Section: Intensive Care Unit

Original Research Article

# DETERMINANTS OF MATERNAL MORTALITY IN ICU IN A TERTIARY CARE CENTRE

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## Abstract

**Background:** Intensive Care Units (ICUs) are critical for providing comprehensive medical care to severely ill patients, including those experiencing obstetric complications. This study aims to identify factors influencing mortality rates among obstetric patients in the ICU, focusing on their clinical characteristics, treatment, and outcomes. **Materials and Methods:** A prospective study was conducted on all obstetric admissions to a critical care unit in a tertiary care teaching hospital. Data collected included demographic information, obstetric and medical history, ICU course, investigations, treatment details, and maternal and fetal outcomes. **Result:** The study included 50 critically ill obstetric patients with an average age of 25.03 years and a gestational period of 32.02 weeks. Cardiac causes (62%) were the most prevalent diagnosis. Vasopressor and ventilator support were required for 58% and 78% of patients, respectively. The mean ICU stay was 4.73 days, and the hospital stay was 6.91 days. The maternal survival rate was 70%, and the fetal survival rate was 52%. **Conclusion:** Cardiac dysfunction was the primary reason for ICU admission among obstetric patients. Effective use of ICU resources and accurate severity assessments are crucial for improving maternal outcomes in critical care settings.

## INTRODUCTION

An intensive care unit (ICU) is a well-organized system designed to provide comprehensive medical care to severely ill patients. It involves close monitoring, specialised treatment, and various methods of physiological support to sustain patients' lives during a critical period of organ system failure.[1] In 2015, a total of 303,000 mothers worldwide died, based on data collected from 171 countries. The estimated range for this number is between 291,000 and 349,000, with a confidence interval of 80%. Since 1990, the annual decline in maternal death rate has been greater in eastern Asia at a rate of 5% (ranging from 4.0% to 6.0%), compared to the Caribbean which has seen a decline of 1.8%. In 2015, the maternal mortality rate (MMR) for industrialised countries was 12 deaths per 100,000 live births with an 80% confidence interval (CI) ranging from 11 to 14. In contrast, the MMR for sub-Saharan Africa (SSA) was 546 deaths per 100,000 live births with an 80% CI ranging from 511 to 652.[2]

According to research by the WHO, UNICEF, World Bank Group, and the United Nations Population Division, the global maternal mortality ratio decreased by around 38% between 2000 and 2017.[3] However, this situation is not consistent across the globe, and in Sub-Saharan Africa, the prevalence of this issue remains at an unacceptably high level. The disparities in maternal mortality rates in certain regions of the world are indicative of unequal access to high-quality healthcare services and underscore the socioeconomic divide between affluent and impoverished populations.[4] By 2030, Africa will fall short of achieving the Sustainable Development Goal (SDG) of 70 maternal deaths per 100,000 live births. Instead, the maternal mortality rate (MMR) is projected to be approximately 347 deaths per 100,000 live births. To achieve the 2030 Sustainable Development Goals, Africa and its partners must make intensified efforts to decrease the Maternal Mortality Ratio (MMR) by around 13% annually from its 2015 level.[5]

In 2017, the maternal mortality rate (MMR) in low-income countries was 462 deaths per 100,000 live births, while in high-income countries it was just 11


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deaths per 100,000 live births. The Sustainable Development Goals (SDG) set a target of achieving a worldwide Maternal Mortality Ratio (MMR) of fewer than 70 per 100,000 births by 2030. Additionally, no country should have an MMR that exceeds twice the global average. According to data from 2017, Ethiopia had a maternal mortality ratio (MMR) of 401 per 100,000 live births.[6]

The mortality rate in obstetric intensive-care units varies significantly, with rates ranging from 0% to 4.9% in high-income nations and from 2% to 43.6% in low and middle-income countries.[6] Although the mortality rate of obstetrics patients in the intensive care unit (ICU) was high, there is evidence to suggest that the proper utilisation of a high-quality ICU can reduce maternal mortality.[7]

