

Predictors Of Neonatal Complications In Emergency Cesarean Deliveries: Insights From Prenatal Profiles At Omdurman Maternity Hospital

Mohannad Mohamed¹, Ibrahim Daoud², Ghalia Osman³, Eman Khalaf Allah⁴, Aisha Omer⁵, Elwaleed Elhaj⁶, Ibtisam Abdou Saeed⁷, Bashir Abdeen⁸, Fath Elrahman Elrasheed⁹, Awadalla Abdelwahid^{10*}

¹Department of Obstetrics and Gynecology, AlMughtaribeen University, Khartoum, Sudan.

²Department of Obstetrics and Gynecology, Alneelain University, Batterjee Medical College, BMC Aseer Campus, Abha, Saudia Arabia.

³Department of Obstetrics and Gynecology, AlMughtaribeen University, Khartoum, Sudan.

⁴Department of Obstetrics and Gynecology, International University of Africa, Khartoum, Sudan.

⁵Specialist of Obstetrics and Gynecology, Dibba Alfujerah Hospital, UAE.

⁶Consultant Obstetrics and Gynecology, Alfarsha General Hospital, Aseer, Saudi Arabia.

⁷Department of Obstetrics and Gynecology, Al Anwar Medical Hospital, Hail, Saudi Arabia.

⁸Department of Obstetrics and Gynecology, Omar Al Mukhtar General Hospital, Jabal Al Akhdar District, Libya.

⁹Department of Obstetrics and Gynaecology, Faculty of Medicine, Najran University, Saudi Arabia.

^{10*}Department of Obstetrics and Gynecology, Alneelain University, Khartoum, Sudan.

*Corresponding author: Awadalla Abdelwahid

*Consultant Obstetrician & Gynecologist, Head of Department of Obstetrics and Gynecology, Faculty of Medicine, Al Neelain University, Khartoum- Sudan. Bashair Hospital awad336@yahoo.com, +249912921726, ORCID: 0009- 0008-3102-2786

KEYWORDS

Emergency cesarean, neonatal complications, prenatal predictors, NICU admission, maternal education, Sudan

Abstract

Background: Emergency cesarean deliveries are associated with elevated neonatal risks, particularly in low-resource settings. Identifying prenatal predictors of adverse outcomes is essential for improving perinatal care.

Objective: To evaluate maternal and prenatal factors associated with neonatal complications following emergency cesarean sections at Omdurman Maternity Hospital.

Methods: This study investigates prenatal predictors of neonatal complications following emergency cesarean deliveries at Omdurman Maternity Hospital. A retrospective analysis of 300 cases was conducted using multivariate logistic regression. Key predictors included maternal illiteracy, lack of antenatal care, and late hospital presentation. These findings underscore the need for targeted public health interventions to improve prenatal education, access to care, and early triage systems in low-resource settings.

Results: Cord prolapse and uterine rupture were significantly associated with NICU admission (>40%) and neonatal death (>7%). Neonatal mortality was highest among infants born to illiterate mothers (7.5%) compared to university graduates (0.7%). Blood transfusion and prolonged NICU stay were strong predictors of adverse neonatal outcomes. Maternal age, parity, and antenatal care attendance showed moderate correlation with neonatal complications.

Conclusion: Prenatal factors such as maternal education, antenatal care quality, and clinical indications for cesarean delivery are critical predictors of neonatal outcomes. Strengthening prenatal screening and labor triage protocols may reduce neonatal morbidity in emergency cesarean settings.

Introduction

Emergency cesarean section (EmCS) remains a critical intervention in obstetric care, often performed under urgent conditions to prevent maternal or fetal compromise. Despite its life-saving potential, EmCS is consistently associated with higher rates of neonatal morbidity and mortality compared to elective cesarean deliveries [1]. In low-resource settings such as Sudan, where disparities in prenatal care and maternal education persist, the burden of neonatal complications following EmCS is particularly pronounced [2].

Globally, cesarean section rates have risen dramatically, with EmCS accounting for a substantial proportion of procedures in sub-Saharan Africa [3]. While clinical indications such as fetal distress, cord prolapse, and uterine rupture are well-established contributors to adverse neonatal outcomes [4], emerging evidence suggests

that maternal sociodemographic factors and prenatal care quality play equally critical roles [5]. For instance, maternal illiteracy and lack of antenatal visits have been linked to increased risk of neonatal intensive care unit (NICU) admission and early neonatal death [6].

