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Determinants of neonatal mortality at Kamenge Teaching Hospital, Burundi: a prospective cohort study

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Abstract

Background Despite the implementation of a free healthcare policy for pregnant women and children under five since 2006, neonatal mortality remains high in Burundi. Indeed, twenty-one neonates per 1,000 live births died in 2019. This study aimed to assess neonatal survival and identify factors associated with neonatal mortality in one tertiary hospital of Bujumbura, Burundi.

Methods We recruited 885 babies whose births occurred between October and December 2020 in Kamenge Teaching Hospital of the University of Burundi and followed them over four months. We applied life table methods and implemented the Cox proportional hazard regression model to evaluate neonatal survival and determine factors associated with neonatal mortality.

Results Among 885 live births, 30 neonates died and 133 were lost to follow-up, resulting in a neonatal mortality rate of 36.65 per 1,000 live births. Notably, 90% of neonatal deaths occurred within the first week of life, with 40% within the first 24 h. The leading causes of death included complications related to prematurity (60%), asphyxia (13.33%), infections (13.33%), and congenital malformations (13.33%). Mortality increases with severe prematurity (AHR: 14.60, 95%CI 5.83–36.54), fewer ANC (AHR: 6.67, 95%CI 1.54–29.25), and Apgar score below 6 at five minutes (AHR: 4.37, 95%CI 1.66–11.44).

Conclusion Neonatal mortality remains high, predominantly driven by preventable and curable complications. Further research is needed to explore this subject on a large scale to inform targeted interventions.

Keywords Survival analysis, Neonatal mortality, Determinants, Kamenge Teaching Hospital, Burundi

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Introduction

The first 28 days of life represent the most critical period associated with the highest risk of mortality [1]. Globally, 2.4 million newborns died in 2019, accounting for 47% of all deaths among children under five years, an increase from 40% in 1990 [1]. Although overall child mortality has improved since 1990, the pace of decline in neonatal mortality has lagged behind that of older children, a pattern that has persisted over the past three decades. Specifically, while the global under-five mortality rate decreased by nearly 60% from 93 to 38 deaths per 1,000 live births between 1990 and 2019, that newborns declined by only 52%, dropping from 37 to 17 deaths per 1,000 live births over the same timeframe [2]. Consequently, neonatal mortality now constitutes a growing share of under-five mortality, especially in low- and middle-income countries (LMICs) where health systems persistently confront capacity challenges including shortages, maldistribution of resources and underfunding [3].

In 2019, approximately 1.94 million newborns died in South Asia and sub-Saharan Africa alone, representing 80% of neonatal deaths globally [2]. This elevated mortality remained high in these regions even though substantial global progress has been made. Evidence shows that 16 million newborn deaths could be prevented by 2030 if low-income countries reduce their neonatal mortality rate (NMR) to levels comparable to those of high-income countries [4].

Within the East African Community, Burundi had the second highest neonatal mortality rate with an estimated 21 deaths per 1,000 live births in 2019 [1]. Considering that many causes of neonatal mortality are preventable, the world has set a global target to attain below 12 neonatal deaths per 1,000 live births by 2030, a threshold many high-income countries have achieved while majority of LMICs are still far from [5]. Burundi has politically committed to this global agenda hoping that its existing policies that fully subsidise healthcare services for pregnant women and children until the age of five could support progress towards achieving this target by 2030 [6]. This financial scheme coexists with the performance-based incentives aimed at bolstering quality care by financially rewarding facilities reporting lower mortality rates [7]. Despite this resolve, NMR remains higher than expected and the trend indicates that progress towards the 2030 goal is very unlikely. In fact, at the current annual reduction rate of 2.7% [8], Burundi risks falling short of the Sustainable Development Goals 3.2 target by 2030. In light of the above circumstances and with an aim to assist Burundian health policymakers and medical practitioners, we conducted an empirical analysis of the leading factors of neonatal mortality using a relatively considerable sample of newborns in a robust study design.

Methods

Study design, setting and population

We conducted a cohort study systematically enrolling all newborns that occurred at Kamenge Teaching Hospital (KTH), an academic teaching of the University of Burundi. KTH is a referral hospital with a 0.85% of the total national births and 621 sick newborns admitted into the neonatal intensive care unit in 2019 [9]. Recruitment was done over a period of three months from the 1 st of October until the 31 st of December in 2020. KTH is located in the north-east of Bujumbura Municipality, a province which has the highest proportion of facility-based deliveries assisted by trained healthcare providers [10]. Enrolled newborns were followed until January 2021, cumulating an approximately 23,003 days of newborn follow-up. We did not include newborns who were born outside the study setting and transferred in. Over the study period, a total 892 mothers gave birth within the study setting. Of these, 868 consented to participate yielding a total 885 newborns. We show using Fig. 1 the newborn survival flow diagram demonstrating the loss-to-follow up rate as well as the survival and mortality rates.

