

Survival analysis of maternal mortality and associated risk factors in North Sumatra Province, Indonesia: A retrospective cohort study

Analisis kelangsungan hidup kematian ibu dan faktor risiko yang berhubungan di Provinsi Sumatera Utara, Indonesia: Studi kohort retrospektif

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Abstract

Background: Maternal mortality remains a major public health challenge, reflecting the overall performance of maternal health services. Despite global and national efforts, maternal deaths continue to occur, particularly in low- and middle-income countries. Understanding the temporal pattern of maternal mortality and its associated risk factors is essential for informing targeted interventions.

Objectives: This study aimed to analyze the association between maternal risk factors and maternal mortality in North Sumatra Province using a survival analysis.

Methods: A retrospective cohort study was conducted using maternal mortality surveillance data recorded in the Maternal Perinatal Death Notification (MPDN) system from January to December of 2023. Of the 202 recorded maternal deaths, 140 met the inclusion criteria and were included in the survival analysis. Survival time was defined as the duration (days) from hospital admission to death. Kaplan–Meier estimation was used to assess survival probability, and Cox proportional hazards regression was applied to identify independent risk factors.

Results: The mean maternal age was 31.66 ± 6.57 years. Most deaths occurred among multiparous women and those who had fewer than six antenatal care visits. The mean survival time following hospital admission was 1.41 ± 0.56 days, which indicates rapid clinical deterioration. Kaplan–Meier analysis demonstrated a steep decline in survival probability within the first 24 hours of admission. In the multivariable Cox regression analysis, a history of cesarean section was independently associated with an increased mortality risk (HR 8.66; 95% CI 1.95–41.30). However, the wide confidence interval suggests a limited precision.

Conclusion: Maternal mortality in North Sumatra predominantly occurs during the early phase of hospitalization. A history of cesarean section appears to function as a marker of clinical severity rather than a direct causal determinant. Strengthening early emergency obstetric response and referral systems is essential for reducing preventable maternal deaths.

Keywords:

Maternal mortality, survival analysis, Cox regression, obstetric risk factors

Abstrak

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Latar Belakang: Kematian ibu masih menjadi tantangan besar dalam kesehatan masyarakat dan mencerminkan kinerja keseluruhan layanan kesehatan maternal. Meskipun berbagai upaya global dan nasional telah dilakukan, kematian ibu tetap terjadi, terutama di negara berpendapatan rendah dan menengah. Pemahaman terhadap pola temporal kematian ibu serta faktor risiko yang berhubungan sangat penting untuk merancang intervensi yang tepat sasaran.

Tujuan: Penelitian ini bertujuan untuk menganalisis hubungan antara faktor risiko maternal dan kematian ibu di Provinsi Sumatera Utara menggunakan pendekatan analisis survival.

Metode: Studi kohort retrospektif dilakukan dengan menggunakan data surveilans kematian ibu yang tercatat dalam sistem Maternal Perinatal Death Notification (MPDN) dari Januari hingga Desember 2023. Dari 202 kematian ibu yang tercatat, sebanyak 140 kasus memenuhi kriteria inklusi dan dianalisis dalam model survival. Waktu survival didefinisikan sebagai durasi (dalam hari) sejak masuk rumah sakit hingga terjadinya kematian. Estimasi Kaplan–Meier digunakan untuk menilai probabilitas kelangsungan hidup, dan regresi Cox proportional hazards digunakan untuk mengidentifikasi faktor risiko independen.

Hasil: Rata-rata usia ibu adalah $31,66 \pm 6,57$ tahun. Sebagian besar kematian terjadi pada ibu multipara dan pada mereka yang menjalani kunjungan antenatal kurang dari enam kali. Rata-rata waktu survival setelah masuk rumah sakit adalah $1,41 \pm 0,56$ hari, yang menunjukkan perburukan klinis yang cepat. Analisis Kaplan–Meier menunjukkan penurunan tajam probabilitas kelangsungan hidup dalam 24 jam pertama setelah masuk rumah sakit. Pada analisis regresi Cox multivariat, riwayat persalinan sesar secara independen berhubungan dengan peningkatan risiko kematian (HR 8,66; IK 95% 1,95–41,30). Namun, interval kepercayaan yang lebar menunjukkan keterbatasan presisi estimasi.

