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# War-Induced Maternal Stress and Its Relationship to Caesarean Section Rates During Armed Conflict in Sudan, 2025: A Cross-Sectional Study

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## Abstract

# Background

Since April 2023, the armed conflict in Sudan has precipitated the near-collapse of the healthcare system and induced unprecedented psychological distress among pregnant women. This study investigates the relationship between war-induced maternal stress and Cesarean delivery (CD) rates in conflict-affected regions of Sudan.

# Methods

A cross-sectional study was conducted among 177 women who delivered after April 2023. Psychological stress was assessed using the Perceived Stress Scale (PSS-10). Data were analyzed using multivariable logistic regression and mediation analysis to determine the independent impact of stress on delivery mode and its role in mediating the effects of displacement.

# Results

The CD rate was remarkably high at 41.8%. The mean PSS score was 22.8 ± 6.3; notably, Women undergoing Cesarean delivery had significantly higher mean PSS scores than those with vaginal delivery (24.9 vs. 21.2; $p < 0.001$). Although categorical stress levels were not significantly associated with delivery mode, psychological stress remained independently associated with Cesarean delivery in multivariable analysis. Multivariable analysis confirmed that each one-point increase in the PSS score was associated with a 9.8% increase in the odds of undergoing a CD (AOR = 1.098; 95% CI: 1.030–1.169; $p = 0.004$). Furthermore, Mediation analysis suggested that psychological stress may represent one pathway linking displacement and Cesarean delivery.

# Conclusion

War-induced psychological stress emerged as an independent factor associated with Cesarean delivery. With higher stress levels being associated with an increased likelihood of Cesarean delivery. These findings underscore the "invisible costs" of conflict, where emotional trauma may contribute to increased obstetric interventions. Integrating mental health screening and psychosocial support into humanitarian obstetric care is urgent to mitigate the long-term maternal and neonatal consequences of the conflict.

## Introduction

War is defined not only as direct conflict between opposing parties but also as a broad spectrum of aggressions that profoundly impact the social and economic stability of communities. It exerts a severe impact on population health, often resulting in mortality and disability rates that exceed those caused by

major diseases. War disrupts social structures and inflicts long-term physical and psychological harm. Direct casualties represent only a fraction of its total impact, as indirect consequences—such as poverty and malnutrition—frequently remain underreported. As a political tool, war precipitates widespread humanitarian disasters and public health emergencies(1, 2).

Since April 2023, the armed conflict in Sudan has severely disrupted healthcare infrastructure, leaving approximately 11 million people in urgent need of assistance. Over 100 attacks on healthcare facilities in Sudan have been documented; however, the true figure is likely higher, as escalating violence limits the ability to independently verify incidents and associated casualties (1). The ongoing conflict has led to a near collapse of health-care services. By 23 July, fewer than one-third of hospitals in affected areas remained operational, with many rendered unusable or halted services due to attacks, evacuation, conversion for military use, prolonged power cuts, and an acute shortage of medical supplies and skilled health workers particularly in conflict-affected states. This has severely limited access to quality antenatal care, safe delivery facilities, and essential obstetric services(1). The seizure of key public health institutions, including the National Public Health Laboratory, the Central Blood Bank, and National Medical Supplies, has further compromised service delivery(3).

Prior to the conflict, Sudan's healthcare system was already underfunded and fragmented, characterized by significant inequities regarding access, quality, and affordability. Health worker density remained far below World Health Organization (WHO) minimum thresholds, and the majority of healthcare costs were paid out of pocket. While precise figures for maternal deaths during the current conflict are not yet fully documented, literature suggests that displaced women of reproductive age in conflict settings experience mortality rates three times higher than those in stable environments. These conditions contribute to nearly 60% of the global burden of maternal mortality. (1, 4) Maternal mental health has also been significantly affected, with a marked increase in the prevalence of anxiety and depression. In a study conducted in Sudan during the ongoing war, 24% of the total sample (n = 388) experienced adverse outcomes, including antenatal, intrapartum, and postpartum complications. (1)