Data collection

We collected data using a structured questionnaire (Appendix 1) adopted from the World Health Organization (WHO) neonatal verbal autopsy standards [11]. It was initially developed in French and translated into Kirundi, the local language. Two nurses and three midwives working in the maternity ward of KTH were recruited and trained to collect data by interviewing each mother within the first 12 h after childbirth. In addition, they documented clinical data for both the mother and the newborn using the obstetrical record "Partogram", a graphical tool used to assess the progress of labour, maternal and foetal health [12]. We followed newborns through two approaches. For those admitted into the neonatal intensive care unit, we reviewed admission/discharge records starting from the first day of life and then every seven days. In the event of a death, the date and cause were documented by physicians and recorded accordingly. For newborns who were not hospitalized or discharged within their first 28 days, we conducted follow-up checks via weekly phone calls with the mother or head of household to inquire whether the baby was still alive.

Definition and management of variables

This study used set of independent variables pertinent to the topic and were informed by the literature. They include socio-demographic, pregnancy, delivery and neonatal characteristics (see details in Appendix 1). Categorisation of variables followed logical and scientific

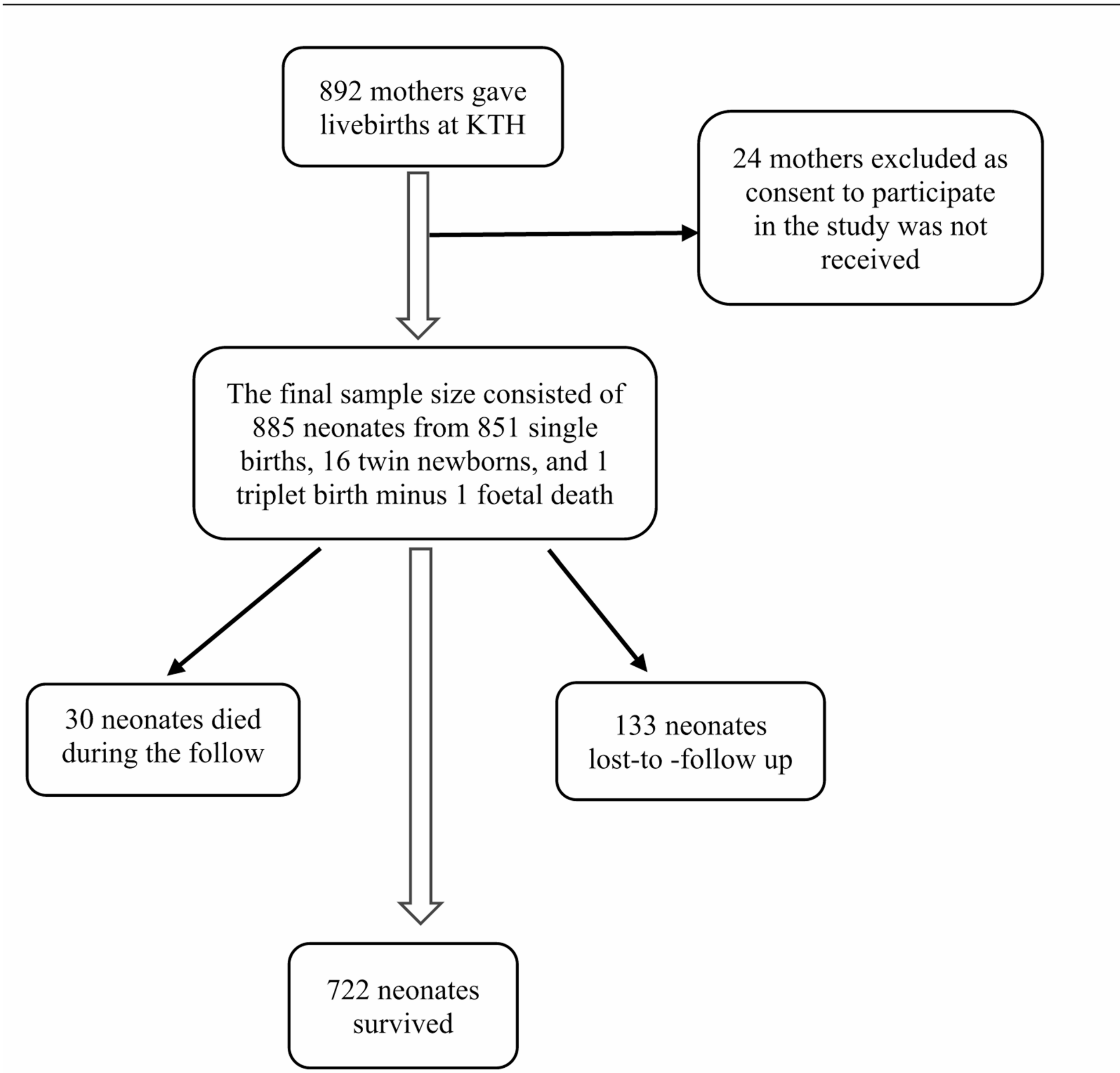

Fig. 1 Flow diagram of followed neonates at KamengeTeaching Hospital, October-December 2020, ($N = 885$)

evidence as demonstrated in Appendix 2. Our outcome was neonatal mortality and dichotomised taking the value 1 if the newborn died and 0 otherwise.

Data analysis

First, we estimated the cumulative time each newborn contributed to the study by counting the total number of days each study participant survived before the event of interest; death, loss to follow-up, or survival until the 28th day, whichever came first. Data were imported, cleaned, recorded, and analysed using Stata version 18.5. Next, we performed descriptive statistics such as frequency tables alongside percentages. To capture loss-to-follow newborns, we calculated the adjusted NMR using Eq. 1 [13].