Kesimpulan: Kematian ibu di Provinsi Sumatera Utara terutama terjadi pada fase awal perawatan di rumah sakit. Riwayat persalinan sesar tampaknya lebih berperan sebagai penanda tingkat keparahan klinis daripada sebagai faktor penyebab langsung. Penguatan respons obstetri emergensi dini serta sistem rujukan sangat penting untuk menurunkan angka kematian ibu yang dapat dicegah.

Kata Kunci:

Kematian ibu, analisis survival, regresi Cox, faktor risiko obstetric

Introduction

Maternal mortality remains a critical indicator of health system performance, reflecting the quality, accessibility, and timeliness of the obstetric care. The World Health Organization defines maternal death as the death of a woman during pregnancy or within 42 days of termination of pregnancy due to causes related to or aggravated by pregnancy or its management (World Health Organization, 2023). Despite global declines in maternal mortality over the past two decades, substantial disparities persist, particularly in low- and middle-income countries (LMICs) (Aga et al., 2025).

Indonesia continues to face challenges in reducing its maternal mortality rate. Although the national maternal mortality ratio has decreased in recent years, it remains above the target set by the Sustainable Development Goals (SDGs) (Say et al., 2014). North Sumatra Province is among the regions reporting a persistently high number of maternal deaths, indicating potential gaps in early risk identification, referral systems, and emergency obstetric preparedness (Badan Pusat Statistik, 2023).

Maternal mortality is influenced by complex interactions between biological factors, obstetric complications, healthcare accessibility and systemic readiness. Hemorrhage, hypertensive disorders of pregnancy, infection, and underlying medical conditions remain the leading causes of maternal death worldwide (Midhet et al., 2025; Anumudu et al., 2025; Safitri et al., 2025). However, many studies have analyzed maternal mortality as a dichotomous outcome (alive vs. dead) without considering the temporal progression from hospital admission to death.

Time-to-event analysis provides a more informative approach to understanding maternal mortality dynamics. Survival analysis enables the estimation of survival probabilities and identification of factors associated with early mortality following admission (Beis et al., 2024). Despite its methodological advantages, the application of survival analysis in provincial-level maternal mortality research in Indonesia is limited.

Therefore, this study aimed to examine the temporal patterns of maternal mortality and identify associated risk factors using survival analysis in North Sumatra Province in 2023. By integrating clinical and demographic variables

with time-to-death outcomes, this study seeks to provide a more comprehensive understanding of maternal mortality patterns to inform evidence-based health system strengthening in Ghana.

Methods

Study Design

This study employed a retrospective cohort design using secondary data from maternal mortality surveillance records in North Sumatra Province between January 1 and December 31, 2023.

Study Setting and Period

This study was conducted in collaboration with the Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Sumatera Utara.

Data were obtained from the Maternal Perinatal Death Notification (MPDN) system, managed by the North Sumatra Provincial Health Office. Data collection and processing will be performed from April to September 2025, covering all eligible maternal death cases occurring during the 2023 calendar year.

Study Population and Sample

The study population comprised all maternal deaths recorded in the Maternal Perinatal Death Notification (MPDN) system in North Sumatra Province from January 1 to December 31, 2023. A total of 202 maternal deaths were recorded.

After applying inclusion and exclusion criteria, 140 eligible cases were included in the final survival analysis. Inclusion criteria comprised all maternal deaths occurring in healthcare facilities among women officially domiciled in North Sumatra Province. Cases were excluded if death occurred at home, during transportation, or if the hospital admission time was unavailable.

Data Collection Procedure

The study was initiated after obtaining ethical approval from the Health Research Ethics Committee of Universitas Sumatera Utara and research permission from the North Sumatra Provincial Health Office. Data were retrieved from the online MPDN archive (<https://mpdn.kemkes.go.id>) and supplemented with maternal delivery records

obtained from the Provincial Health Office during the study period.

The collected data included demographic characteristics (maternal age and parity), obstetric history, history of medical and obstetric interventions, pregnancy complications, cause of death, and pregnancy status at the time of death. Information on maternal risk factors included maternal characteristics, medical conditions, educational background, availability of healthcare facilities, delays in management, and quality of healthcare services. All data were systematically recorded, tabulated, and analyzed.

Study Variables

The primary outcome was survival time, defined as the duration (in days) from hospital admission to maternal death. Survival time was analyzed as a continuous, time-to-event variable. The independent variables included maternal risk factors, such as maternal age, parity, frequency of antenatal care (ANC) visits, history of interventions, history of pregnancy-related complications, and pregnancy status at the time of death.