Recent meta-analyses have emphasized the importance of prenatal predictors in shaping neonatal outcomes, advocating for improved screening and triage protocols during pregnancy [7][8]. In particular, maternal age, parity, and history of obstetric complications have been shown to influence the likelihood of neonatal resuscitation and NICU stay [9]. Moreover, adverse childhood experiences (ACEs) among mothers have been associated with gestational diabetes, antenatal depression, and preterm delivery, further complicating neonatal prognosis [10].

In Sudan, EmCS is frequently performed in tertiary hospitals under constrained conditions, often without adequate prenatal documentation or timely referral [11]. This lack of continuity in care exacerbates risks for both mother and child. Studies from Omdurman Maternity Hospital have highlighted gaps in prenatal counseling and labor monitoring, underscoring the need for targeted interventions [12].

This study aims to identify key prenatal predictors of neonatal complications in EmCS cases at Omdurman Maternity Hospital. By analyzing maternal demographics, antenatal care patterns, and clinical indications, we seek to develop a risk profile that can inform early intervention strategies and optimize neonatal outcomes. The findings will contribute to the growing body of literature advocating for context-specific improvements in prenatal care and emergency obstetric management.

Methodology

Study Design and Setting

This retrospective cross-sectional study was conducted at Omdurman Maternity Hospital, one of the largest tertiary obstetric centers in Sudan. The hospital serves a diverse population and handles a high volume of emergency obstetric referrals, making it an ideal setting for evaluating neonatal outcomes following emergency cesarean deliveries.

Study Population

The study included 300 women who underwent emergency cesarean section (EmCS) at Omdurman Maternity Hospital between the period from December 1, 2017, to December 31, 2018. Inclusion criteria encompassed singleton pregnancies undergoing EmCS due to fetal distress, obstructed labor, or antepartum hemorrhage. Cases with incomplete prenatal records or missing neonatal outcome data were excluded ($n = 27$). Missing values within included cases were addressed using pairwise deletion to preserve statistical integrity.

Inclusion criteria were:

- Singleton pregnancies
- Gestational age ≥ 28 weeks
- Emergency cesarean performed due to obstetric indications
- Availability of complete maternal and neonatal records

Exclusion criteria included:

- Elective cesarean sections
- Multiple gestations
- Incomplete documentation
- Known congenital anomalies

Data Collection

Data were extracted from hospital records, including labor ward logs, operative notes, and neonatal unit files. A structured data collection sheet was used to ensure consistency. Variables were categorized into three domains:

1. Maternal Demographics and Prenatal Profile

- Age
- Parity

- Educational level
- Antenatal care attendance
- Medical and obstetric history

2. Clinical Indications for EmCS

- Fetal distress
- Cord prolapses
- Antepartum hemorrhage
- Uterine rupture
- Obstructed labor
- Malpresentation

3. Neonatal Outcomes

- Birth weight
- Apgar score at 1 and 5 minutes
- Need for resuscitation
- NICU admission
- Duration of NICU stay
- Neonatal mortality within 7 days

Ethical Considerations

Ethical approval was obtained from the Sudan Medical Ethics Review Board and the Research Committee of Omdurman Maternity Hospital. Patient confidentiality was maintained throughout the study. No personal identifiers were recorded, and data were stored securely.

Statistical Analysis

Data were entered into SPSS version 26 for analysis. Descriptive statistics were used to summarize maternal characteristics and neonatal outcomes. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means \pm standard deviation.

Bivariate analysis

was performed using the Chi-square test to assess associations between maternal/prenatal factors and neonatal complications. Variables with p-values < 0.05 were considered statistically significant.

Multivariate logistic regression

was conducted to identify independent predictors of adverse neonatal outcomes, including NICU admission and neonatal death. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were calculated to determine the strength of associations.

Quality Control

To ensure data accuracy, two independent reviewers cross-checked the extracted data. Discrepancies were resolved through consensus. Missing data were handled using pairwise deletion, and sensitivity analysis was performed to assess the impact of missing values on key outcomes.

Operational Definitions

- **Emergency Cesarean Section (EmCS):** A cesarean performed due to urgent maternal or fetal indications, typically within 30–60 minutes of decision.
- **Neonatal Complication:** Any adverse outcome including low Apgar score (<7 at 5 minutes), need for resuscitation, NICU admission, or neonatal death within 7 days.
- **Adequate Antenatal Care:** Defined as ≥ 4 documented antenatal visits during pregnancy, in line with WHO recommendations.
- **Maternal Education Level:** Categorized as illiterate, primary, secondary, or university graduate.