$$NMR = \frac{D}{N - 0.5L} \quad (1)$$

Where D represents the number of deaths, N is the number of newborns, and L are loss-to-follow up.

Further, we implemented the Life Table approach to estimate cumulative neonatal survival probabilities and applied the Log-rank to test statistical survival distributions between different levels of variables and those with a p-value < 0.15 were included in the Cox-proportional

Table 1 Descriptive characteristics of newborns at KamengeTeaching Hospital, October-December 2020, (*N* = 885)

Variables	Frequency	Percentage (%)
Maternal age (years)		
20–35	696	78.64
<20/>35	189	21.36
Mother's employment		
Employed	520	58.76
Non employed	365	41.24
Residence of the mother		
Urban	653	73.79
Rural	232	26.21
Education of the mother		
Secondary/university	501	56.61
None/primary	384	43.39
Gravidity		
1	234	26.44
2–3	337	38.08
>3	314	35.48
Parity		
1	265	29.94
2–3	348	39.32
>3	272	30.73
Born from a complicated pregnancy		
Yes	99	11.19
No	786	88.81
Ultrasound performed		
≥3 times	400	45.20
<3 times	485	54.80
ANC visits		
≥4	479	54.12
<4	406	45.88
Term birth		
≥37WG	756	85.42
<37WG	129	14.58
Sex of the newborn		
Male	470	53.11
Female	415	46.89
Birth weight		
≥2500 g	754	85.20
<2500 g	131	14.80
Apgar score at five min		
0–5	25	2.82
6–10	860	97.18
Delivery mode		
Vaginal	416	47.01
Caesarean	469	52.99
Pregnancy type		
Singleton	846	95.59
Multiple	39	4.41

ANC Antenatal care, *WG* Weeks of gestation

Table 2 Life table of neonates at Kamenge teaching Hospital, October-December 2020, (*N* = 885)

Time interval	Total	Deaths	LFU	CSP (%)	95%CI
0-1st day	885	12	0	98.64	[0.97–0.99]
2-7th day	873	15	23	96.95	[0.95–0.97]
8-14th day	835	2	17	96.72	[0.95–0.97]
15-21st day	816	0	46	96.72	[0.95–0.97]
22-28th day	770	1	47	96.59	[0.95–0.97]
28th day	722	0	722	96.59	[0.95–0.97]

CSP Cumulative Survival Probability, *LFU* Lost to follow up

hazard regression model. This involved successive stepwise backward elimination ensuring to maintain the model that has the lowest Bayesian information criterion in predicting the factors associated with neonatal mortality. Multiple statistical approached were used to test the model fitness. They include Wald test, Kaplan–Meier and "log log" plots, and Schoenfeld residuals test.