Maternal age was categorized as <20, 20–35, and ≥35 years. Parity was classified as primigravida, secundigravida, multigravida, or grandemultigravida. ANC frequency was categorized based on national recommendations as fewer than six visits or six or more visits. The history of interventions included no intervention, cesarean section, manual placental removal, and hysterectomy.

Pregnancy complications included hypertension, preeclampsia, eclampsia, hemorrhage, chronic disease, infection, and malpresentation. The pregnancy status at the time of death was classified as pregnant, during delivery, or postpartum. Survival time was categorized as <24, 24–48, or ≥48 h.

Data Analysis

Descriptive statistics were used to summarize the maternal characteristics. Kaplan–Meier survival curves were generated to estimate survival probability over time. Differences in survival distribution were assessed using log-rank tests. Multivariable Cox proportional hazards regression was used to identify the

independent predictors of maternal mortality. Hazard ratios (HRs) with 95% confidence intervals (95% CIs) were reported.

The proportional hazards assumption was evaluated prior to the model interpretation.

Ethical Consideration

Ethical approval for this study was obtained from the Health Research Ethics Committee of the Universitas Sumatera Utara (No. 534/KEPK/USU/2025). Research permission was granted by the North Sumatra Provincial Health Office (No. 800.1.4.1/2603/DINKES/VII/2025). The ethical approval documentation is provided in the Supplementary Materials.

Results

Maternal Demographic and Obstetric Characteristics

A total of 202 maternal death records were identified in the Maternal Perinatal Death Notification (MPDN) system in North Sumatra Province for 2023. After applying the predefined inclusion and exclusion criteria, 140 patients were included in the final analysis. The demographic characteristics of the study population are presented in Table 1. The mean maternal age was 31.66 ± 6.57 years old. Most women were multiparous, followed by primiparous and secundiparous. Antenatal care utilization was generally low, with most mothers having fewer than six ANC visits during pregnancy.

Tabel 1. Maternal demographic characteristics.

Variable	N=140	
	N	%
Maternal age (Mean $\pm$ SD)	31.66 $\pm$ 6.57 years	
Parity	<0,05	
Primiparous	41	
Secundiparous	22	
Multiparous	64	
Antenatal care visits	>0,05	
< 6 visits	121	
$\geq$ 6 visits	19	

Clinical Profiles and Circumstances of Maternal Death

Most maternal deaths occurred without documented medical interventions. When interventions were performed, hysterectomy and

cesarean section were the most frequently performed procedures. Hemorrhage was the leading obstetric complication, followed by hypertensive disorders and chronic medical conditions. A considerable proportion of deaths occurred during the postpartum period, indicating a vulnerable period following delivery. A comprehensive summary of the clinical conditions and pregnancy status at the time of death is presented in Table 2.

The duration of hospitalization prior to death was generally short, with an average length of stay of approximately 1.4 days, highlighting the rapid clinical deterioration preceding the maternal death.

Tabel 2. Clinical characteristics and circumstances of maternal deaths.

Variable	N=140	
	N	%
History of medical interventions		
Blood transfusion	1	0.7
Cesarean section	3	2.1
Hysterectomy	4	2.9
Manual placental removal	2	1.4
None	130	92.9
History of complications		
Hypertension	21	15.0
Preeclampsia	17	12.1
Eclampsia	2	1.4
Hemorrhage	33	23.6
Infection	3	2.1
Malpresentation	1	0.7
Chronic disease	21	15.0
Other diseases	11	7.9
No complications	31	22.1
Pregnancy status at death		
Pregnant	32	22.9
In labor	36	25.7
Postpartum	54	38.6
Other	18	12.8
Length of hospital stay prior to death (Mean $\pm$ SD)		
Time in minutes	2036.43 $\pm$ 814.50	
Time in hours	33.94 $\pm$ 13.57	
Time in days	1.41 $\pm$ 0.56	

Factors Associated with Length of Hospital Stay Prior to Death

Exploratory analyses suggested that deaths within the first 24 h of admission were more frequent among multiparous women, those with inadequate ANC attendance, and those experiencing hemorrhagic complications. However, these patterns did not reach statistical significance in the

bivariate analysis. The distribution of maternal risk factors across the categories of hospital stay duration is shown in Table 3.

