentage (%)**	**Discharged n (%)**	**Died n (%)**	**Sig.**
Mother's Age at Delivery					
<20	36	17.56	24 (66.7)	12 (33.3)	0.800[F]
20-29	104	50.73	73 (70.2)	31 (29.8)	
30-39	57	27.80	36 (63.2)	21 (36.8)	
40-49	8	3.90	5 (62.5)	3 (37.5)	
Marital Status					
Married	152	74.15	105 ((69.1)	47 (30.9)	0.362[C]
Unmarried	53	25.85	33 (62.3)	20 (37.7)	

Parity					
Low Parity	73	35.61	45 (61.6)	28 (38.4)	0.186[C]
Multi Parity	89	43.93	66 (74.2)	23 (25.8)	
Grand Multipara	43	20.98	27 (62.8)	16 (37.2)	
Blood pressure at Delivery					
Normal blood pressure	43	20.98	32 (74.4)	11 (25.6)	<0.0001[C]
Elevated blood pressure	88	42.93	70 (80)	18 (20)	
High blood pressure	74	36.10	36 (48.6)	38 (51.4)	
Condition Requiring Special Attention					
Non	97	47.32	86 (88.7)	11 (11.3)	<0.0001[F]
Prolonged labour	56	27.32	32 (57.1)	24 (42.9)	
Mal presentation	19	9.27	11 (57.9)	8 (42.1)	
PIH	8	3.90	6 (75)	2 (25)	
Preeclampsia	25	12.20	3 (12)	22 (88)	

Table 1b. **Comparison of background and clinical characteristics with Neonatal death**

Background Characteristics			**Neonatal outcome (died)**		
Categorical Variable	**Total (n=205)**	**Percentage (%)**	**Discharged n(%)**	**Died n (%)**	**Sig.**
Labour Complication					
No	76	37.07	68 (89.5)	8 (10.5)	<0.0001*
Yes	129	62.93	70 (54.3)	59 (45.7)	
HIV Status					
Reactive	28	13.66	120 (67.8)	57 (32.2)	0.713
Non-reactive	177	86.34	18 (64.3)	10 (35.7)	
Mode of Delivery					
Vaginal birth	144	70.24	102 (70.8)	42 (29.2)	0.099
Caesarean section	61	29.76	39 (59)	25 (41)	
Apgar Score at 1min					
Normal Apgar score	49	23.90	43 (87.8)	6 (12.2)	<0.0001*
Moderately abnormal Apgar score	84	40.98	69 (82.1)	15 (17.9)	
Concerning Apgar score	72	35.12	26 (36.1)	46 (63.9)	
Apgar Score at 5mins					

Normal Apgar score	34	16.59	30 (88.2)	4 (11.8)	0.001*
Moderately abnormal Apgar score	67	32.68	50 (74.6)	17 (25.4)	
Concerning Apgar score	104	50.73	58 (55.8)	46 (44.2)	
Term at Birth					
Full term	123	60.00	112 (91.1)	11 (8.9)	<0.0001*
Pre term	82	40.00	26 (31.7)	56 (68.3)	
Sex of Neonate					
Female	78	38.05	58 (74.4)	20 (25.6)	0.092
Male	127	61.95	80 (63)	47 (37)	
Weight of Neonate at birth					
Normal birth weight	114	55.61	103 (90.4)	11 (9.6)	<0.0001*
Low birth weight	91	44.39	35 (38.5)	56 (61.5)	

Apgar = *Activity, pulse, grimace, appearance, respiration****, HIV =*** *Human Immunodeficiency Virus,* ***F =*** *Fisher's exact test,* ***C =*** *Chi-square test,* ***PIH =*** *Pregnancy Induced Hypertension*

Factors associated with Neonatal Death

The factors associated with neonatal death among neonates born at Kanyama first level hospital and referred to UTH-NICU in 2021 and 2022 are shown in Tabe 2 after conducting an investigator led stepwise regression elimination process.

A univariable logistic regression revealed that labour complications increased the odds of neonatal death 7.16 times (p <0.0001, 3.19-16.1). Some conditions requiring special attention such as prolonged labour increased the odds of neonatal death 5.86 times (p<0.0001, 2.58-13.3)), Mal presentation increased the odds of neonatal death 5.69 times (p= 0.002, 1.88-17.18). PIH increased the odds of neonatal death 2.61 times (p <0.275, 0.47- 14.5). It was also found that Preeclampsia increased the odds neonatal death 57.3 times (p<0.0.001, 14.7-140). The study also revealed that moderate Apgar score at 1 minute increased the odds of neonatal death 1.56 times (0.56-4.32) while concerning Apgar score at 1 minute increased the odds of neonatal death 12.7 times (p<0.0001, 4.76-33.8) and term at birth increases the odds of neonatal death 21.9 times (10.1-47.6) (Table 2).

