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Research Article

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Assessment of Maternal Mortality Rate and Associated Risk Factors at Tertiary Hospitals in Burundi (2020-2021): A retrospective Cohort Study

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Abstract

Background: *Burundi continues to struggle with maternal mortality (MM). Early risk factor identification is crucial for thorough intervention measures to be developed to prevent pregnancy-related problems.*

Objective: *To investigate maternal mortality rate (MMR) and identify its associated risk factors among women aged 15 to 49 years at four tertiary hospitals in Burundi.*

Methods: *We collected data describing all pregnancies from January 2020 to December 2021 among women enrolled in Centre Hospital-University of Kamenge (CHUK), Military Hospital of Kamenge (MHK), Prince Regent Charles Hospital (PRCH), and Clinical Hospital Prince Louis Rwagasore (CHPLR) referral hospitals. We reported the proportion of mothers who died per pregnancy and the MMR. Multivariate regression models were used to determine the maternal, pregnancy-related, delivery, and postpartum factors that were associated with maternal death.*

Results: *There were 31,968 deliveries in total in CHUK, MHK, PRCH, and CHPLR referral hospitals, 125 of which resulted in maternal fatalities. The total live births were 31,067, yielding an MMR of 402/100,000 live births. Our findings suggest significant associations between MMR and direct and indirect causes of maternal death, (F (8, 116) = 2.18, $p < .05$); haemorrhage and uterine rupture, where p was less than 0.05; community-level characteristics, (F (7, 117) = 9.91, $p < .05$); and type of delay, (F (3, 121) = 2.76, $p < .05$). Whereas, second delay was significantly associated with MMR, with $p = 0.005$.*

Conclusion: *Reducing maternal fatalities in CHUK, MHK, PRCH, and CHPLR requires the implementation of ANC programs on the management of obstetric problems.*

Keywords: Maternal Mortality Rate; Burundi; Tertiary Hospitals; Risk Factors; Pregnancy-Related Deaths.

1. Introduction

According to the World Health Organization (WHO), maternal mortality (MM) is defined as the death of a woman while she is pregnant or within 42 days of her pregnancy ending, regardless of the length or location of the pregnancy, from any cause connected to or aggravated by the pregnancy or its management, but not from accidental or incidental causes [1, 2, 3]. According to the WHO, each year, 585,000 women die worldwide from complications related to pregnancy, childbirth, or postpartum [4]. In Sub-Saharan Africa, in particular, 99% of maternal deaths occur. Of the estimated 2.6 million stillbirths that occurred globally in 2015, 98% occurred in low- and middle-income countries (LMICs) [5]. In addition, women in LMIC have an approximately 33-fold higher lifetime risk of dying from maternal-related causes than women in high-income countries [6]. Specifically, this risk remains high in resource-limited settings such as Burundi [7]. It is estimated that approximately 2 in 100 Burundian women will die from pregnancy-related disorders, including haemorrhage, infection, eclampsia, and unsafe abortion during childbirth [8]. The strong interest of the international community in maternal health has given rise to numerous studies, on the one hand, to measure the frequency of maternal deaths, to evaluate the respective share of the different causes, and on the other hand, to evaluate the actions implemented in different contexts to face. Hence, assessing maternal mortality rate (MMR) and associated risk factors at tertiary hospitals in Burundi (2020-2021) is of great significance for early prevention and effectively reducing the prevalence and MM risk.

A lack of quality care is demonstrated by maternal deaths. This is why fewer fatalities from these causes have been a global and national priority for all nations. The fifth Millennium Development Goal (MDG) purpose was to enhance maternal health, and the first goal was to reduce maternal fatalities by 75 percent between 1995 and 2015. Due to the global maternal mortality ratio's only 44% decline from 384 to 216 for every 100,000 live births, this goal was generally not met. Half of these deaths take place in sub-Saharan Africa, and 99% of them take place in low-income nations [9,10]. Compared to high-income countries (HICs), these nations have a 1 in 180 probability of women dying from problems related to pregnancy [10]. Pending further investigations.