Results

Characteristics of newborns

We see in Table 1 that the majority of newborns (95.5%) were singletons and nearly 97% of these had an Apgar score at five minutes greater than or equal to 6. Preterm, low birth weight and complicated childbirths were highly prevalent, representing each 15%. Also, nearly 78% of neonates were born of younger mothers, aged between 20 and 35 years while another 73% of mothers resided in urban settings. Regarding pregnancy monitoring, nearly 45% and 54% of neonates were born from pregnancies monitored by at least 3 ultrasounds and more than 3 ANC, respectively. C-sections were performed in nearly half of the deliveries. More about the descriptive statistics are presented in Table 1.

Cumulative survival probability

In Table 2 we present the cumulative survival probability alongside the loss-to-follow ups. Overall, our observation amounted to 23,003 neonate-days with an overall NMR of 36.65 per 1,000 live births. Both Table 2 and Fig. 2 demonstrate that newborn mortality was higher during the first week of life, with fewer deaths past that period. With 27 neonates dying during the first week of life as illustrated in Table 2, our study suggests early neonatal mortality represents about 90% of the total newborn deaths that occurred during the study period. We found that the leading causes of mortality were complications related to prematurity (60%), asphyxia (13.33%), infections (13.33%), and abnormal congenital (13.33%).

Results of bivariate and multivariate analysis

The results of the Log-rank test and the Cox-proportional hazard regression model are presented in Table 3. We found that prematurity, fewer number of ANC visits,

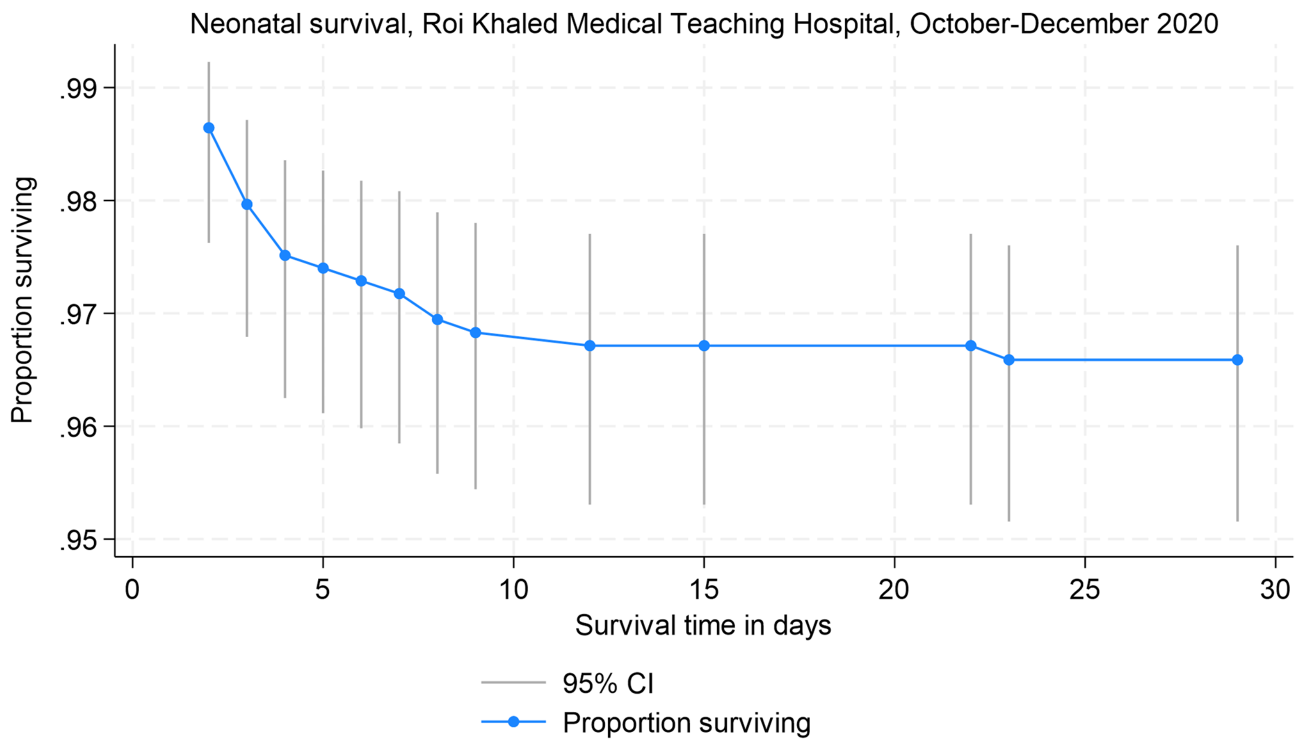

Fig. 2 Lifetable graph of neonates at Kamenge Teaching Hospital, October-December 2020 (*N* = 885)