At multiple logistic regression, taking the other variables in the model into account, the final investigator-led model reveals that labour complications increased the odds of neonatal death 3.46 times (p=0.039, 1.06-11.3). Some conditions requiring special attention such as prolonged labour increased the odds of neonatal death 2.26 times (p=0.126, 0.79-6.46), Mal presentation increased the odds of neonatal death 1.41 times (p= 0.636, 0.34-5.75). PIH increased the odds of neonatal death 1.41 times (p=0.764, 0.15-13.2) and preeclampsia increased the odds of neonatal deaths 20.4 times (p=0 .001, 3.65-114). Further concerning Apgar score at 1 minute increased the odds of neonatal death 12.7 times (p<0.0001, 1.35-15.0) and moderately abnormal Apgar score increased the odds of neonatal death 1.56 times (p=0.394, 0.45-5.71) Lastly taking account of all other variables the odds of neonatal death for neonates born at pre-term were increased 7.50 times (p<0.0001, 2.88-19.8) (Table 2).

Model performance

Model performance was evaluated using model sensitivity and specificity. The model's sensitivity in this investigation was 82.09%. the sensitivity was acceptable at 82% and concluded that the model would perform well in classifying neonates as either died or discharged. The likelihood ratio test was done on the full model and nested model, the p-value =0.1278, implying that the nested model was better than the full model. A Receiver Operating Curve (ROC) found area under the curve of 0.92, which was closer to 1 than 0.5, this shows an acceptable discrimination for the model and thus an indication that the classification was not by chance.

Table 2: The best predictors model logistic regression for factors associated with neonatal death

	Univariable estimates			Multivariable estimates		
Determinants	**COR**	**95% CI**	**P-VALUE**	**AOR**	**95% CI**	**P-VALUE**

Labour Complication						
No	**Ref**			**Ref**		
Yes	7.16	3.19, 16.1	<0.0001	3.46	1.06,11.3	0.039
Condition Requiring Special Attention						
Non	**Ref**			**Ref**		
Prolonged labour	5.86	2.58,13.3	<0.0001	2.26	0.79,6.46	0.126
Mal presentation	5.69	1.88,17.18	0.002	1.41	0.34,5.75	0.636
PIH	2.61	0.47,14.5	0.275	1.41	0.15,13.2	0.764
Preeclampsia	57.3	14.7,140	<0.0001	20.4	3.65,114	0.001
Apgar score at 1 minute						
Normal Apgar score	**Ref**			**Ref**		
Moderately abnormal	1.56	0.56,4.32	0.394	1.60	0.45,5.71	0.469
Concerning Apgar score	12.7	4.76,33.8	<0.0001	4.50	1.35,15.0	0.014
Term at Birth						
Full term	**Ref**			**Ref**		
Pre-term	21.9	10.1,47.6	<0.0001	7.50	2.88,19.8	<0.0001

Apgar = Activity, pulse, grimace, appearance, respiration, PIH = Pregnancy Induced Hypertension, COR = Crude odds ratio, AOR = Adjusted Odds ratio, CI = Confidence Interval.

DISCUSSION

The present study revealed that the prevalence of neonatal death was high among the neonates born at Kanyama first level hospital and admitted to UTH-NICU. The factors associated with neonatal death include labour complications, conditions requiring special attention, Apgar score at 1 minute and term at birth

In this study Neonatal death among neonates was significantly high with the overall neonatal death prevalence among the admitted neonates higher than the findings of a study in Ethiopia by Thomas et al. that had an overall prevalence of neonatal death was 11.4% [17]. The reason could be due to the differences in sample sizes. The findings of this study were consistent with results from a study conducted at Women & Newborn Hospital, UTH that found that the overall Neonatal death percentage during the study period was 31.8 % [16]. This is disproportionately high and might be regarded as one of the contributors to the country's high neonatal mortality of 24 deaths per 1000 live births as of 2020. The SDG target is to reduce neonatal mortality to as low as 12 deaths per 1000 live births [19].

Factors Associated with Neonatal death
Intermediate factors

The study reviewed that neonates born from mothers with labour complications were more likely to die compared to neonates born from mothers without labour complications. These results are consistent with a study done in Singapore which found that mothers with labour complications had a significant proportion of neonates die in the first 28 days of life [1]. The results of this study are also consistent with the findings of a study conducted by Basir et al. (2010)[3] in Sudan which found that delivery complications were significantly associated with neonatal mortality. This finding suggests that there is need strengthen quality of antenatal services and Emergency Obstetric and Newborn Care (EmONC) trainings.