Maternal mortality rates in Burundi continue to be high trends. 285 fatalities per 100,000 live births were Burundi's 2015 MDG 5 target. In 2011, an area of Burundi recorded a maternal mortality rate of 208 (range 8-360) deaths/100 000 live births [11]. According to the Burundi Maternal and Perinatal Death Surveillance and Response guidelines, the area of Bujumbura in Burundi has been putting various tactics into practice to prevent maternal deaths. These strategies include alerting the authorities of these deaths within 48 hours and having a discussion about them within seven days. Plans for action are developed during these sessions to close any gaps that are found. Therefore, it is important to explore the MMR of Burundi between 2020 and 2021.

Pregnant women must be saved as soon as difficulties occur by using prompt and suitable measures. CHUK, MHK, PRCH, and CHPLR occasionally accept women who are suffering from advanced obstetric difficulties as a result of delays from either home or referring medical facilities where the care was subpar. This is because CHUK, MHK, PRCH, and CHPLR serve as referral centers for the entire region. According to Deborah Maine and Sereen Thaddeus these delays can be divided into three categories [12]. When a family decides to seek care later than necessary, there is a first delay. This might be because the woman is unable to determine where she wants to give birth, doesn't recognize the danger indicators, doesn't have the money to get herself to a hospital, or is unaware of them. On the route to the medical institution is where the second delay occurs. The absence of transportation to a medical center or poor roads may be to blame for this. When a woman cannot receive immediate and proper care at a medical facility due to staffing shortages, staffing shortages caused by insufficient skills, or a shortage of tools, medications, or medical supplies, this is known as the third delay [13]. Third delays might also include a delayed referral from one medical establishment to another. The leading causes of MM are these delays, especially in African countries [14,15]. Thus, it is essential to investigate the associated risk factors for MM at tertiary hospitals in Burundi.

According to national guidelines, maternal deaths that occur in CHUK, MHK, PRCH, and CHPLR are discussed to determine the reasons and delays. As stated in the recommendations on maternal and perinatal death surveillance and response, sadly not all members attended these meetings. This made it challenging to carry out the action plans. Furthermore, there had never been a yearly analysis of the factors contributing to these fatalities. Despite the low numbers of maternal deaths that occurred in the years 2020 to 2021, we chose to conduct this retrospective cohort study on the assessment of maternal mortality rate, associated risk factors at tertiary hospitals in Burundi (2020-2021), and suggest interventions that can aid the hospitals in reducing these deaths.

2. Methods

2.1 Study Design

This is a retrospective cohort study of all maternal deaths that occurred in Centre Hospital-University of Kamenge (CHUK), Military Hospital of Kamenge (MHK), Prince Regent Charles Hospital (PRCH), and Clinical Hospital Prince Louis Rwagasore (CHPLR) referral hospitals in Burundi between January 2020 and December 2021.

2.2 Study Setting

Burundi's CHUK, MHK, PRCH, and CHPLR serve as referral centers for all Burundian councils and are the city's oldest public hospitals. Additionally, they provide care for patients from nearby communities in nearby regions (Bujumbura, Bubanza, Cibitoke, and Rumonge). Burundi has a population of 12.55 million people, stretches over 27,000 km2, and is characterized by a tropical climate.

2.3 Data Collection

Data were collected from women who resided within study clusters, including Bujumbura, Bubanza, Cibitoke, and Rumonge, through abstraction of medical records. We collected information from the CHUK, MHK, PRCH, and CHPLR referral hospitals for all maternal death files between 1 January 2020 and 30 December 2021. The data was gathered and the case files were examined using a checklist to gather data. Maternal characteristics, including sociodemographic characteristics (age, education level, religion, marital status); community-level characteristics (residence, income quartile, occupation, easy access to health facilities), clinical and therapeutic characteristics (parity, ANC visits), and antenatal, delivery, and postpartum characteristic (direct and indirect obstetric causes, type of delay) were among the data gathered.

In this study, the dependent variable was maternal mortality rate and the independent variable was the associated risk factors for maternal mortality.

In this study, we included all pregnant women who were admitted or referred to CHUK, MHK, PRCH, and CHPLR between 1 January 2020 and 30 December 2021. Although the goal was to identify women as early as possible in pregnancy, women could be enrolled at any point during pregnancy or after delivery. Antenatal and delivery characteristics were recorded within 3-7 days after delivery. Postpartum characteristics were collected at a clinic or home visit at 6 weeks after delivery. This information was collected regardless of maternal or infant status at 6 weeks after delivery. We excluded women who were lost to follow-up prior to delivery and those who did not have records indicating maternal status at the 6-week follow-up visit. Pregnancy outcomes, including stillbirths and neonatal characteristics, were not included in this paper. We defined maternal death as the death of a woman while pregnant or within 42 days of the end of pregnancy, in accordance with the WHO.