In this context, understanding obstetric outcomes during armed conflict is imperative. Although maternal mortality in conflict zones has been studied, the specific impact and prevalence of chronic maternal stress on Cesarean delivery (CD) rates remains poorly understood. Maternal stress, exacerbated by war-related factors such as displacement, insecurity, and limited access to essential services, has become a major concern(1). Evidence indicates that maternal stress has the strongest impact on birth outcomes when exposure occurs during the first or second trimester. Research in this field has demonstrated that prenatal stress can elevate cortisol levels and trigger systemic inflammation; furthermore, psychosocial factors further compound these negative pregnancy outcomes.(5) While many studies have established a general association between maternal anxiety, depression, and post-traumatic stress disorder (PTSD) with adverse birth outcomes, limited evidence has demonstrated a direct correlation between maternal stress and CD rates(6). Chronic psychological distress throughout pregnancy is associated with an increased risk of neonatal and obstetric complications, including preterm birth, postpartum depression, and unplanned Cesarean delivery (7). Stress-related neuroendocrine activation as early as 15–20 weeks'

gestation has been associated with adverse outcomes later in pregnancy. These effects are linked to epigenetic mechanisms, whereby early placental corticotropin-releasing hormone (CRH) expression influences the timing and course of delivery rather than inducing immediate labor. In addition, stress-related inflammatory and immune dysregulation during pregnancy has been linked to various adverse obstetric outcomes(8).

The global rise in cesarean delivery has emerged as a public health concern, particularly in settings where rates exceed evidence-based medical necessity (9). CD rates vary widely across regions, ranging from over 63.4% in Eastern Asia to 7.1% in Sub-Saharan Africa. National averages often obscure inequalities, with some populations experiencing a deficit of necessary procedures while others undergo medically unnecessary surgeries. Despite ongoing research, these inequities persist, characterized by increasing rates in overusing countries and widening access gaps in underserved regions(9). In conflict settings, such as Yemen, CD rates have been reported to be triple the WHO-recommended threshold. In Libya, a study conducted between 2003 and 2013 found that CD rates more than doubled over twelve years, with significant increases observed during periods of conflict(10). In Sudan, CD rates have increased significantly during the current conflict; for instance, a study at Atbara Maternity Hospital reported a rise from 25.7% in 2022 (pre-war) to 39.69% between July and September 2024 (11). Similarly, among Syrian refugees, CD rates increased sharply during the war, from 29% in 2010 to 51% by early 2017.(12) While the Cesarean delivery is a life-saving procedure when medically indicated, overuse can lead to serious complications—such as surgical site infections (10.9% incidence)—with higher risks associated with emergency procedures compared to elective ones (13). Cesarean deliveries also contribute disproportionately to maternal mortality in low-income countries, with mortality up to 100.

Therefore, the aim of this study was to examine the relationship between war-induced maternal stress and the rate of Cesarean deliveries among women in conflict-affected areas in Sudan. This study addresses a critical research gap regarding the impact of maternal stress in such volatile environments. Understanding this relationship can provide valuable insights for policymakers, healthcare professionals, and humanitarian organizations, facilitating the development of targeted interventions to improve maternal health outcomes in conflict-affected regions. Notably, the WHO recommends that Cesarean deliveries should not exceed 15% of all births(9)

## Methods

# Study Design and Setting:

This cross-sectional study was conducted in Sudan following the outbreak of armed conflict on April 15, 2023, to investigate the relationship between war-induced maternal stress and Cesarean delivery (CD) rates in conflict-affected regions. This design facilitated a point-in-time assessment of maternal stress and delivery modes during the ongoing conflict.

## Study Population

The study enrolled pregnant women exposed to the armed conflict after April 15, 2023, who delivered in healthcare facilities, refugee camps, internally displaced person (IDP) camps, or community settings within conflict-affected areas.

## Inclusion Criteria:

- Women of reproductive age delivering after 15 April 2023.
- Exposure to conflict-related events during pregnancy.
- A history of vaginal or Cesarean delivery during the study period.

## Exclusion Criteria:

- Pre-existing medical conditions predisposing to pregnancy complications (e.g., pre-eclampsia, placenta previa).
- Pre-existing psychiatric disorders (e.g., depression, anxiety, or other diagnosed mental health conditions).
- Elective CD for non-medical reasons.
- A history of two or more previous CD procedures.
- Cases where the current CD was indicated solely due to previous CD Scar.

## Sample Size and Sampling:

The required sample size was calculated using a single population proportion formula, based on an estimated prevalence of 23% and a 95% confidence interval, resulting in a target of 273 participants. Participants were recruited using convenience sampling to ensure the inclusion of women from various conflict-affected areas. Although the calculated minimum sample size was 273 participants, recruitment was substantially affected by the ongoing armed conflict. Population displacement, insecurity, internet disruptions, and limited access to healthcare facilities restricted participant enrollment, resulting in a final sample of 177 women.