The present study revealed that neonates born from mothers with conditions requiring special attention such as prolonged labour were more likely to die compared to neonates born to mothers with no condition requiring special attention. These finds are in line with a study done by Anggondowatti T et al. (2017)[2] in Indonesia that found that the obstructed and prolonged labour was one of most prevalent reason for admission into the neonatal intensive care unit. Another study done by Thomas G et al. (2021)[17] in Ethiopia found that pregnancy complications such as prolonged labour was significantly associated with neonatal mortality.

The study revealed that neonates born from mothers with conditions requiring special attention such as pregnancy induced hypertension were more likely to die compared to neonates born to mothers without any condition requiring special attention. This finding is comparable to a study done by Chen et al. (2006)[4] in United States of America that found that moderate to severe pregnancy induced hypertension was

associated with lower risk of infant death in preterm births but higher risk in term births.

The present study revealed that condition requiring special attention such as mal presentation increased the odds of neonatal death compared to neonates with no condition requiring special attention. This finding is comparable with the findings of a study done by Duffy C et al. (2018)[5] in seven study sites in six countries, namely; India, Pakistan, Kenya, Zambia, Democratic Republic of Congo, Guatemala that found that mal presentation was significantly associated with an increased risk of neonatal mortality. This was in line with another study done by Upadhyay et al. (2022)[20] in India that found that mal presentation is among the maternal factors associated with neonatal death.

The study found that neonates born from mothers with conditions requiring special attention such as preeclampsia were more likely to die compared to neonates born to mothers with no condition requiring special attention. These findings were comparable with a study done in Jordan that found that neonatal mortality rate was significantly higher among neonates born to women with preeclampsia compared to neonates born from mothers with no condition requiring special attention[22]. This finding was also consistent with the findings of a study done by Thomas et al. (2021)[17] in Ethiopia that found that index pregnancy complications such as preeclampsia were significantly associated with neonatal mortality. This finding suggests that more needs to be done with regards pregnancy monitoring through quality antenatal services, improved referral system and Every Newborn Action Plan (ENAP) proven intervention [21].

Proximate factors

This study revealed that neonates born at pre-term were more likely to die compared to neonates born at full. This is comparable to other studies done in Singapore and Mexico that found that neonates born at pre-term i.e. gestational age of less than 37 weeks are more likely to die [1, 15]. This finding suggests that there is need to improve the quality of care in NICU by providing quality equipment and adequately trained stuff in EmONC protocols.

The study showed that neonates born with a concerning Apgar score at one minute (0-3) were more likely to die compared to neonates born with a normal Apgar score (7-10). These findings were similar to findings of a study done in China that revealed that the neonatal mortality rate of births with a low Apgar score (0-3) was higher than that of births with a normal Apgar score (7-10) [13]. The finding was consistent with the findings of another study conducted by Li F et al. (2013)[9] in the United States of America which found that very low Apgar scores (0-3) resulted in high rates of neonatal mortality. This finding suggests that standard clinical practice for obstetric and neonatal care teams to work closely together to ensure that all relevant maternal (pregnancy and birth) and neonatal factors are explored in neonatal investigation.

The findings of this study are important for NICUs. Through examining the factors associated with death in an urban high-density community, further insight is provided, allowing care providers, policymakers, and researchers to address improvements in areas that will most benefit patients. Seemingly the interventions such as establishment of first level hospitals, antenatal and Emergency Obstetric and Newborn Care (EmONC) over the years have not achieved the intended results in reducing neonatal deaths and its burden on the highest referral hospital in Zambia.

This study had several limitations that should be considered in interpreting the results. Similar to studies in this area, these findings relied on retrospective data and are subject to a great deal of missing data.

CONCLUSIONS

The study's findings highlighted the need to reassess current efforts for reducing neonatal deaths. Neonatal death was found to be high among neonates referred to a NICU from Kanyama First Level Hospital. Associated factors include condition requiring special attention, labour complications, Apgar score at 1 minute and term at birth. This has negative consequences, and the emphasis should be on improving the capabilities of health workers through EmONC training. Educating women in childbearing age on the importance of antenatal to enhance pregnancy monitoring and as well as improving the referral systems and in the long run open a NICU at Kanyama first Level hospital. To further enhance newborn survival, a qualitative study on the outcomes of neonates born to preeclamptic moms should be prioritized to further examine and understand the dynamics.

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