2.4 Data Analysis

The collected data were entered into a computer application called Excel, and the entered data were then analyzed. Data imputation was used to impute missing values with reasonable estimates. We excluded factors with significant missing fields. For maternal, antenatal, delivery, and postpartum characteristics, we reported the percentage of births resulting in maternal death, using all recorded maternal deaths as the denominator irrespective of the delivery outcome (miscarriage, stillbirth, live birth, etc.). We also used the standard maternal mortality rate (MMR=maternal deaths/100,000 live births) to record maternal deaths by site over time. The 95% confidence interval for the maternal mortality rate was calculated using the proportion of maternal deaths for each site and year.

Multivariate regression models were used to determine the maternal, pregnancy-related, delivery, and postpartum factors that were associated with maternal death. We included all medical and social variables that could be associated with maternal mortality and were reliably collected in CHUK, MHK, PRCH, and CHPLR. We included variables that were present at enrollment or around the time of delivery and excluded factors with significant missing fields. For the purposes of the multivariate regression model, we defined the variable haemorrhage as an antepartum or postpartum haemorrhage, and the variable hypertension as an antepartum hypertension or postpartum seizure or convulsion. The model was further adjusted for clinical site. All the statistical analyses in our study were performed using SPSS software (version 22.0, SPSS Inc, Chicago, USA).

3. Results

Table 1 reveals that 31,968 women gave birth at CHUK, MHK, PRCH, and CHPLR referral hospitals between January 2020 and December 2021. The number of live births was 31,067 and 125 of those births resulted in maternal fatalities that were officially documented. This makes MMR for 2020-2021 to be 402/100,000 live births. 1,501 of the mothers were referred to CHUK, MHK, PRCH, and CHPLR after childbirth.

Characteristic	Number
Number of women who delivered at CHUK, MHK, PRCH, and CHPLR	31,968
Number of maternal deaths	125
Number of women who were referred after childbirth	1,501
Live births	31,067

Table 1: General information

Of 31,968 women who delivered at CHUK, MHK, PRCH, and CHPLR, there were 31,067 live births, and 125 maternal deaths between January 2020 and December 2021. This makes MMR for 2020-2021 to be 402 per 100,000 live births.

Table 2 shows distributions of individual characteristics for all the women under study. 31,968 women in Burundi delivered a baby between January 2020 and December 2021 at CHUK, MHK, PRCH, and CHPLR. Most of the women aged <33 (79.41%) years reported being pregnant, compared to women aged ≥33 (20.59%) years. Majority (52.0%) of the women had secondary education level, compared to the illiterates (1.6%). Most (59.5%) of the women were Catholics, compared to Muslims (2.6%). A large number (95.0%) of the women were married, compared to the singles (0.7%). Majority (69.3%) of the women resided in urban regions, compared to those that resided in rural areas (30.7%). Most (56.0%) women were in the middle-income quartile, compared to those in the high quartile (5.6%). Majority (55.7%) of the women were farmers, compared to traders (9.3%). A bigger portion (66.3%) of the women had easy access to health facilities, compared to those that did not (33.7%). Most (55.3%) women had attended at least 4 ANC visits, compared to those that had at least 1 visit (13.1%).

	N (%)
Total	31,968 (100.0)
Age (years)	
<33	25,386 (79.41)
≥33	6,582 (20.59)
Education level	
Illiterate	528 (1.6)
Primary	9,587 (30.0)
Secondary	16,619 (52.0)
Tertiary	5,234 (16.4)
Religion	
Catholic	19,028 (59.5)
Protestant	12,104 (37.9)
Muslim	836 (2.6)
Marital status	
Single	236 (0.7)
Married	30,374 (95.0)
Divorced	1,358 (4.3)
Residence	
Urban	22,141 (69.3)
Rural	9,827 (30.7)
Income quartile	
Low	12,387 (38.7)
Middle	17,908 (56.0)
High	1,682 (5.3)
Occupation	
Trader	2,976 (9.3)
Farmer	17,803 (55.7)
Official	6,432 (20.1)
Unemployed	4,757 (14.9)
Easy access to health facility	
Yes	21,207 (66.3)
No	10,761 (33.7)
ANC visits	
None	10,106 (31.6)
At least 1 visit	4,197 (13.1)
At least 4 visits	17,665 (55.3)