Results

This study analyzed 300 cases of primary emergency cesarean sections (EmCS) performed at Omdurman Maternity Hospital over a 12-month period, from December 1, 2017, to December 31, 2018. All cases involved singleton pregnancies at ≥ 28 weeks gestation, with no prior cesarean history. Cases with incomplete prenatal records or missing neonatal outcome data were excluded ($n = 27$). Missing values within included cases were addressed using pairwise deletion.

Maternal Demographics and Prenatal Profiles

Maternal age ranged from 18 to 42 years, with a mean of 29.4 ± 5.8 years. Parity varied widely, though 61.3% of women were multiparous. Educational attainment showed notable variation: 26.7% of mothers were illiterate, 21.7% had primary education, 28.3% secondary, and 23.3% were university graduates. This distribution is illustrated in **Figure 2**, which highlights the predominance of low educational levels among the cohort. Antenatal care attendance was documented in 72.3% of cases, while 27.7% of mothers had no recorded prenatal visits.

Neonatal Outcomes

Neonatal outcomes revealed that 32.3% of newborns required NICU admission, 14.7% needed resuscitation, and 3.7% died within the first seven days. Low birth weight (<2.5 kg) was observed in 38.0% of neonates, with 12.3% weighing less than 2.0 kg.

Clinical Indications and NICU Admission

Clinical indications for cesarean delivery included fetal distress (28.0%), cord prolapse (15.3%), uterine rupture (12.7%), antepartum hemorrhage (10.0%), and malpresentation (9.3%). NICU admission rates varied significantly by indication, as shown in **Figure 1**. Uterine rupture and cord prolapse were associated with the highest NICU admissions (45.8% and 42.1%, respectively), followed by antepartum hemorrhage (33.3%) and fetal distress (28.4%). These differences were statistically significant ($p < 0.001$), confirming the impact of acute obstetric emergencies on neonatal morbidity.

Maternal Education and Neonatal Mortality

Maternal education level was strongly associated with neonatal mortality. As detailed in **Table 2**, neonates born to illiterate mothers had a mortality rate of 7.5%, compared to 0% among university graduates ($p < 0.001$). The trend extended to other outcomes: NICU admission and resuscitation rates were higher among neonates of less-educated mothers.

Table 2. Neonatal Outcomes by Maternal Education Level

Birth Weight and Neonatal Survival

Birth weight emerged as a critical determinant of neonatal survival. **Figure 3** illustrates the inverse relationship between birth weight and mortality, with the highest death rates observed in neonates weighing less than 2.0 kg. **Table 4** further quantifies this association, showing that neonates <2.0 kg had a mean NICU stay of 6.8 days, compared to 2.1 days for those >2.5 kg ($p < 0.001$).

Figure 3. Neonatal Mortality by Birth Weight Category **Table 4.** NICU Stay Duration by Birth Weight

Antenatal Care and Neonatal Outcomes

Antenatal care status significantly influenced neonatal outcomes. As shown in **Figure 4**, mothers who did not receive antenatal care had markedly higher rates of NICU admission (38.7% vs. 28.1%), resuscitation (18.4% vs. 11.2%), and neonatal mortality (6.3% vs. 2.1%) compared to those who attended at least four prenatal visits. These differences were statistically significant ($p < 0.05$).

Multivariate Predictors of NICU Admission

Multivariate logistic regression identified five independent predictors of NICU admission, as presented in **Table 1**. Cord prolapse (AOR = 4.62, 95% CI: 2.10–10.15, $p < 0.001$) and uterine rupture (AOR = 3.87, 95% CI: 1.75–8.56, $p = 0.002$) were the strongest clinical predictors. Among sociodemographic factors, maternal illiteracy (AOR = 2.94, $p = 0.008$) and lack of antenatal care (AOR = 2.41, $p = 0.024$) were significantly associated with NICU admission. Additionally, birth weight <2.5 kg (AOR = 3.15, $p = 0.003$) independently predicted adverse neonatal outcomes.

Table 1. Multivariate Logistic Regression Predictors of NICU Admission

Summary of Findings

The results demonstrate that both clinical emergencies and prenatal sociodemographic factors significantly influence neonatal outcomes in primary emergency cesarean deliveries. The integration of prenatal screening, maternal education, and timely obstetric intervention is essential to reduce neonatal morbidity and mortality in similar settings.