# Data Collection :

Data were collected using a structured questionnaire, specifically developed for the purposes of this study. To ensure linguistic and cultural appropriateness, the tool was initially drafted in Arabic. The questionnaire's content and clarity were validated through a pilot study involving 30 participants from a similar population, whose data were excluded from the final analysis. The instrument was designed to capture comprehensive information across the following domains:

- Socio-demographic characteristics: Age, marital status, and residency.
- Obstetric history: Gravidity, parity, history of previous Cesarean delivery (CD), and prior pregnancy or delivery complications.
- Medical and mental health status: History of chronic diseases and diagnosed psychiatric disorders.
- Exposure to conflict-related events: Displacement status and specific war-related experiences.
- Healthcare access and stress assessment: Conflict-related stress exposure and the Perceived Stress Scale (PSS-10). Stress was assessed using the Arabic translation of the PSS-10, which was cross-referenced with the original English version to ensure conceptual equivalence. Both versions are recognized by the scale's originators at Carnegie Mellon University. The PSS-10 was selected for its brevity and validated utility; additionally, two specific questions regarding pregnancy-related stress were incorporated to enhance contextual relevance. Although the survey was administered postnatally, participants were explicitly instructed to answer the PSS-10 based on their experiences and feelings during the pregnancy period.
- Delivery outcomes: Delivery method, gestational age at delivery, and pregnancy/delivery complications.

The questionnaire was distributed electronically via online platforms. A hybrid data collection approach was utilized, combining researcher-led interviews at healthcare facilities with self-administered online surveys. All data collection was supervised by trained co-investigators to ensure accuracy, consistency, and completeness. An English version of the full questionnaire is provided as a supplementary file.

## Variables:

Dependent Variable: Delivery type, categorized as a binary variable (Vaginal Delivery vs. Cesarean delivery).

Independent Variable: Psychological stress, measured using the Arabic-translated version of the Perceived Stress Scale (PSS-10). This 10-item scale yields scores ranging from 0 to 40, which were categorized into mild (0–12), moderate (13–24), and high (25–36) stress levels. For statistical analysis, the PSS score was also treated as a continuous variable.

Covariates (Confounders): Variables controlled in the statistical analysis included age (continuous), history of previous Cesarean delivery (Yes/No), gestational age at delivery (categorical: <28.5 weeks, 28.5–<39 weeks, 39 weeks, > 39 weeks), displacement (Yes/No), history of chronic diseases (Yes/No), and pre-war diagnosed mental disorders (Yes/No).

# Data Analysis:

Data were cleaned, coded in Excel, and analyzed using SPSS version 26.0. A p-value < 0.05 was considered statistically significant.

Descriptive Analyses: Frequencies and percentages were used for categorical variables, while means with standard deviations were used for continuous variables to describe sample characteristics.

Bivariate Analyses: Independent sample t-tests were used to compare the means of continuous variables between the vaginal delivery and Cesarean delivery groups. Chi-square tests compared the distribution of categorical variables between the two groups.

Binary Logistic Regression: Univariable logistic regression estimated the crude Odds Ratio (OR) for each independent variable. Multivariable logistic regression estimated the adjusted Odds Ratio (AOR) to control for potential confounders. The number of candidate variables included in the multivariable model was selected to maintain an acceptable events-per-variable ratio and reduce the risk of model overfitting. Model quality was assessed using the omnibus test of model coefficients, the Hosmer–Lemeshow goodness-of-fit test, and Nagelkerke $R^2$ to estimate the explained variance.

Mediation Analysis: The Baron and Kenny methodology was applied to assess whether psychological stress mediates the relationship between displacement and Cesarean delivery, testing the following paths:

1. a. Path A: From displacement to psychological stress.
2. b. Path B: From psychological stress to Cesarean delivery.
3. c. Path C: The total effect of displacement on Cesarean delivery.
4. d. Path C': The direct effect of displacement on Cesarean delivery after controlling for psychological stress.

Receiver Operating Characteristic (ROC) Curve Analysis: ROC analysis evaluated the discriminative ability of the PSS score to differentiate between vaginal and Cesarean deliveries. The Area Under the Curve (AUC) with 95% confidence intervals was calculated, and the optimal cut-off point was determined using Youden's Index to maximize sensitivity and specificity.