According to the 2019 atlas of African health statistics, the maternal mortality rate (MMR) in Africa was 542 per 100,000 live births in 2015. According to reports, this fatality was 34 times greater than the MMR (measles, mumps, and rubella) death rate in Europe and was considered to be unacceptably high.[5]

The World Health Organisation (WHO) set the Millennium Development Goal 5 (MDG5) with the objective of decreasing the Maternal Mortality Ratio (MMR) by 75% from 1990 to 2015. However, the worldwide maternal mortality ratio (MMR) had a decrease from 385 deaths per 100,000 live births in 1990 to 216 in 2015. The decrease amount was around 43.9%, and the planned reduction has not been achieved yet.[2]

The study conducted in three public hospitals in Addis Ababa, Ethiopia, from January 2015 to December 2017, revealed a maternal mortality ratio of 156 per 100,000 live births. Preeclampsia/Eclampsia, postpartum haemorrhage, and puerperal sepsis are significant contributors to maternal deaths. Among all hospital deaths, 27.4% occur in the intensive care unit (ICU).[8]

The admission criteria to the Intensive Care Unit (ICU) were similar in both developing and developed countries, with the exception of a notably higher maternal mortality rate in developing countries. There is a shortage of studies that report on patient outcomes after being admitted to the ICU.[9] Furthermore, the mortality rate of obstetrics patients in the intensive care unit and the specific causes of death were not accurately documented in Ethiopia.[8]

The objective of this study was to determine the factors that influence death rates in the intensive-care unit for obstetrics patients. Given the frequent occurrence of maternal death in the ICU, the use of early warning technologies can be beneficial in identifying obstetric women who are in severe condition. This would enable the administration of targeted treatment to reduce mortality rates. This project aims to assist health institutions, policymakers, and other stakeholders in providing crucial maternal care. It will achieve this by identifying interventions that have the most potential to decrease maternal mortality and enhance maternal health nationwide. The findings of this study were particularly advantageous for healthcare practitioners and hospital management in determining how to distribute resources effectively in order to decrease maternal mortality rates in the intensive-care unit. In general, there was a lack of readily available information on the factors that contribute to death in obstetrics intensive care units. Therefore, this research aims to gather reliable data that can accurately predict a problem and offer direction for implementing improved management strategies to decrease maternal ICU mortality.

## MATERIALS AND METHODS

A prospective analysis of all obstetric admissions to a critical care unit of a tertiary care teaching hospital was conducted from. The critical care department has multiparameter monitors, microprocessor-controlled ventilators providing invasive and noninvasive ventilation. The patients included in this study were critically ill obstetric patients requiring ventilator support or major organ supportive therapy. These patients were brought to the critical care department at various stages of pregnancy to 6 weeks after parturition. Data collection: The data collected included basic demographic data, obstetric and medical history, hospital and ICU course, investigations, treatment including administration of vasopressor and ventilator support, and the maternal and foetal outcome.

## RESULTS

The study population of 50 individuals, characterized by an average age of 25.03 years and an average gestation period of 32.02 weeks, reveals various health and clinical outcomes. Antenatal care was provided to 36% of the participants. Transfers occurred pre-delivery for 32%, post-delivery for 58%, and post-abortion for 10%. Notable medical histories included hypertension (8%), hypothyroidism (2%), and diabetes mellitus (2%). Significant clinical findings showed an average hemoglobin level of 8.84 g/dL, PaO2/FiO2 ratio of 223.03, serum PCT of 1.8 ng/mL, and serum lactate of 1.5 mmol/L. Diagnoses included cardiac causes (31 cases), pneumonia (5 cases), and ARDS (14 cases). Vasopressor support was required by 58% and ventilator support by 78%, with 22% requiring NIV. The average ICU stay was 4.73 days, and hospital stay was 6.91 days. Maternal outcomes indicated a survival rate of 70% and a mortality rate of 30%, while 52% of fetuses survived. Among survivors, 41.5% had cardiac causes, 21.9% had ARDS, and 5 had pneumonia, whereas among non-survivors, 46.66% had cardiac causes, and 26.6% had ARDS, with a case fatality rate of 36.8% for cardiac causes and 40% for ARDS. No fatalities were reported for pneumonia.