Table 2: Covariate demographic information of pregnant women under study (n = 31,968)

Table 3 shows the association of maternal deaths with sociodemographic factors of deceased women under study. 125 women were reported to have succumbed to maternal death. 65 (52.0%) of the deceased women were aged ≥33 years, whereas 60 (48.0%) were aged <33 years. 65 (52.0%) of the deceased women had primary education, 34 (27.2%) had secondary education, 24 (19.2%) were illiterate, and 2 (1.6%) had tertiary education. 75 (60.0%) of the deceased women were Catholics, 44 (35.2%) were Protestants, and 6 (4.8%) were Muslims. 109 (87.2%) of the deceased women were married, 9 (7.2%) were divorced, and 7 (5.6%) were single.

	N (%)
Total	125 (100.0)
Age (years)	
<33	60 (48.0)
≥33	65 (52.0)
Education level	
Illiterate	24 (19.2)
Primary	65 (52.0)
Secondary	34 (27.2)
Tertiary	2 (1.6)
Religion	
Catholic	75 (60.0)
Protestant	44 (35.2)
Muslim	6 (4.8)
Marital status	
Single	7 (5.6)
Married	109 (87.2)
Divorced	9 (7.2)

Table 3: Association of maternal deaths with sociodemographic factors of deceased women under study (n = 125)

Table 4 shows the multivariate regression model for the assessment of maternal mortality rate and sociodemographic factors. The regression analysis shows that there was no statistically significant association between maternal mortality rate and sociodemographic factors, (F (8, 116) = 0.66, $p > .05$).

	B	Std. Error	Sig.
(Constant)	402.0	0.023	0.000
Age	-0.003	0.01	0.68
Illiterate	0.014	0.03	0.58
Primary	0.000	0.024	0.98
Secondary	-0.01	0.024	0.997
Catholic	0.002	0.02	0.88
Protestant	-0.003	0.012	0.86
Single	-0.01	0.02	0.62
Married	0.001	0.012	0.95

*Sig = significant

ANOVA	df	F	Sig.
Regression	8	0.66	0.73
Residual	116		
Total	124		

*Sig = significant

Table 4: Multivariate regression models for the assessment of maternal mortality rate and sociodemographic factors

Table 5 shows the association of maternal deaths with community-level characteristics of deceased women under study. 82 (65.6%) of the deceased women resided in urban regions, whereas 43 (34.4%) resided in rural areas. 101 (80.8%) of the deceased women had low-income quartile, 22 (17.6%) had middle-income quartile, and 2 (1.6%) had high-income quartile. 67 (53.6%) of the deceased women were farmers, 33 (26.4%) were unemployed, 17 (13.6%) were traders, and 8 (6.4%) had official occupations. 83 (66.4%) of the deceased women had easy access to health facility, whereas 42 (33.6%) did not.

	N (%)
Total	125(100.0)
Residence	
Urban	82 (65.6)
Rural	43 (34.4)
Income quartile	
Low	101 (80.8)
Middle	22 (17.6)
High	2 (1.6)
Occupation	
Trader	17 (13.6)
Farmer	67 (53.6)
Official	8 (6.4)
Unemplyed	33 (26.4)
Easy access to health facility	
Yes	83 (66.4)
No	42 (33.6)

Table 5: Association of maternal deaths with community-level characteristics of deceased women under study (n = 125)

Table 6 shows the multivariate regression model for the assessment of maternal mortality rate and community-level characteristics. The regression analysis shows that there was a statistically significant association between maternal mortality rate and community-level characteristics, ($F(7, 117) = 9.91$, $p < .05$).

	B	Std. Error	Sig
(Constant)	402.0	0.02	0.000
Residence	-0.11	0.02	0.000
Easy access to health facility	0.12	0.015	0.000
Low	0.01	0.019	0.46
Middle	0.003	0.019	0.87
Trader	0.000	0.01	0.97
Farmer	0.000	0.010	0.98
Unemployed	0.009	0.010	0.41

*Sig = significant

ANOVA	df	F	Sig.
Regression	7	9.91	0.000
Residual	117		
Total	124		

*Sig = significant

Table 6: Multivariate regression models for the assessment of maternal mortality rate and community-level characteristics

Table 7 shows the association of maternal deaths with clinical and therapeutic characteristics of deceased women under study. 102 (81.6%) of the deceased women had a parity of 1 child, whereas 23 (18.4%) had a parity of ≥2 children. Majority 77 (61.6%) of the deceased women attended at least 1 ANC visit, whereas 48 (38.4%) of them did not. 16 (12.8%) of the deceased women attended all 4 ANC visits, whereas 109 (87.2%) did not.