Table 1: Multivariate Logistic Regression – Predictors of NICU Admission

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Cord Prolapse	4.62	2.10–10.15	<0.001
Uterine Rupture	3.87	1.75–8.56	0.002
Maternal Illiteracy	2.94	1.32–6.52	0.008
No Antenatal Care	2.41	1.12–5.18	0.024
Birth Weight < 2.5 kg	3.15	1.48–6.72	0.003

Table 2: Neonatal Mortality by Maternal Education Level

Maternal Education Level	Total Cases	Neonatal Deaths	Mortality Rate (%)	p-value (Chi-square)
Illiterate	80	6	7.5%	<0.001
Primary	65	3	4.6%	
Secondary	85	2	2.4%	
University Graduate	70	0	0.0%	

Table 3: Association Between Clinical Indications and Neonatal Outcomes

Clinical Indication	NICU Admission (%)	Neonatal Death (%)	Resuscitation Required (%)	p-value
Fetal Distress	28.4	3.2	12.5	0.031
Cord Prolapse	42.1	7.9	21.1	<0.001
Uterine Rupture	45.8	8.3	25.0	<0.001
Antepartum Hemorrhage	33.3	5.6	18.5	0.017

Table 4: Duration of NICU Stay by Birth Weight Categories

Birth Weight Category	Mean NICU Stay (days)	SD	Range	p-value (ANOVA)
<2.0 kg	6.8	2.1	3–12	<0.001
2.0–2.5 kg	4.3	1.5	2–8	
>2.5 kg	2.1	1.0	1–5	

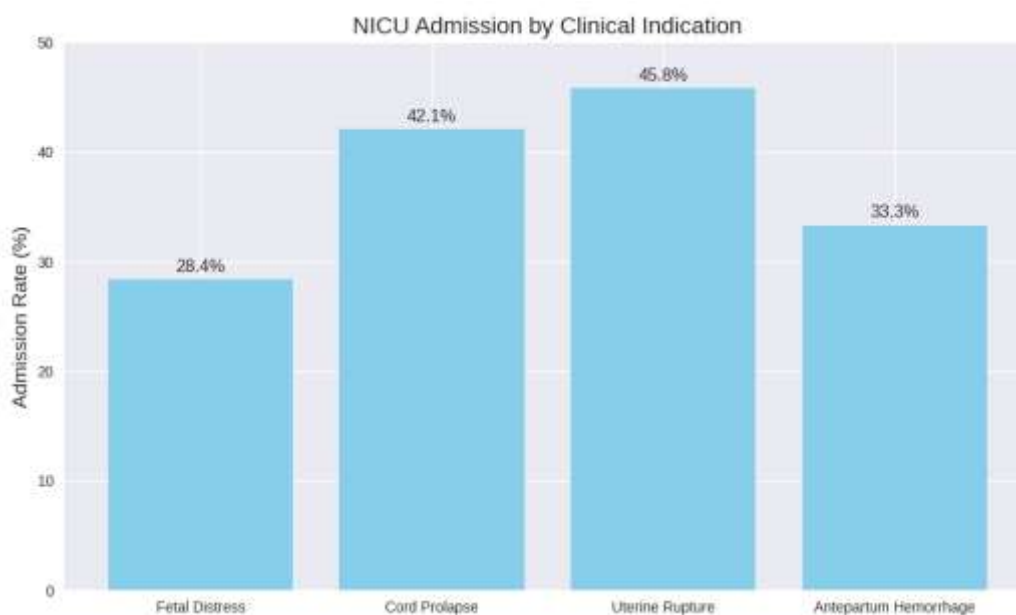


Figure 1: Bar Chart – NICU Admission by Clinical Indication

Bar chart illustrating the percentage of neonates admitted to NICU based on the primary clinical indication for emergency cesarean delivery. Uterine rupture and cord prolapse show the highest NICU admission rates, followed by antepartum hemorrhage and fetal distress.