Table 3. Bivariate analysis of clinical factors associated with length of hospital stay prior to maternal death.

Variable	Length of hospital stay prior to death, n (%)			p-value*
	<24 hours	24 – 48 hours	>48 hours	
Parity				0.399
Primiparous	26 (31.7)	4 (36.4)	11 (32.4)	
Secundiparous	12 (14.6)	4 (36.4)	6 (17.6)	
Multiparous	44 (53.7)	3 (27.3)	17 (50)	
Antenatal care (ANC) visits				0.164
<6 visits	77 (82.8)	11 (100)	33 (91.7)	
≥ 6 visits	16 (7.2)	0 (0)	3 (8.3)	
History of medical interventions				0.154
Blood transfusion	1 (1.1)	0 (0)	0 (0)	
Cesarean section	0 (0)	0 (0)	3 (8.3)	
Hysterectomy	2 (2.2)	1 (9.1)	1 (2.8)	
Manual placental removal	2 (2.2)	0 (0)	0 (0)	
None	88 (94.6)	10 (90.9)	32 (88.9)	
History of complications				0.344
Hypertension	16 (17.2)	2 (18.2)	3 (8.3)	
Preeclampsia	9 (9.7)	1 (9.1)	7 (19.4)	
Eclampsia	0 (0)	1 (9.1)	1 (2.8)	
Hemorrhage	25 (26.9)	3 (27.3)	5 (13.9)	
Infection	2 (2.2)	0 (0)	1 (2.8)	
Malpresentation	1 (1.1)	0 (0)	0 (0)	
Chronic disease	12 (12.9)	1 (9.1)	8 (22.2)	
Other diseases	5 (5.4)	1 (9.1)	5 (13.9)	
No complications	23 (24.7)	2 (1.2)	6 (16.7)	
Pregnancy status at death				0.504
Pregnant	20 (21.5)	2 (18.2)	10 (27.8)	
In labor	27 (29)	3 (27.3)	6 (16.7)	
Postpartum	31 (33.3)	6 (54.5)	17 (47.2)	
Other	15 (16.2)	0 (0)	3 (8.3)	

*Bivariate analysis was performed using Pearson's chi-square test or Fisher's exact test, as appropriate.

Determinants of Maternal Mortality

In the multivariable Cox proportional hazards analysis, most maternal characteristics and clinical conditions did not independently influence the maternal mortality risk. Notably, a history of

cesarean section was identified as the only factor significantly associated with an increased hazard of maternal death after adjustment for confounding variables. The full multivariate model is presented in Table 4.

Table 4. Multivariable Cox proportional hazards analysis of clinical factors associated with maternal mortality.

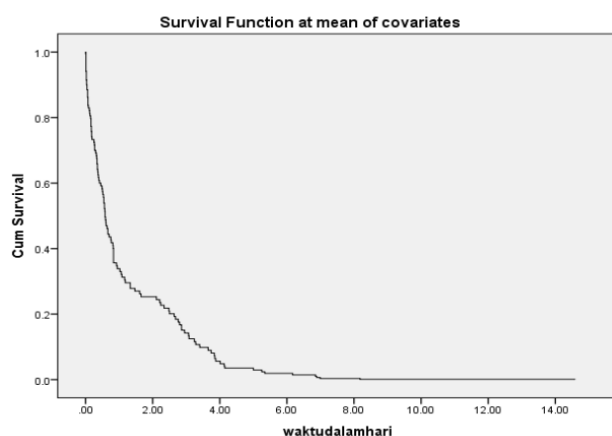
Variable	p-value	Hazard Ratio (HR)	95% CI (Lower–Upper)
Antenatal care (ANC) frequency	0.442	1.262	0.697 – 2.283
Parity	0.978		
Primiparous	0.854	0.946	0.522 – 1.715
Secundiparous	0.993	1.002	0.645–1.556
History of medical interventions	0.039		
Blood transfusion	0.315	0.495	0.126–1.817
Cesarean section	0.007	8.664	1.951–41.299
Hysterectomy	0.313	0.577	0.198–1.682
Manual placental removal	0.416	2.407	0.289–20.012
History of complications	0.479		
Hypertension	0.833	0.936	0.039–1.732

Variable	p-value	Hazard Ratio (HR)	95% CI (Lower–Upper)
Preeclampsia	0.236	0.666	0.109–1.304
Eclampsia	0.826	0.825	0.273–4.558
Hemorrhage	0.351	1.308	0.340–2.302
Infection	0.253	0.696	0.744–1.294
Malpresentation	0.287	0.319	0.375–2.617
Chronic disease	0.863	0.836	0.039–6.396
Other diseases	0.205	0.601	0.109–1.322
Pregnancy status at death	0.125		
Pregnant	0.535	1.204	0.437–1.169
In labor	0.234	0.731	0.549–2.166
Postpartum	0.685	1.169	0.669–2.490

* Multivariable analysis was performed using the Cox proportional hazards model.