	N (%)
Total	125 (100.0)
Parity	
1	102 (81.6)
≥2	23 (18.4)
Attended at least 1 ANC visit	
Yes	77 (61.6)
No	48 (38.4)
Attended all 4 ANC visits	
Yes	16 (12.8)
No	109 (87.2)

Table 7: Association of maternal deaths with clinical and therapeutic characteristics of deceased women under study (n = 125)

Table 8 shows the multivariate regression model for the assessment of maternal mortality rate and clinical and therapeutic characteristics. The regression analysis shows that there was no statistically significant association between maternal mortality rate and clinical and therapeutic characteristics, ($F (3, 121) = 0.33$, $p > .05$).

	B	**Std. Error**	**Sig**
(Constant)	402.0	0.02	0.000
Parity	0.003	0.01	0.69
Attended at least 1 ANC visit	0-.005	0.006	0.43
Attended all 4 ANC visits	-0.004	0.008	0.65

*Sig = significant

ANOVA	**df**	**F**	**Sig.**
Regression	3	0.33	0.81
Residual	121		
Total	124		

*Sig = significant

Table 8: Multivariate regression models for the assessment of maternal mortality rate and clinical and therapeutic characteristics

Table 9 shows the direct and indirect obstetric causes of death of deceased women under study. Uterine rupture (14), haemorrhage (12), severe bleeding (12), pre-eclampsia/eclampsia (9), and infection (8) were the direct obstetric causes of MM. Hypertension (58), anaemia (7), and malaria (5) were the indirect obstetric causes of MM.

	N (%)
Total	125 (100.0)
Direct obstetric causes	
Haemorrhage	12 (9.6)
Infection	8 (6.4)
Uterine rupture	14 (11.2)
Pre-eclampsia/eclampsia	9 (7.2)

Severe bleeding	12 (9.6)
Indirect obstetric causes	
Anaemia	7 (5.6)
Malaria	5 (4.0)
Hypertension	58 (46.4)

Table 9: Direct and indirect obstetric causes of death of deceased women under study (n = 125)

Table 10 shows the multivariate regression model for the assessment of maternal mortality rate and direct and indirect causes of maternal death. The regression analysis shows that there was a statistically significant association between maternal mortality rate and direct and indirect causes of death, (F (8, 116) = 2.18, $p < .05$). In addition, there was a statistically significant association between maternal mortality rate and haemorrhage and uterine rupture, where in both cases p is less than 0.05.

	B	**Std. Error**	**Sig**
(Constant)	402.0	0.004	0.000
Haemorrhage	0.024	0.010	0.017
Infection	-0.002	0.011	0.856
Uterine rupture	0.024	0.009	0.010
Pre-eclampsia/eclampsia	-0.002	0.011	0.829
Severe bleeding	-0.005	0.009	0.597
Anaemia	-0.008	0.012	0.513
Malaria	-0.002	0.014	0.873
Hypertension	0.003	0.006	0.600

*Sig = significant

ANOVA	**df**	**F**	**Sig.**
Regression	8	2.177	0.034
Residual	116		
Total	124		

*Sig = significant

Table 10: Multivariate regression model for the assessment of maternal mortality rate and direct and indirect causes of maternal death

Table 11 shows type of delay characteristics of deceased women under study. The third delay (delayed referral from other facilities, delay in receiving appropriate treatment at referral hospitals, and delay in receiving adequate care at a referring facility as well as at the referral hospitals) resulted in 106 maternal deaths. The second delay (delayed identification and arrival at the referral hospitals for treatment) resulted in 14 maternal deaths, whereas the first delay (delayed decision to seek appropriate medical attention for an obstetric emergency) resulted in 5 maternal deaths.