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The table compares the characteristics of survivors and non-survivors within a study population of 50 individuals. The average age was slightly higher in non-survivors (26.00 years) compared to survivors (24.84 years). The period of gestation was slightly lower in non-survivors (30.78 weeks) than in survivors (32.34 weeks). Antenatal care was more common among survivors (37.2%) compared to non-survivors (26.6%). Pre-delivery transfers were more frequent among non-survivors (40%) compared to survivors (28.5%), whereas post-delivery transfers were higher in survivors (60%) compared to non-survivors (53.3%). Post-abortion transfers were similar between both groups.

Among survivors, previous diagnoses of hypertension (11.4%), hypothyroidism (2.8%), and diabetes mellitus (2.8%) were noted, while none of the non-survivors had these conditions. Anemia was present in 65.7% of survivors and 60% of non-survivors. Hemoglobin levels were comparable between survivors (8.92 g/dL) and non-survivors (8.67 g/dL). PaO2/FiO2 ratios were higher in survivors (233.72) than in non-survivors (165.79). Serum PCT levels were higher in survivors (10.9 ng/mL) than in non-survivors (7.1 ng/mL), whereas serum lactate levels were significantly higher in non-survivors (440.40 U/L) compared to survivors (150.62 U/L).

All non-survivors required vasopressor and ventilator support, compared to 40% and 68.57% of survivors, respectively. Non-invasive ventilation (NIV) was more common in survivors (28.57%) compared to non-survivors (6.6%), while invasive mechanical ventilation (IMV) was more frequent among non-survivors (80%) compared to survivors (28.57%). The average duration of ICU stay was longer for survivors (5.07 days) than non-survivors (3.28 days), as was the duration of hospital stay (7.54 days for survivors versus 4.28 days for non-survivors).

The table compares various characteristics between survivors and non-survivors in the study population and highlights statistically significant differences using p-values. The cause of mortality shows a significant difference, with cardiac causes being more frequent among non-survivors (p=0.0262). Specifically, 18 survivors and 13 non-survivors had cardiac causes, while ARDS/pneumonia was observed in 17 survivors and 2 non-survivors.

Serum PCT levels also demonstrated a significant difference (p=0.0001), with 32 survivors having normal levels compared to only 2 non-survivors, while 3 survivors and 13 non-survivors had abnormal levels. PaO2 levels were significantly different (p=0.0003), with 28 survivors showing normal levels versus 4 non-survivors, and 7 survivors having abnormal levels compared to 11 non-survivors.

Serum lactate levels were significantly higher in non-survivors (p=0.003), with 23 survivors showing normal levels compared to 3 non-survivors, and 12 survivors with abnormal levels versus 12 non-survivors. Vasopressor requirement was also significantly different (p=0.0001), with 5 survivors needing vasopressors compared to 12 non-survivors, whereas 30 survivors did not need vasopressors compared to 3 non-survivors.

Ventilator requirement was significantly associated with survival outcomes (p=0.0006), with 2 survivors needing ventilators compared to 7 non-survivors, while 33 survivors did not need ventilators compared to 8 non-survivors. These findings underscore the critical differences in clinical and biochemical markers between survivors and non-survivors, highlighting key areas for clinical focus.