Survival Analysis

Survival analysis demonstrated a mean maternal survival time of 1.41 days following the hospital admission. The Kaplan–Meier survival curve (Figure 1) showed a rapid decline in survival probability, indicating that most maternal deaths occurred within a short period after hospitalization.



Picture 1. Survival analysis of maternal mortality

Discussion

Although pregnancy and childbirth are fundamentally physiological processes, they inherently carry the risk of serious complications and maternal death in the absence of adequate surveillance and timely management. Maternal mortality represents not only an individual clinical failure but also a complex interplay of biological vulnerability, social determinants, and health system performance. In high-income countries, substantial reductions in maternal mortality have been achieved through the effective prevention of unintended pregnancies, comprehensive antenatal care delivered by skilled health professionals, high-quality institutional services, and the

empowerment of women. In contrast, maternal death remains a common and pressing public health challenge in many low- and middle-income countries (Singh et al., 2022).

The demographic profiles of the maternal deaths observed in this study reflect this broader context. The mean maternal age was in the early thirties, with a substantial proportion of multiparous women and a predominance of fewer than six antenatal care (ANC) visits during pregnancy. These findings are consistent with previous reports identifying maternal age, parity, and utilization of maternal health services as important contributors to the maternal mortality rate. Although global maternal mortality has declined over recent decades, significant disparities persist, particularly in resource-limited settings where socioeconomic conditions, educational attainment, and access to quality healthcare services continue to shape maternal outcomes (Dias De Oliveira et al., 2023).

Regarding clinical characteristics prior to death, most women had no documented history of medical intervention, while obstetric hemorrhage and hypertensive disorders were the most frequently identified complications. A large proportion of deaths occurred during the postpartum period, underscoring women's persistent vulnerability after delivery. This pattern highlights the critical importance of postpartum monitoring and continuity of care, which are often insufficient in low-resource settings such as India. Beyond individual clinical factors, maternal deaths in this study were closely linked to health system challenges, including delays in management, incomplete initial assessments, limited monitoring, delayed referral, and inadequate availability of equipment and emergency obstetric services in the hospital. These findings emphasize the importance

of maternal death surveillance and systematic analysis of contributory factors to inform evidence-based health policies and optimize resource allocation (Dias De Oliveira et al., 2023).

In the bivariate analysis, parity, frequency of ANC visits, history of complications, and condition at death were not significantly associated with the length of hospitalization until maternal death. Although deaths within the first 24 hours were more frequent among multiparous women, this difference was not statistically significant, consistent with the findings of Vousden et al., who reported no significant association between parity and time to maternal death (Badan Pusat Statistik, 2023). While multiparity has often been linked to increased maternal morbidity, its direct relationship with mortality may be mediated by more influential factors, particularly the quality and timeliness of healthcare. Conversely, other studies have reported a higher risk of maternal death among primigravid women, especially in the presence of significant comorbidities (Dias De Oliveira et al., 2023). These discrepancies highlight the heterogeneity of maternal risk profiles across populations and health systems.

Similarly, the frequency of ANC visits was not significantly associated with the duration of hospitalization until death, despite the predominance of early deaths among women with fewer than six ANC visits. This finding aligns with the study by Roro et al., which suggested that the number of ANC visits alone does not necessarily predict pregnancy outcomes (Roro et al., 2022). Inadequate content and quality of ANC services, as well as the application of reduced ANC models, may partly explain the lack of association. Nevertheless, the broader literature consistently emphasizes the critical role of ANC in preventing maternal deaths. The World Health Organization has progressively increased the recommended minimum number of ANC contacts to improve maternal outcome. Evidence from Tesfay et al. demonstrates that adequate coverage and quality of ANC are significantly associated with reduced obstetric complications and maternal mortality, reinforcing the role of ANC as a key preventive strategy rather than merely a monitoring tool (Tefay et al., 2023).