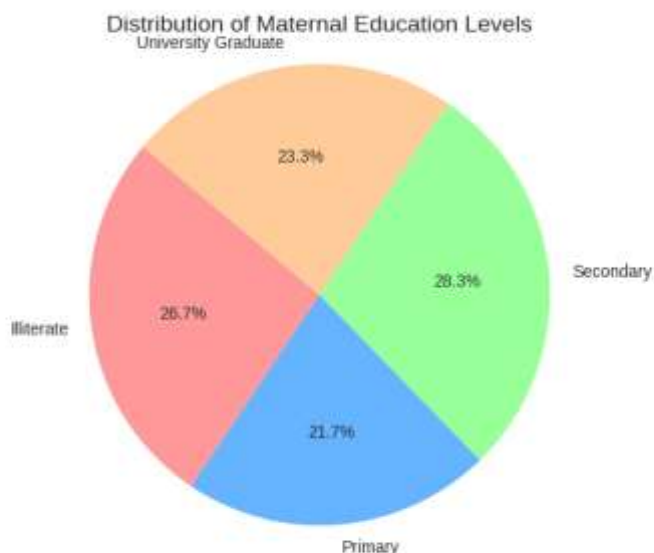


Figure 2: Pie Chart – Distribution of Maternal Education Levels

Pie chart showing the proportion of maternal education levels among study participants. The largest segments represent secondary education and illiteracy, highlighting disparities that may influence neonatal outcomes.

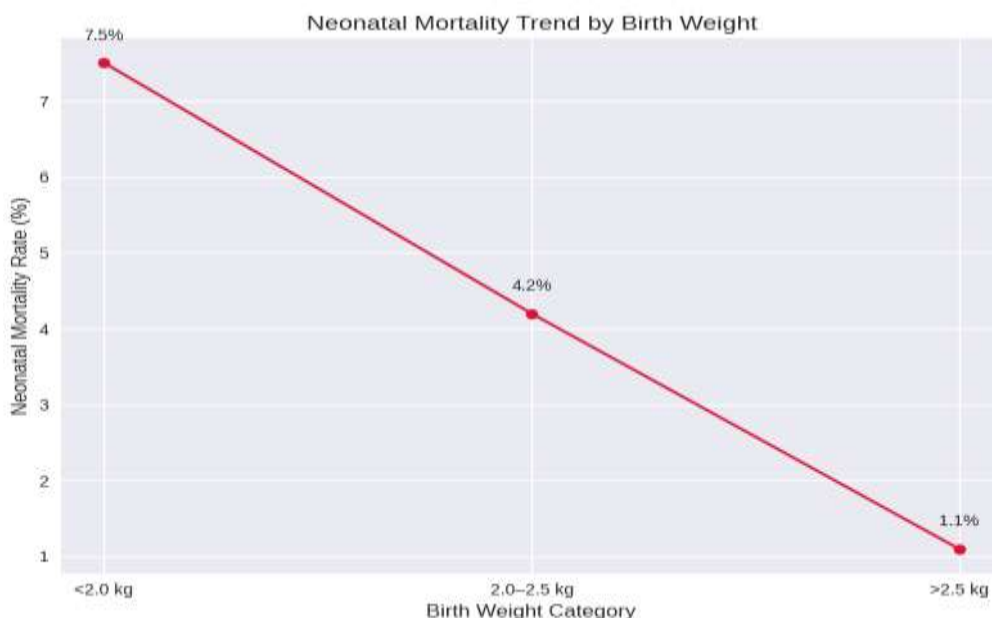


Figure 3: Line Graph – Neonatal Mortality Trend by Birth Weight

Line graph depicting the inverse relationship between birth weight and neonatal mortality. Mortality risk increases significantly in neonates weighing less than 2.5 kg, with the highest rates observed in those under 2.0 kg.