# Results

### 1. Baseline Characteristics of the Study Sample

A total of 177 pregnant women meeting the inclusion criteria were enrolled in the study. Among them, 103 women (58.2%) delivered via spontaneous vaginal delivery (SVD), while 74 (41.8%) delivered via Cesarean delivery (CD). All vaginal deliveries included in this study were spontaneous, and no operative vaginal deliveries (forceps- or vacuum-assisted deliveries) were recorded.. The mean age of the participants was 28.9 ± 5.3 years. The vast majority of the study sample (96.6%) were married (Table 1). Regarding obstetric history, 10.2% of participants reported one previous Cesarean delivery. Comparative analysis between the vaginal and CD delivery groups revealed no statistically significant differences in most sociodemographic characteristics, including age and marital status. However, a history of previous Cesarean delivery was significantly more prevalent among women in the CD group (18.9%) compared to

those in the vaginal delivery group (3.9%; p = 0.001). Furthermore, a statistically significant difference was observed in gestational age at delivery (p = 0.008), with a higher proportion of deliveries occurring prior to 39 weeks in the CD group.

Table 1
Socio-demographic, Obstetric, and Stress Characteristics of the Study Sample (N = 177)

| Characteristic | Category | Value (N = 177) |
|---|---|---|
| **Age (Years)** | | 28.8 (5.3) |
| **Perceived Stress Scale Score** | | 22.7 (6.8) |
| **Marital Status** | Married | 96.60% |
| | Divorced | 0.60% |
| | Separated | 2.80% |
| **Displacement Status** | Displaced | 75.70% |
| | Not Displaced | 24.30% |
| **Previous Cesarean delivery History** | No history of Previous CD | 89.80% |
| | Has history of previous CD | 10.20% |
| **Perceived Stress Level** | Low | 10.20% |
| | Moderate | 44.63% |
| | High | 45.19% |
| **GA (weeks)** | < 28.5 weeks | 2.80% |
| | 28.5 - <39 weeks | 9.60% |
| | 39 weeks | 62.70% |
| | > 39 weeks | 24.70% |
| **Period of Pregnancy in Conflict Zone [a]** | Was in a safe place | 66 (52%) |
| | 1st trimester | 19 (15%) |
| | 2nd trimester | 17 (13.4%) |
| | 3rd trimester | 25 (19.7%) |

Legend: Values are presented as mean (standard deviation, SD) for continuous variables and frequency (%) for categorical variables. PSS = Perceived Stress Scale; GA = Gestational Age; CD = Cesarean Delivery.

 Calculated based on participants who were actively pregnant during the conflict period (n = 127$).

Table 2
**A** Comparison of Baseline Characteristics Between Vaginal Delivery and Cesarean Delivery Groups (N = 177).

| Characteristic | Vaginal Delivery (N = 103) | Cesarean delivery (N = 74) | Test statistic | P-value |
|---|---|---|---|---|
| **Age (years)** | 29.45 (5.66) | 28.13 (4.77) | t = 1.56 | 0.121 |
| **Marital Status** | | | $\chi^2$ = 1.40 | 0.495 |
| Married | (97.1%) 100 | (95.9%) 71 | | |
| Divorced | (0%) 0 | (1.4%) 1 | | |
| Separated | (2.9%) 3 | (2.7%) 2 | | |
| **Pre-War Residence** | | | $\chi^2$ = 6.89 | 0.736 |
| Khartoum State | (59.2%) 61 | (56.8%) 42 | | |
| Other Sudanes States | (34.0%) 35 | (39.2%) 29 | | |
| Outside Sudan | (5.8%) 6 | (4.1%) 3 | | |
| **Displacement Status** | | | $\chi^2$ = 0.12 | 0.728 |
| Not Displaced | (25.2%) 26 | (23.0%) 17 | | |
| Displaced | (74.8%) 77 | (77.0%) 57 | | |
| **Previous CD History** | | | $\chi^2$ = 10.66 | **0.001** |
| No | (96.1%) 99 | (81.1%) 60 | | |
| Yes | (3.9%) 4 | (18.9%) 14 | | |
| **GA at Delivery** | | | $\chi^2$ = 11.87 | **0.008** |
| < 28.5 weeks | (1.0%) 1 | (5.4%) 4 | | |
| 28.5 - <39 weeks | (5.8%) 6 | (14.9) 11 | | |
| 39 weeks | (61.2%) 63 | (64.9%) 48 | | |
| > 39 weeks | (32.0%) 33 | (14.9%) 11 | | |

Legend: Values are presented as mean (SD) for continuous variables and frequency, n (%) for categorical variables. Bold P-values indicate statistical significance at $P < 0.05$. t = Independent samples t-test statistic; $\chi^2$ = Chi-square test statistic; CD = Cesarean Delivery; GA = Gestational Age.