With respect to obstetric complications, hemorrhage and hypertensive disorders were the most common causes of death within the first 24 h, although no statistically significant association

with length of hospitalization was identified. This observation should be interpreted within the broader framework of maternal mortality causation, where delays in care, suboptimal initial management, and limited system readiness often outweigh the influence of clinical diagnosis alone. The predominance of hemorrhage, hypertensive disorders of pregnancy, infections, and non-obstetric causes as leading contributors to maternal death is consistent with the ICD-10 classifications and global trends. Notably, differences in the distribution of causes between women admitted in stable versus critical conditions suggest that timely and appropriate early interventions may substantially reduce preventable deterioration and fatal outcomes (Munthali et al., 2025).

In contrast to other variables, multivariable analysis identified a history of medical intervention, particularly cesarean section, as a significant factor associated with an increased risk of maternal mortality. This finding should not be interpreted as indicating a causal role of the procedure itself but rather as reflecting the severity of the underlying clinical condition necessitating surgical intervention. Singh et al. emphasized that delays in diagnosis and intervention, as well as limitations in facility preparedness and provider capacity, critically influence maternal outcomes, especially in cases requiring advanced obstetric care (Singh et al., 2022). In this context, cesarean section may serve as a marker of clinical complexity and systemic challenges, rather than an isolated procedural risk.

Survival analysis further demonstrated that maternal deaths predominantly occurred within a relatively short period after hospital admission, with a declining survival probability over time. This temporal pattern is consistent with prior studies reporting that a substantial proportion of maternal deaths occur during labor or within the first 24 hours postpartum (Kea et al., 2023). The World Health Organization has stated that most maternal deaths are preventable through timely and adequate interventions, although a small proportion may remain unavoidable even under optimal care. In this study, the duration of hospitalization until death underscores the critical importance of the first day of care, during which the quality of the initial assessment, rapid decision-making, and availability of resources are decisive for maternal survival. These findings align

with those of Munthali et al., who demonstrated that maternal deaths cluster within the first days of admission among both stable and critically ill women (Munthali et al., 2025).

This study has several strengths. First, it utilized maternal death data derived from a provincial maternal death notification system, allowing the analysis to reflect real-world conditions across a large geographic area. Second, the application of survival analysis provided a temporal perspective on maternal mortality, enabling the assessment of time-to-event patterns not captured by conventional cross-sectional approaches. Third, the inclusion of both demographic and clinical variables allowed for a comprehensive evaluation of the factors associated with maternal death within the available dataset.

Nevertheless, several limitations of this study should be acknowledged. The retrospective design relied on secondary data, which may be subject to incomplete documentation and limited variable details, particularly regarding the quality and timing of clinical interventions. The analysis was restricted to recorded maternal deaths, precluding direct comparisons with surviving mothers and limiting causal inference. In addition, some potentially important confounders, such as socioeconomic status, delays in care-seeking, and facility-level characteristics, could not be assessed because of data constraints. These limitations may have influenced the observed associations and should be considered when interpreting our findings.

Conclusion

This study demonstrates that maternal mortality in North Sumatra Province is characterized by a critical early phase of deterioration following the hospital admission. Most deaths occurred within a short period, with survival analysis revealing a marked decline in survival probability during the first 24 h. This temporal clustering highlights the importance of immediate clinical stabilization, rapid decision-making, and emergency obstetric preparedness.

Although several demographic and obstetric characteristics were examined, most were not independently associated with a shortened survival time. A history of cesarean section emerged as the only statistically significant predictor in the multivariable analysis; however, this association

likely reflects the severity of underlying obstetric complications and systemic healthcare constraints rather than a direct procedural effect.

These findings suggest that maternal mortality is driven not only by individual risk profiles but also by the responsiveness and readiness of healthcare facilities during obstetric emergencies. Strengthening early triage systems, improving referral coordination, ensuring timely availability of surgical and blood transfusion services, and enhancing critical care capacity are essential strategies for reducing preventable maternal deaths.

Future research should incorporate comparative cohorts of surviving mothers and include facility-level and health system indicators to disentangle clinical severity from the structural determinants of mortality. Integrating survival analysis into routine maternal death surveillance may provide valuable real-time insights into high-risk time windows and inform targeted quality-improvement interventions.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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