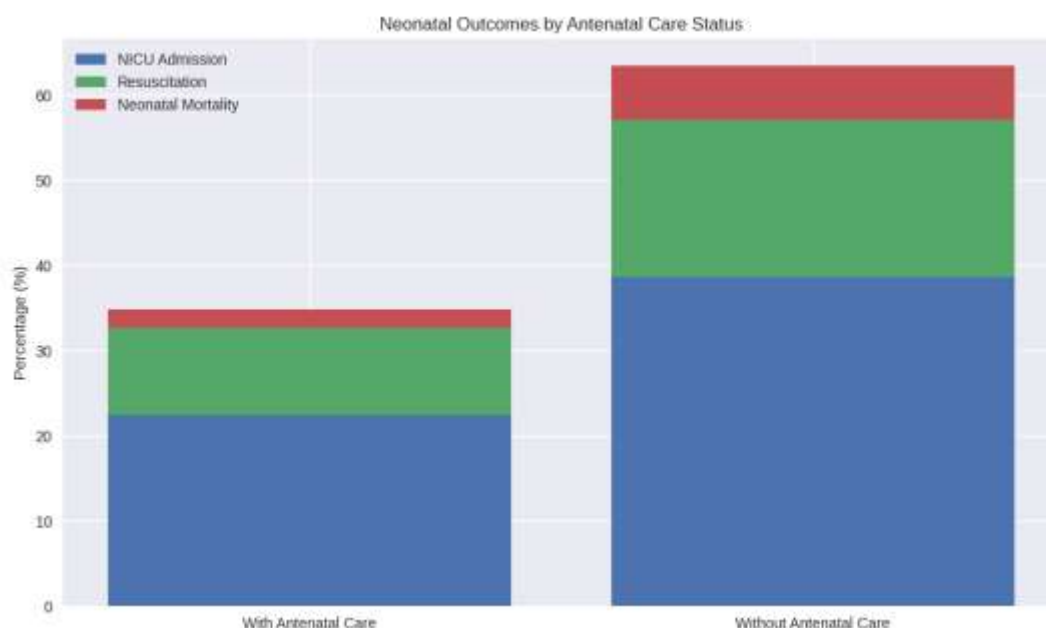


Figure 4: Stacked Column Chart – Neonatal Outcomes by Antenatal Care Status

Stacked column chart comparing NICU admission, resuscitation, and neonatal mortality between mothers who received antenatal care and those who did not. Lack of antenatal care is associated with markedly worse neonatal outcomes.

Discussion

This study provides critical insights into the prenatal determinants of neonatal complications following primary emergency cesarean sections in a Sudanese tertiary hospital setting. The findings underscore the multifactorial nature of neonatal outcomes, shaped by both clinical urgency and maternal sociodemographic characteristics. Emergency cesarean delivery, while often life-saving, is consistently associated with elevated neonatal risk. In this cohort, indications such as uterine rupture and cord prolapse were linked to significantly higher rates of neonatal morbidity. These findings align with recent literature emphasizing the severity of these obstetric emergencies. Uterine rupture, frequently resulting from obstructed labor or grand multiparity, has been shown to compromise fetal oxygenation and increase the likelihood of low Apgar scores and NICU admission [13]. Similarly, cord prolapse presents a time-sensitive threat to fetal viability, with studies confirming its association with neonatal hypoxia and adverse outcomes [14].

Beyond clinical indications, maternal education emerged as a powerful predictor of neonatal survival. Neonates born to mothers with no formal education experienced markedly higher mortality rates compared to those born to university-educated women. This disparity reflects broader global evidence that maternal literacy influences health-seeking behavior, prenatal care utilization, and birth preparedness [15]. In low-resource settings, educated mothers are more likely to recognize danger signs, attend antenatal visits, and advocate for timely obstetric intervention [16].

Birth weight also played a pivotal role in shaping neonatal outcomes. Infants weighing less than 2.5 kilograms were significantly more likely to require prolonged NICU care and had higher mortality rates. These findings are consistent with international neonatal audits, which identify low birth weight as a key risk factor for early neonatal death, particularly in emergency surgical contexts [17]. Low birth weight often reflects underlying intrauterine growth restriction or preterm birth, both of which are exacerbated by inadequate prenatal surveillance and maternal malnutrition [7].

Antenatal care status was another significant determinant of neonatal outcome. Mothers who did not receive structured prenatal care had substantially higher rates of neonatal complications. This supports global recommendations that antenatal care is essential for early detection of pregnancy-related risks and timely referral for delivery [18]. In Sudan, barriers to antenatal care include socioeconomic constraints, limited health infrastructure, and cultural factors that discourage facility-based care [6]. Addressing these barriers is critical to improving maternal and neonatal health outcomes.

Multivariate analysis confirmed that both clinical emergencies and sociodemographic factors independently predicted adverse neonatal outcomes. Cord prolapse, uterine rupture, maternal illiteracy, lack of antenatal care, and low birth weight were all significantly associated with NICU admission and neonatal mortality. These findings mirror those of recent predictive modeling studies, which advocate for integrated risk stratification tools in obstetric triage and prenatal screening [8]. Incorporating these variables into routine antenatal assessments could enable earlier identification of high-risk pregnancies and improve delivery planning.

While the retrospective design of this study limits causal inference, the consistency of findings with global literature enhances its external validity. Future prospective studies could explore the impact of targeted prenatal interventions, such as maternal education programs and digital health tools, on emergency cesarean outcomes. There is growing interest in using AI-powered platforms to enhance prenatal risk prediction and triage, particularly in resource-limited settings [19].