**TABLE 2B**

Comparison of War Exposure and Psychological Stress Between Vaginal Delivery and Cesarean Delivery Groups.

| Characteristic | Vaginal Delivery (N=103) | Cesarean delivery (N=74) | Test statistic | P-value |
|---|---|---|---|---|
| **PSS Score** [a] | 21.22 (6.71) | 24.89 (6.46) | t = -3.67 | <0.001 |
| **Stress Level** | | | $\chi^2$ = 3.63 | 0.163 |
| Low | 13 (12.6%) | 5 (6.8%) | | |
| Moderate | 55 (53.4%) | 24 (32.4%) | | |
| High | 35 (33.9%) | 45 (60.8%) | | |
| **Conflict Zone Exposure** [b] | | | $\chi^2$ = 1.27 | 0.737 |
| No, Safe Place | 40 (54.8%) | 26 (48.1%) | | |
| Yes, 1st trimester | 9 (12.3%) | 10 (18.5%) | | |
| Yes, 2nd trimester | 9 (12.3%) | 8 (14.8%) | | |
| Yes, 3rd trimester | 15 (20.5%) | 10 (18.5%) | | |
| **Residence at Delivery** | | | $\chi^2$ = 0.09 | 0.76 |
| Outside Sudan | 30 (29.1%) | 20 (27.0%) | | |
| Inside Sudan | 73 (70.9%) | 54 (73.0%) | | |
| **Conflict Events Exposure** | | | | |
| Clashes | 27 (26.2%) | 19 (25.7%) | $\chi^2$ = 0.01 | 0.936 |
| Checkpoints | 29 (28.2%) | 29 (39.2%) | $\chi^2$ = 2.38 | 0.123 |
| Services Disruption | 44 (42.7%) | 33 (44.6%) | $\chi^2$ = 0.06 | 0.804 |
| Bombing | 15 (14.6%) | 12 (16.2%) | $\chi^2$ = 0.09 | 0.763 |
| Insecurity | 28 (27.2%) | 23 (31.1%) | $\chi^2$ = 0.32 | 0.572 |
| None | 17 (16.5%) | 10 (13.5%) | $\chi^2$ = 0.30 | 0.585 |

Legend: Values are presented as mean (SD) for continuous variables and n (%) for categorical variables. Bold P-values indicate statistical significance at $P < 0.05$. t = Independent samples t-test statistic; $\chi^2$ = Chi-square test statistic; PSS = Perceived Stress Scale; CD = Cesarean Delivery.

 Stratified analysis excluding women with previous CD history (n=159) showed consistent significance: Vaginal 21.32 (6.59) vs. CD 25.42 (5.86), $P < 0.001$.

 Based on participants who were pregnant during the conflict period (Vaginal Delivery n=73, Cesarean Delivery n=54).

**2. War Exposure and Psychological Stress**

A majority of participants (75.7%) reported being displaced from their homes due to the conflict. Psychological stress was assessed using the 10-item Perceived Stress Scale (PSS-10). The mean PSS score for the entire sample was 22.8 ± 6.3.

Women who delivered via Cesarean delivery exhibited significantly higher mean PSS scores compared to those who delivered vaginally (24.9 ± 6.5 vs. 21.2 ± 5.5, respectively), and this difference was statistically significant ($p < 0.001$). Categorical analysis of stress levels revealed that while the majority of women in the vaginal delivery group (53.4%) experienced moderate stress, a notably higher proportion of women in the Cesarean delivery group (60.8%) reported high stress levels, although this difference did not reach statistical significance ($p = 0.163$) (Table 2A and 2B).

**3. Logistic Regression Analysis**

Logistic regression analysis was conducted to identify independent factors associated with Cesarean delivery. Table 3 presents the results of both univariable and multivariable analyses.