	N (%)
Total	125 (100.0)
Type of Delay	
Delay I	5 (4.0)
Delay II	14 (11.2)
Delay III	106 (84.8)

Table 11: Type of delay characteristics of deceased women under study (n = 125)

Table 12 shows the multivariate regression model for the assessment of maternal mortality rate and type of delay characteristics. The regression analysis shows that there was a statistically significant association between maternal mortality rate and type of delay, (F (3, 121) = 2.76, p < .05). From the model, second delay shows that it was statistically significantly associated with maternal mortality rate, with p = 0.005.

	B	Std. Error	Sig
(Constant)	402.00	0.007	0.000
Delay I	0.0011	0.014	1.000
Delay II	0.025	0.009	0.005
Delay III	-0.00019	0.008	1.000

*Sig = significant

ANOVA	df	F	Sig.
Regression	3	2.755	0.045
Residual	121		
Total	124		

*Sig = significant

Table 12: Multivariate regression model for the assessment of maternal mortality rate and type of delay characteristics

4. Discussion

Our study was a retrospective cohort study to assess maternal mortality rate and associated risk factors at four tertiary hospitals in Burundi, namely, the Centre Hospital-University of Kamenge (CHUK), Military Hospital of Kamenge (MHK), Prince Regent Charles Hospital (PRCH), and Clinical Hospital Prince Louis Rwagasore (CHPLR), from January 2020 to December 2021. One measure of healthcare quality in a nation and a country is maternal mortality (MM). In Burundi's tertiary hospitals, the maternal mortality rate and related risk factors were evaluated using a variety of techniques. Facility-based analyses go beyond simple statistical analysis to identify the cause of maternal death as well as other contributing factors like delays and care delivery gaps. Hence, it was essential to carry out this retrospective cohort study to assess maternal mortality rate (MMR) and associated risk factors at CHUK, MHK, PRCH, and CHPLR hospitals in Burundi.

This study is the first to examine the risk variables related to MMR in four tertiary hospitals in Burundi (2020-2021). A total of 31,968 women gave birth at the CHUK, MHK, PRCH, and CHPLR referral hospitals between January 2020 and December 2021, 125 of the women passed away due to conditions that were either directly or indirectly related to the pregnancy, childbirth, or their care. The mean age of women with maternal deaths was 33 years. In this study, for the deliveries in 2020-2021, there were 31,067 live births. After the conventional calculation of MMR was extrapolated, this equates to 402 deaths for every 100,000 live births. The poor caliber of obstetric care is reflected in these high rates. Other referral facilities, such as Médecins Sans Frontières, gave contrasting reports of an MMR of 208 (range 8-360) deaths/100,000 live births for the Kabezi district of Burundi in 2011 [16]. According to our research, MMR has been more prevalent in Burundi during the past decade.

Our findings suggest a significant association between MMR and direct and indirect causes of maternal death, (F (8, 116) = 2.18, p < .05). There was a significant association between MMR and haemorrhage and uterine rupture, where in both cases p is less than 0.05. There was a significant association between MMR and community-level characteristics, (F (7, 117) = 9.91, p < .05). Additionally, there was a significant association between MMR and type of delay, (F (3, 121) = 2.76, p < .05). Whereas, second delay (delayed identification and arrival at the referral hospitals for treatment) was significantly associated with MMR, with p = 0.005. Our results suggest significant implications for MM risk management approach, including early detection, effective reduction, and prevention.

Haemorrhage was responsible for 12 deaths. Obstetric haemorrhage deaths continue to occur despite numerous treatments and prevention measures being in place. Obstetric haemorrhage was determined to be the primary global cause of direct maternal deaths in recent studies [17,18]. Since uterine atony is the primary cause of all obstetric haemorrhages, the hospital must make sure that every woman undergoing delivery receives active management of the third stage of labor. In the same way, medical personnel should always be prepared to act quickly and cooperatively in the case of an obstetric haemorrhage. This can be accomplished by teaching basic life-saving techniques including intrauterine balloon tamponade, abdominal aortic compression, and bimanual uterine compression to every healthcare professional working in CHUK, MHK, PRCH, and CHPLR maternity units. A standard operating process and access to safe blood should be in place for monitoring women who have emergency obstetric procedures.