**Table 1: Characteristics and outcomes of the study population(n=50).**

| **Characteristic feature** | **n (%)** |
|---|---|
| Age (years)** | 25.03±4.47 |
| Period of gestation (weeks)** | 32.02±7.43 |
| Antenatal care provided during pregnancy | 18 (36) |
| Timing of transfer | |
| Pre delivery | 16 (32) |
| Post delivery | 29 (58) |
| Post abortion | 5 (10) |
| Previous medical History of | |
| Hypertension | 4 (8) |
| Hypothyroidism | 1 (2.0) |
| Diabetes mellitus | 1 (2.0) |
| Significant Clinical finding | |
| Hemoglobin** | 8.84±2.62 |
| PaO2/FiO2** | 223.03±104.75 |
| Serum PCT | 1.8±.405 |
| Serum lactate | 1.5±.345 |
| Diagnosis | |
| Cardiac causes | 31 (62) |
| Pneumonia | 5 (10) |
| ARDS | 14 (28) |
| Number of patients requiring vasopressor support | 29 (58) |
| Number of patients requiring ventilator support | 39 (78) |
| Patients requiring NIV | 11 (22) |
| Duration of ICU stay (days) | 4.73±3.23 |
| Duration of hospital stay (days) | 6.91±3.99 |
| Maternal outcome | |


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| | |
|---|---|
| Alive | 35 (70) |
| Death | 15 (30) |
| Fetal outcome(alive) | 26 (52) |

**Table 2: Characteristics of survivors and non-survivors**

| Characteristics | Survivors(n=35),n(%) | Non survivors (n=15),n(%) |
|---|---|---|
| Age(years) | 24.84±4.56 | 26.00±4.10 |
| Period of gestation(weeks) | 32.34±7.12 | 30.78±8.96 |
| Antenatal care provided during pregnancy | 13 (37.2) | 4 (26.6) |
| Timing of transfer | | |
| Pre delivery | 10(28.5) | 6 (40) |
| Post delivery | 21(60) | 8 (53.3) |
| Post abortion | 3 (8.5) | 1 (6.6) |
| Previous medical diagnosis | | |
| Hypertension | 4 (11.4) | 0 (0.0) |
| Hypothyroidism | 1 (2.8) | 0 (0.0) |
| Diabetes mellitus | 1 (2.8) | 0 (0.0) |
| Anemia present | 23 (65.7) | 9(60) |
| Hemoglobin | 8.92±2.65 | 8.67±2.46 |
| PaO2/FiO2 | 233.72±94.51 | 165.79±128.77 |
| Serum PCT | 10.9 ± 14.6 ng/ml | 7.1 ± 12.8 ng/ml |
| Serum lactate | 150.62± 46.54 U/L | 440.40 ± 84.52 U/L |
| Number of patients requiring Vasopressor support | 14 (40) | 15 (100) |
| Number of patients requiring ventilator support* | 24 (68.57) | 15 (100) |
| Patients requiring NIV | 10 (28.57) | 1 (6.6) |
| Patients requiring IMV | 10 (28.57) | 12 (80) |
| Duration of ICU stay(days) | 5.07±3.17 | 3.28±3.23 |
| Duration of hospital stay (days) | 7.54±3.91 | 4.28±3.29 |

**Table 3: Association of various characteristics and survival status of patients**

| | Survivors | Non-survivors | p-value |
|---|---|---|---|
| Cause of mortality | | | |
| Cardiac cause | 18 | 13 | 0.0262 |
| ARDS/pneumonia | 17 | 2 | |
| Serum PCT | | | |
| Normal | 32 | 2 | 0.0001 |
| Abnormal | 3 | 13 | |
| PaO2 | | | |
| Normal | 28 | 4 | 0.0003 |
| Abnormal | 7 | 11 | |
| Serum Lactate | | | |
| Normal | 23 | 3 | 0.003 |
| Abnormal | 12 | 12 | |
| Vasopressor requirement | | | |
| Yes | 5 | 12 | 0.0001 |
| No | 30 | 3 | |
| Ventilator requirement | | | |
| Yes | 2 | 7 | 0.0006 |
| No | 33 | 8 | |