and lower Apgar score at five minutes have an association with neonatal mortality. The highest risk of death was observed among preterm babies. Indeed, the hazard of mortality among preterm neonates was 15 times higher compared to those born at term (AHR: 14.60, 95%CI 5.83–36.54). This hazard decreased with the higher number of ANC attendance while fewer than 4 ANC corresponded to 7 times high risk of neonatal death (AHR: 6.67, 95%CI 1.54–29.25). Furthermore, neonates who had an Apgar score of 5 and below at five minutes were 4 times more likely to die (AHR: 4.37, 95%CI 1.66–11.44).

Discussion

The NMR at KTH was 36.65 per 1,000 live births. This rate is high compared to that found by studies conducted in some developing countries [14–16]. This divergence could be explained in terms of study methods; most studies were retrospective or cross-sectional which should have underestimated the mortality rate. Also, this study was conducted in the unique public teaching hospital, which is sometimes clouded, and this should have played a role. A study in emergency obstetric and neonatal care units of three rural district hospitals in Bujumbura found that 50 neonates died out of 1,000 livebirths in 2011 [17]. This was explained by the fact that the units received only patients referred for complicated pregnancies and/or deliveries, which were likely to contribute. Also, the study used in-patient data only. In this study, complications related to prematurity were the leading causes of neonatal mortality, representing 60% of all causes. Therefore, the high neonatal mortality rate could be explained by the low ANC attendance which constitutes a platform for screening, diagnosis, and prevention of diseases including prematurity. On the other hand, in this low-income setting, inadequate capacity to manage preterm births can be a reason.

Regarding neonatal survival time, this study revealed that 40% of neonatal deaths occurred with 24 h of life and 90% during the first week. This distribution is consistent with findings from the literature review [16, 18–20] and a study carried out in Burundi [21]. A prospective cohort study in Tigray region, northern Ethiopia, reported that most neonates died within their first week of life due to complications occurring during pregnancy and childbirth. Poor quality of prenatal care, delayed complications' identification, and management of complicated pregnancy and childbirth should have been reasons according to the same study [19]. The high early neonatal mortality in this study could be explained by the precocity of complications related to prematurity, and on the other hand, by poor ANC attendance among pregnant women. The first week of life is a critical period for neonatal survival.

The leading causes of neonatal mortality were complications related to prematurity, asphyxia, infections, and congenital malformations. These results are consistent with WHO reports on neonatal mortality causes as well as findings from other studies [18, 22–24]. We noted

Table 3 Log-rank test and Cox-proportional hazard regression model of factors associated with neonatal mortality at Kamenge teaching Hospital, October-December 2020

	Log-rank test		Cox proportional hazard model		
Variables	**X^2**	***P*-value**	**AHR**	**95%CI**	***P*-value**
Maternal age	0.04	0.846			
20–35					
<20/>35					
Mother's employment	1.88	0.1707			
Employed					
Non employed					
Residence	0.24	0.622			
Urban					
Rural					
Education	5.03	0.024			
≥Secondary					
≤Primary					
Gravidity	4.66	0.097			
<2					
2–3					
>3					
Parity	3.35	0.187			
<2					
2–3					
>3					
Born from a complicated pregnancy	49.55	< 0.001			
Yes					
No					
Ultrasound performed	6.00	0.014			
≥3 times					
<3 times					
ANC visits	28.16	< 0.001			
≥4			1		
<4			6.67	[1.54–29.25]	0.011
Term birth	112.40	< 0.001			
≥37WG			1		
<37WG			14.60	[5.83–36.54]	< 0.001
Sex	0.60	0.439			
Male					
Female					
Birth weight	78.17	< 0.001			
≥2500 g					
<2500 g					
Apgar score at 5 min	23.36	< 0.001			
0–5			4.37	[1.66–11.44]	0.003
6–10			1		
Delivery mode	3.62	0.057			
Vaginal					
Caesarean					
Pregnancy type	2.30	0.129			
Singleton					
Multiple					