Pre-eclampsia/eclampsia caused 9 maternal deaths. This is consistent with earlier research's results that the majority of fatalities were brought on by severe cases of pre- and eclampsia [19]. Additionally, a shortage of qualified staff and delays in CHUK, MHK, PRCH, and CHPLR have had a severe impact on the obstetric care of patients with pre-eclampsia/eclampsia. This was the case in the vast majority of Burundian ANC clinics. Eclampsia-related fatalities can be avoided along the entire spectrum of obstetric treatment. Blood pressure readings and urine tests for proteinuria at the antenatal clinic can help detect pregnant women who have hypertensive disorders so that the illness can be appropriately managed before it worsens, progresses to eclampsia, and ultimately results in death. However, this is not the situation in the majority of Burundian prenatal facilities. Additionally, inadequate ANC has been identified in recent research to identify pregnancy-related hypertension disorders [20]. To lower the risk of MM in women, strict ANC attendance should be emphasized.

Malaria was the cause of 5 maternal deaths at CHUK, MHK, PRCH, and CHPLR in the years 2020-2021. Regional disparities in MM can be explained by malaria, which is the first non-obstetric cause of the condition [21]. If infection prevention and control guidelines are not followed while providing obstetric care, this disease, which is widespread in sub-Saharan Africa, can develop. Pregnant women who have malaria are more likely to experience anemia, which increases the risk of newborn mortality and contributes to maternal death during delivery from haemorrhage. Malaria also increases the risk of stillbirth, premature birth, and low birth weight. Maternal mortality can be caused by malaria directly or indirectly. Malaria infections claim the lives of 10,000 pregnant women each year. Additionally, anemia, which increases a woman's risk for post-partum haemorrhage, the leading cause of maternal death, is a major result of malaria [22]. These findings highlight the significance of requiring strict adherence to malaria infection prevention and control practices from all medical personnel caring for pregnant and lactating patients.

Anaemia significantly contributed to 7 maternal fatalities in this investigation. These results are consistent with recent research that found anaemia to be the primary factor in between 1 and 46% (mean 10.0%) of maternal fatalities across 23 investigations. In contrast, several reports—the majority of which came from Latin America. However, 52 studies were from Africa and 45 from Asia did not list anemia as a cause of mortality [23]. Due to the potential for fast cardiac decompensation, acute onset anaemia during pregnancy considerably increases the risk of death. While chronic anaemia is thought to be a frequent contributing factor, especially to the effects of haemorrhage and infection, severe acute anaemias are thought to be a primary and quick cause of death, such as in Nigeria when associated with the acute haemolysis of sickle cell disease [24]. By increasing the susceptibility of the mother to infection, iron-deficiency anaemias may contribute to higher morbidity and death [25]. Individual exposure to anaemia and its correlations demands further research.

Third delay was responsible for causing 106 of the maternal deaths that occurred at CHUK, MHK, PRCH and CHPLR. Third delay includes delays in receiving treatment at the referral hospitals, delays in receiving referrals from other healthcare institutions, insufficient provider skill sets at the facility recommending the patient, and insufficient provider skill sets at the referral hospitals. While the lack of transport may have contributed to the delay in referral from another facility, the healthcare professionals may also have been unable to recognize the referral criteria for a lower facility's inability to provide the necessary continuation of care. Due to the high number of newly hired healthcare professionals working in lower-level facilities at the moment, this may be attributed to a lack of experienced staff. Deaths were also impacted by delayed referrals and a healthcare provider's lack of expertise. One of the patients arrived at CHUK late due to an inadequately repaired lower uterine section that was still bleeding. Deaths resulting from insufficient expertise also happened in MHK, PRCH, and CHPLR, where in some cases a novice doctor performing a caesarean section failed to stop bleeding in uterine atony, leading to a subtotal hysterectomy and the woman's unfortunate death. The majority of preventable maternal deaths, according to a study conducted in China, were caused by county institutions with inadequate knowledge and abilities [26]. Further investigations are required to exhaust MM risk resulting from the third delay.

Severe bleeding also brought about 12 maternal deaths. Uterine rupture is the usual source of severe bleeding and was responsible for 14 maternal fatalities. Particularly in some cases, risk factors for uterine rupture include grand multiparity, fetal malposition, malpresentation, and fetopelvic disproportion. Another important factor that increases the risk of uterine rupture is a prior uterine scar. In this investigation, all uterine rupture-related maternal deaths occurred either at home, where the women had been giving birth for more than 24 hours or after being referred from another facility [15]. Women who are multiparous and those who have had uterine scarring need to be warned against attempting home deliveries. Patients at risk of uterine rupture should be sent much sooner to higher-level facilities such as CHUK, MHK, PRCH, and CHPLR referral hospitals, for the continuum of care from prenatal clinics and facilities lacking surgical rooms. To identify any deviations in labor's progression and take the necessary measures, emphasis should be placed on the usage of partographs.