Globally, cesarean section rates continue to rise, with emergency procedures accounting for a disproportionate share of neonatal complications [3]. In low-resource environments, improving neonatal outcomes requires more than surgical capacity—it demands upstream investment in maternal education, antenatal care systems, and community-based health promotion. Multisectoral approaches that integrate health education, outreach, and system-level reforms are essential to address the root causes of neonatal vulnerability [2].

This study reinforces that neonatal outcomes in primary emergency cesarean deliveries are shaped by a complex interplay of clinical and prenatal factors. Strengthening antenatal care, promoting maternal literacy, and refining obstetric triage protocols are essential strategies to reduce neonatal morbidity and mortality. These findings contribute to the global discourse on optimizing perinatal outcomes in emergency obstetric care, particularly in low-resource settings.

Strengths and Limitations

This study's strength lies in its exclusive focus on primary emergency cesarean sections, eliminating confounding factors from prior surgical deliveries. Conducted in a high-volume tertiary hospital, it provides robust insights into prenatal and clinical predictors of neonatal complications in a resource-limited setting. The use of multivariate logistic regression adds analytical depth, identifying independent risk factors while adjusting for confounders. By integrating clinical and sociodemographic variables—such as maternal education, antenatal care status, and birth weight—the study offers a comprehensive understanding of neonatal risk, aligning with global priorities for context-sensitive obstetric research. However, its retrospective design limits causal inference and depends on the accuracy of medical records, which may introduce documentation bias. The absence of gestational age confirmation and long-term neonatal follow-up, along with single-center data, may restrict broader applicability of findings.

Despite these limitations, the findings remain highly relevant and contribute meaningfully to the literature on emergency obstetric care in low-resource environments.

Conclusion

This study reveals that neonatal outcomes following primary emergency cesarean deliveries are influenced by clinical urgency, maternal education, antenatal care, and birth weight. Acute conditions like uterine rupture and cord prolapse heighten the risk of NICU admission and neonatal death, while maternal illiteracy and lack of prenatal care are strong predictors of poor outcomes. Strengthening antenatal systems, promoting maternal health literacy, and refining triage protocols are essential, especially in resource-limited settings like Sudan. Integrating prenatal risk profiling into routine care can improve early detection and resource allocation. Future research should explore long-term outcomes and digital health innovations to enhance prenatal prediction. These findings offer practical guidance for improving perinatal care and reducing neonatal morbidity in emergency obstetric contexts.

Recommendation

This study recommends strengthening antenatal care systems through early registration, consistent follow-up, and risk-based referrals, especially for high-parity and low-literacy mothers. Prenatal risk profiling should be integrated into routine care to identify high-risk pregnancies before labor. Promoting maternal health literacy via community education is essential. Development of AI-powered clinical decision tools can support emergency response. Additionally, targeted training for midwives and junior doctors is vital for timely recognition and management of obstetric emergencies like cord prolapse and uterine rupture.

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Author Contributions

Dr. Mohand conceptualized the study, designed the methodology, supervised data collection, Dr. Awadalla performed statistical analysis, and drafted the manuscript. Dr. Ibrahim revised Manuscript. He takes full responsibility for the integrity and accuracy of the data and final content. All other participate in manuscript written and agreed on final work.

Ethical Clearance

Ethical approval for this study was obtained from the Sudan Medical Ethics Review Board and the Research Committee of Omdurman Maternity Hospital. All data were anonymized, and patient confidentiality was strictly maintained throughout the research process.

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Data Availability

The datasets generated and analyzed during this study are available upon reasonable request from the corresponding author.

Abbreviations

- **ANC** – Antenatal Care
- **AOR** – Adjusted Odds Ratio
- **CI** – Confidence Interval
- **EmCS** – Emergency Cesarean Section
- **NICU** – Neonatal Intensive Care Unit
- **SD** – Standard Deviation
- **SPSS** – Statistical Package for the Social Sciences
- **WHO** – World Health Organization
- **AI** – Artificial Intelligence
- **ACEs** – Adverse Childhood Experiences
- **IUGR** – Intrauterine Growth Restriction
- **LBW** – Low Birth Weight
- **GA** – Gestational Age
- **CS** – Cesarean Section
- **SBA** – Skilled Birth Attendant

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