Table 3
Distribution of Demographic and Clinical Variables in the Sample (N = 177)

| Characteristic | Category | Value (N = 177) |
|---|---|---|
| **Age (Years)** | | 28.8 (5.3) |
| **Perceived Stress Scale Score** | | 22.7 (6.8) |
| **Marital Status** | Married | 96.60% |
| | Divorced | 0.60% |
| | Separated | 2.80% |
| **Displacement Status** | Displaced | 75.70% |
| | Not Displaced | 24.30% |
| **Previous Cesarean delivery History** | No history of Previous CD | 89.80% |
| | Has history of previous CD | 10.20% |
| **Perceived Stress Level** | Low | 10.20% |
| | Moderate | 44.63% |
| | High | 45.19% |
| **GA (weeks)** | < 28.5 weeks | 2.80% |
| | 28.5 - <39 weeks | 9.60% |
| | 39 weeks | 62.70% |
| | > 39 weeks | 24.70% |
| **Period of Pregnancy in Conflict Zone [a]** | Was in a safe place | 66 (52%) |
| | 1st trimester | 19 (15%) |
| | 2nd trimester | 17 (13.4) |
| | 3rd trimester | 25 (19.7%) |

Legend: Values are presented as Mean (SD) for continuous variables and frequency (%) for categorical variables. PSS = Perceived Stress Scale; GA = Gestational Age; CD = Cesarean Delivery.

 Percentages calculated based on participants who were actively pregnant during the conflict period (n = 127).

In the multivariable model, three variables remained independently associated with an increased likelihood of CD. Specifically, each one-point increase in the PSS score corresponded to a 9.8% increase in the odds of Cesarean delivery (adjusted odds ratio [AOR] = 1.098; 95% CI: 1.030–1.169; p = 0.004). A history of previous Cesarean delivery emerged as a robust associated factor, with these women being more than 12 times more likely to undergo a CD compared to those without such history (AOR = 12.295;

95% CI: 2.235–67.629; p = 0.003). Additionally, delivery at 39 weeks of gestation was associated with a higher likelihood of CD compared to delivery after 39 weeks (AOR = 4.053; 95% CI: 1.008–16.294; p = 0.049).

Other variables, including maternal age, displacement status, presence of chronic diseases, and prior psychological diagnoses, did not retain independent significance in the final model. The overall model demonstrated goodness-of-fit (Omnibus test p < 0.001; Hosmer–Lemeshow test p = 0.435) and explained approximately 26.3% of the variance in the mode of delivery (Nagelkerke $R^2$ = 0.263).

**4. Mediation Analysis**

Mediation analysis was conducted to assess whether the effect of displacement on Cesarean delivery was mediated by psychological stress (Table 4). Displacement was significantly associated with elevated psychological stress scores (path a: B = 7.123, p < 0.001). Psychological stress was also significantly associated with increased odds of cesarean delivery (path b: AOR = 1.098, p = 0.004). Upon adjusting for psychological stress in the model, displacement was no longer directly associated with Cesarean delivery (Path C': AOR = 0.792, *p* = 0.610). These findings suggest that psychological stress may mediate the association between displacement and Cesarean delivery. However, given the cross-sectional design, this finding should be interpreted as statistical rather than causal mediation. However, this mediation should be interpreted within the limitations of the cross-sectional study design.

Table 4

Mediation Analysis - Indirect Effect of Displacement on Cesarean Delivery Through Perceived Stress.

| P-value | 95% CI | SE | Effect Estimate | Description | Path |
|---|---|---|---|---|---|
| **< 0.001** | 4.91–9.34 | 1.123 | 7.123 | Displacement → PSS Score (β) | Path A |
| **0.004** | 1.030–1.169 | 0.032 | 1.098 | PSS Score → CD (adjusted OR) | Path B |
| 0.728 | 0.562–2.282 | 0.358 | 1.123 | Displacement → CD (crude OR) | Path C |
| 0.61 | 0.323–1.941 | 0.458 | 0.792 | Displacement → CD (adjustedOR) | Path C' |
| **Significant** | | | ≈ 1.94 | Displacement → PSS → CD (OR) | Indirect Effect |

Legend: SE = Standard Error; CI = Confidence Interval; OR = Odds Ratio; AOR = Adjusted Odds Ratio; PSS = Perceived Stress Scale; CD = Cesarean delivery. Bold P-values indicate statistical significance at P < 0.05.

 Path A: Unstandardized linear regression coefficient (β) representing the change in PSS Score associated with displacement status.

 Path B: Adjusted odds ratio from multivariable logistic regression, controlling for age, previous CD history, gestational age, chronic diseases, and displacement status.

 Path C (Total Effect): Crude odds ratio from univariable logistic regression (displacement predicting CD mode).

 Path C' (Direct Effect): Adjusted odds ratio controlling for PSS Score and all covariates.

 Indirect Effect: Calculated as exponential of (Path A × Path B coefficient) = exp(7.123 × 0.093) = exp(0.662) ≈ 1.94. This represents the odds ratio of Cesarean delivery for displaced vs. non-displaced women mediated through increased psychological stress.