## DISCUSSION

The average age of critically ill obstetric patients in this study is comparable to that seen in other Indian studies,[10-16] in contrast to studies conducted in developed nations which indicate a comparatively greater maternal age.[17-19] This phenomenon can be attributed to the lower average age at which people get married and subsequently get pregnant in our community. The gestational age of obstetric patients upon admission to the ICU has been found to differ in several studies and is thought to indicate the underlying reason for admission.[20-22] ICUs that have a significant number of admissions caused by postpartum haemorrhage tend to have a greater proportion of patients with a gestational age exceeding 34 weeks. On the other hand, ICUs that primarily admit patients with pregnancy-induced hypertension (PIH) often have a lower proportion of patients with a gestational age below 34 weeks. The range of values is between 18 and 20. Within our Intensive Care Unit (ICU), the majority of patients exhibited Pregnancy-Induced Hypertension (PIH) and had a comparatively shorter duration of pregnancy. The predominant primary diagnoses resulting in critical care hospitalisations are obstetric hemorrhage,[11-14,17,19,22-29] and pregnancy-induced hypertension (PIH),[13,15,18,22,23,25,30-34] as reported in numerous studies conducted in India and overseas. The majority of individuals in our study experienced cardiac causes, accounting for 62% of the total. The regular utilisation of bedside echocardiogram proved invaluable in both identifying these instances and providing guidance for the appropriate administration of inotropes and vasopressors. Multiple factors have been hypothesised to explain


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the frequent incidence of heart failure in obstetric patients.[35] Pregnancy is a period characterised by distinct changes in the cardiovascular system, as the mother's physiology adjusts to meet the needs of the developing foetus. These alterations render the woman susceptible to heart failure. In addition, existing cardiovascular disorders can be worsened by the changes that happen during pregnancy. Pregnancy induced hypertension (PIH) was observed in 26% of the patients, whereas obstetric haemorrhage was only present in 1 of the case. In our center, the obstetric team primarily manages cases of obstetric hemorrhage in the labor room, with only rare instances requiring transfer to the ICU. Consequently, our study includes a limited number of such cases. Another frequently reported diagnosis was pneumonia (10%) and ARDS (28%). The average duration of ICU stay reported in this study closely aligns with numerous previous studies conducted globally and in India.[10,14,18,27,29] Despite receiving intensive care unit (ICU) treatment, 15 out of our patients, accounting for 30% of the total, did not survive. The incidence of maternal death among critically ill obstetric patients is higher in poor countries compared to industrialised nations. Although certain studies have indicated no deaths, the mortality rate in other reports from intensive care units (ICUs) in wealthy countries generally remained below 5%.[27,30,36] However, research conducted in India have revealed a higher obstetric death rate ranging from 28% to 41%.[9-12,31,32] A recent study has documented a death rate of 16.6%,[37] which aligns closely with our own observations.

While previous studies have shown that inadequate prenatal care can have negative effects on obstetric complications and outcomes,[32] our investigation did not find a significant association between the absence of antenatal care and the risk of maternal mortality. This suggests that the delivery of prenatal care may not consistently avoid maternal problems and mortality. Previous research indicates a correlation between increased maternal mortality and women who have given birth three or more times. However, our study did not identify any significant influence of parity on maternal outcomes.[38] Based on our observations, individuals with a greater severity of disease score and those requiring ventilator and hemodynamic assistance had an increased likelihood of mortality. Hemodynamic and respiratory difficulties requiring inotropic or ventilator support are frequently noted as the main causes for ICU admissions. The necessity for such treatment may act as an indicator of unfavourable outcomes.[33]

## CONCLUSION

Based on our observations, cardiac dysfunction is a primary factor that leads to admission to the ICU. Precise prognostic scores in the intensive care units, in addition to guiding aggressive treatment in patients anticipated to have a negative outcome, can also result in more efficient allocation of limited resources. Furthermore, they enable accurate monitoring of the quality of care and risk assessment for clinical and therapeutic trials.

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