According to this analysis, the second delay (delay in locating and getting to CHUK, MHK, PRCH, and CHPLR referral hospitals for treatment) and the first delay (delayed choice to seek proper medical attention for an obstetric emergency/health facility) each contributed to 14 and 5 maternal deaths, respectively. With respect to other studies, this contribution is less. The first delay was responsible for 90% of maternal deaths, according to research done in India [27]. Another study from Bangladesh found that a number of factors contributed to maternal deaths, including untrained birth attendants or family members performing the delivery, understanding maternal complications slowly, delaying the decision to transfer the mother, and traditional myths that were influenced by lack of knowledge and education [28]. These factors contributed to the delay in getting to a health facility and are closely tied to the under-empowerment of women. Lack of money and transportation were other factors that prolonged the journey to the medical center. Maternal mortality brought on by first- and second delays may be decreased with continued advocacy, financial incentives for traditional birth attendants to accompany pregnant women to medical facilities, and customized birth plans. Our startling findings may be used to pinpoint the primary contributing factor and the most critical cause of death given the rising incidence of maternal deaths and morbidity.

Our research has a number of important benefits. First, using a reasonably large sample size, we conducted a retrospective cohort study of pregnant women to examine the maternal mortality rate and associated risk factors at four tertiary hospitals in Burundi (2020-2021), which had seldom been studied before. Second, we used well-trained, experienced, and closely supervised staff at CHUK, MHK, PRCH, and CHPLR, which resulted in generally reliable clinical data and diagnoses, and diligent documentation of maternal morbidity and mortality. The study's striking findings may offer solutions for the susceptible subgroups in particular for effective MM reduction and early prevention.

However, there are a number of limitations. First, we identified MM cases primarily using complications-specific criteria that depended on clinical expertise, which may have affected the number of sociodemographic features. The study's striking conclusions could provide answers for susceptible subgroups, in particular, for effective MM reduction and early prevention. Second, we only had records of maternal deaths that happened up to the point at which women were discharged or transferred from CHUK, MHK, PRCH, and CHPLR (as opposed to up to 42 days after childbirth or pregnancy termination). Our striking findings may be used to identify the most important determinants for MM as well as the primary cause of death and MMR. Third, there is a potential that some data may be missing because this study is a retrospective study. As a result, the outcomes may vary from those of other studies. A prospective study will be preferable to determine the precise causes of MM. Fourth, because Burundi is a developing nation, the findings may vary, which reduces their external validity.

5. Conclusion

The main causes of maternal mortality in our study were haemorrhage, uterine rapture, and second delay. Haemorrhage is a leading cause of death, which is in line with the WHO report (2005) [29].

The present study highlights the importance of not delaying referral from other healthcare institutions, not delaying treatment at CHUK, MHK, PRCH, and CHPLR, and adequate provider competence at the four referral hospitals and the sending hospitals. All referral facilities need to conduct frequent exercises and job training on how to handle any obstetric emergency. The majority of deaths may have been avoided with the aid of early referral, swift, effective transport facilities, the availability of blood transfusions anticonvulsant medications, and intravenous fluids. Additionally, there should be active management of high-risk groups by frequent ANC visits, direct consultant supervision, blood transfusions, active management of infection, and closer monitoring of women in labour [30]. Nonetheless, it is necessary to do additional research on the patterns of maternal deaths at these hospitals in order to monitor the effectiveness of the interventions put in place. The analysis of every maternal death at the institutional level should be carried out in Burundi.

Ethical Considerations

This research was approved by the Ethics Committee of Central South University and Centre Hospital-University of Kamenge (CHUK), Military Hospital of Kamenge (MHK), Prince Regent Charles Hospital (PRCH), and Clinical Hospital Prince Louis Rwagasore (CHPLR) referral hospitals. The anonymity of the deceased was maintained as per the regulations for discussing maternal deaths.

CRediT Authorship Contribution Statement

Miburo Moise: Writing – original draft, Investigation, Methodology, Formal analysis, Data curation, Conceptualization.
Rachael Gakii Murithi: Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis.
Dai Wenjie: Writing – review & editing, Validation, Supervision, Resources, Project administration, Funding acquisition, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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