Table 5

**A** Classification of Cesarean Deliveries by Urgency (N = 74)

| Cesarean Delivery Type | Count (N = 74) | % of Cesarean deliveries (N = 74) |
|---|---|---|
| **Elective** | 12 | 16.00% |
| **Emergency** | 62 | 83.80% |

Legend: Values are presented as counts (n) and percentages (%) out of total Cesarean deliveries (N = 74). Emergency procedures were defined as those performed during active labor or acute obstetric indications, whereas elective procedures were pre-scheduled prior to labor onset.

**TABLE 5B**

Clinical Indications for Cesarean Deliveries (N = 74)

| Cesarean Delivery Indication | Count (N=74) | % of Cesarean deliveries (N=74) |
|---|---|---|
| **CPD** | 19 | 25.7 |
| **prolonged labor** | 19 | 25.7 |
| **PROM** | 15 | 20.3 |
| **Fetal distress** | 14 | 18.9 |
| **Unknown** | 7 | 9.5 |
| **Others** | 7 | 9.5 |
| **Twins** | 5 | 6.8 |
| **Previous CD** | 2 | 2.7 |
| **Breech** | 2 | 2.7 |
| **Placenta Previa** | 1 | 1.4 |
| **Hypotonic Uterus** | 0 | 0 |

Legend: Values are presented as counts (n) and percentage (%) relative to total Cesarean deliveries (N = 74). Percentages sum to > 100% because multiple concurring clinical indications were recorded for 14 participants. CPD = Cephalopelvic Disproportion; PROM = Premature Rupture of Membranes; CD = Cesarean Delivery.

**5. ROC Curve Analysis**

Receiver Operating Characteristic (ROC) curve analysis was performed to evaluate the discriminative ability of the PSS score to differentiate between cesarean and vaginal deliveries. The area under the curve (AUC) was 0.671 (95% CI: 0.589–0.753; $p < 0.001$), indicating a moderate ability of psychological stress to discriminate between cesarean and vaginal deliveries.

Using Youden's Index, the optimal PSS score cut-off value was identified as ≥ 27.5. At this cut-off point, the sensitivity for correctly identifying cesarean delivery was 65.4%, and the specificity for correctly identifying vaginal delivery was 54.1%.

**6. Clinical Indications and Types of Cesarean Delivery**

Among the women who underwent Cesarean Delivery (n = 74), emergency Cesarean delivery was considerably more common than elective Cesarean delivery, accounting for 62 cases (83.8%) and 12 cases (16.2%), respectively. The most frequent clinical indications for Cesarean Delivery were cephalopelvic disproportion (25.7%) and prolonged labour (25.7%), followed by premature rupture of membranes (20.3%) and fetal distress (18.9%). Less common indications included twin pregnancy (6.8%), previous Cesarean Delivery (2.7%), breech presentation (2.7%), placenta previa (1.4%), while no cases were attributed to hypotonic uterus. Unknown and other indications accounted for 9.5% each. Detailed findings are presented in Tables 5A and 5B.

## Discussion

# Main Findings

This study provides robust evidence that war-related psychological stress was independently associated with Cesarean delivery among pregnant women in Sudan. The multivariable logistic regression analysis demonstrated that each one-point increase in the Perceived Stress Scale (PSS-10) score was associated with a 9.8% increase in the likelihood of undergoing a CD, even after controlling for established confounders such as maternal age, obstetric history, and gestational age at delivery. From a clinical perspective, this effect is substantial; an increase of 10 points on the PSS scale corresponds to an approximately 2.4-fold increase in the odds of a Cesarean delivery.

Furthermore, evidence from the current Sudanese conflict also suggests that Cesarean delivery in this volatile context is associated with a 1.68-fold increase in the likelihood of additional adverse maternal outcomes (OR 1.68, CI [1.05–2.69], p = 0.030) (1). Although the categorical comparison of stress levels did not reach statistical significance (p = 0.163), a greater proportion of women who underwent Cesarean delivery reported high perceived stress (60.8%) compared with those who delivered vaginally (33.9%). These descriptive findings are consistent with the significant association observed when psychological stress was analyzed as a continuous variable in the multivariable logistic regression model. The additional clinical analyses further strengthen the interpretation of these findings. More than four-fifths of all Cesarean deliveries were performed as emergency procedures (83.8%), whereas elective procedures accounted for only 16.2% of cases. The most frequent indications were cephalopelvic disproportion (25.7%), prolonged labor (25.7%), premature rupture of membranes (20.3%), and fetal distress (18.9%). Collectively, these findings suggest that the elevated Cesarean delivery rate observed in this cohort primarily reflected acute obstetric indications rather than elective surgical practice, providing important clinical context for the observed association between maternal psychological stress and delivery mode (1, 11, 14). Our study augments this established evidence by demonstrating a strong, independent association between war-induced psychological stress and Cesarean delivery within the unique and acutely stressful context of the Sudan conflict (6).