ANC Antenatal care, *WG* Weeks of gestation a high neonatal mortality related to complications of prematurity (60%) compared to other findings [25, 26]. However, we found a low proportion of neonatal deaths related to asphyxia and infections compared to WHO estimations and other studies [15, 24, 27–30]. This may reflect the contribution of free healthcare policy for pregnant women and children under five to improve their health. Further, preventive antibiotherapy for neonates with a high risk of infections may have been protective. Nevertheless, the diagnosis of neonatal infections at KTH was made by indirect tests. Without diagnosis by blood culture, they may have been false diagnostics. For neonatal mortality related to congenital malformations, similar trends have been observed in most of studies [22–24, 31]. There is a need to improve antenatal diagnosis as most neonatal deaths related to malformations are not preventable.

The study found a correlation between prematurity and neonatal mortality. In comparison to term births, the hazard of neonatal mortality was 15 times among preterm births. Our results are in line with those recorded in other studies [14, 15, 19, 24]. In this study context, this should be linked to capacity challenges to manage prematurity. Preterm neonates are unable to adapt to extra-uterus life, prenatal care improvement seems crucial to prevent preterm birth and its subsequent consequences. This study also found that neonatal mortality is linked to the number of ANC attendance. The hazard of neonatal mortality was 7 times higher for babies born from pregnancies monitored by less than 4 ANC compared to those born from well monitored pregnancies by at least by 4 ANC. These results are similar to those found by McCurdy et al. (2011) in sub-Saharan Africa and a study in Ethiopia [32]. The reason could be that ANC is an opportunity to quickly detect risk pregnancies and have the necessary information to carry out effective interventions. In fact, ANC visits were found to be the most effective intervention to reduce neonatal mortality in SSA [32]. An Apgar score below 6 at 5 min associated with a hazard of neonatal mortality 4 times compared to neonates with an Apgar score above 5. This relationship corroborates other studies [33–35] which have found that a low Apgar score at five minutes strongly associated with a high risk of neonatal mortality. For instance, regardless of term birth, Apgar score less than 6 associated with an increased neonatal and infant mortality [35]. The Apgar score is used to assess the newborn's respiratory, tonicity, skin coloration, and cardiovascular functioning conditions at birth, five, and ten minutes. Neonates with low Apgar score are fragile and this should be exacerbated by inadequate capacity to take care of vulnerable babies.

Strengths and limitations

This study provides insights into some determinants of neonatal health to take related actions. Establishing neonatal survival and identifying neonatal mortality causes allow clinicians to have information on when to act more to benefit maternal and newborn health. However, 15% lost-to-follow up could have impacted on the estimates of neonatal mortality rate. This study did not explore the capacity and performance of KTH, which should contribute to further understand neonatal health. Another limitation concerns the study population, restricted to newborns at KTH, which limits the generalizability of the findings to the whole country. We recommend further research to explore neonatal health at the country's level.

Policy implications

In the context of Burundi where maternal and under five health services are free of charge, policy-strategies could improve ANC attendance. On the other side, clinicians should actively prioritize the first 24 h to take care of newborns at higher risk of death.

Conclusion

In conclusion, the neonatal mortality is high at KTH, predominantly due to preventable and curable complications. The leading causes of neonatal mortality were complications of prematurity, asphyxia, infections, and congenital malformations. Overall, a high proportion (90%) of neonates died in their first week of life, with 40% within the first 24 h. Moreover, prematurity, few ANC, and low five-minute Apgar score were significantly associated with neonatal mortality.

Abbreviations

ANC	Antenatal care
KTH	Kamenge Teaching Hospital
LMICs	Low-and middle-income countries
NMR	Neonatal mortality rate
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-25468-0.

Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

All authors contributed toward drafting and critically revising the paper and agreed to be accountable for all the aspects of the work. Specifically, JCN conceptualized and designed the study under the supervision of DH. AI, MM, RN, and JCN followed up newborns. JCND, AI, and JDN analysed data, and wrote the first draft. AA, WM, and DH proofread the manuscript for improvement. All authors read and approved the final version of this manuscript for submission.

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Data availability
The datasets generated during the current study are available from the corresponding author.

Declarations

Ethics approval and consent to participate
An ethical approval from the "Comité Institutionnelle d'Ethique et Bioéthique de la Faculté de Médecine, CHUK" CIEB-FMCHUK was given for this study. The declaration of Helsinki carried out all methods.
Trained data collectors obtained written informed consent from participating mothers before interview.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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