# Meaning of the Findings

Evidence from conflict-affected settings supports this pattern. In Yemen, CD rates increased during periods of armed conflict due to systemic strain and policy adaptations, even in the absence of individual-level stress data. This highlights how the disruption of health services can shift delivery practices toward more interventional approaches, underscoring the role of structural factors in clinical decision-making (4). This "conflict pattern" is further evidenced by findings from other regional conflicts. Similarly, longitudinal data from the occupied Palestinian territory between 2002 and 2014 revealed a significant increase in CD prevalence, which doubled from 10% to 20% as the conflict persisted (15) The Syrian war context further corroborates this pattern, where CD rates surged from 29% to over 51% as the conflict intensified. Similar to our findings, the Syrian context highlighted how the reciprocal psychological distress of both mothers and clinicians, combined with deteriorating care quality, shifts

delivery trends toward surgical intervention (12). This shift often serves as a strategic adaptation; as documented in Northwest Syria, mothers may favor scheduled procedures to circumvent the uncertainty of prolonged labor and the risks associated with nighttime travel or emergency transfers in active conflict zones(3).

More broadly, in settings of war and displacement, elevated psychological stress is often inextricably linked to delayed or irregular access to antenatal care (ANC). Reduced continuity of care results in missed opportunities for the early detection and management of pregnancy complications, thereby escalating the likelihood of emergency Cesarean delivery. Evidence from the ongoing conflict in Sudan supports this pathway; recent research indicates that limited access to maternal healthcare services is significantly associated with adverse pregnancy outcomes. High conflict intensity, mass displacement, and the systematic disruption of healthcare infrastructure have crippled accessibility to both antenatal and delivery services. This mirrors findings from Gaza, where over 90% of pregnant women reported moderate to high stress levels, and the inability to afford transportation emerged as a primary barrier to ANC. Similar logistical and financial hardships in Sudan exacerbate psychological stress, which further complicates clinical delivery decisions (16). Such structural barriers may interact with elevated psychological stress to increase the likelihood of emergency obstetric interventions, including Cesarean delivery. The magnitude of this barrier is stark: data reveal that a staggering 86.6% of women in Sudan were unable to access essential healthcare services during the conflict—a failure that more than doubled the risk of adverse pregnancy results (OR 2.35, $p = 0.001$) (1).

Chronic psychological stress precipitates the activation of the HPA axis, resulting in sustained elevations of cortisol and other stress-related hormones. These mechanisms suggest that psychological stress is not solely a psychological state but a systemic biological process; for instance, elevated cortisol levels may contribute to impaired uterine contractility and increase the likelihood of Cesarean delivery. or fetal distress, necessitating medical interventions such as Cesarean delivery (8). These biological pathways are further supported by a recent systematic review demonstrating that prenatal stress is associated with sustained cortisol elevation, increased systemic inflammation, and adverse maternal–fetal outcomes. Such physiological dysregulation can significantly impede labor progression and influence obstetric decision-making (5).

A key finding of this study was that mediation analysis suggested that the association between displacement and Cesarean delivery may operate primarily through maternal psychological stress. After adjustment for stress, the association between displacement and delivery mode was substantially attenuated, supporting the hypothesis that psychological stress may represent an important pathway linking displacement to Cesarean delivery. However, given the cross-sectional design, these findings should be interpreted as statistical rather than causal mediation.(1). This suggests that the inherent vulnerability associated with displacement, compounded by systemic inequities, significantly predisposes women in conflict zones to interventional deliveries. Syrian refugee women also showed a significant increase in Cesarean deliveries compared to native populations (17), highlighting how displacement and the loss of social support networks intensify obstetric risks. Evidence from the Syrian

conflict also shows that displacement significantly increases cesarean rates, with refugees in Lebanon experiencing rates double the WHO recommendations (18). However, our study adds important new evidence by examining this relationship within the specific context of war and armed conflict setting characterized by prolonged exposure to chronic stress, trauma, displacement, and instability. Such conditions may amplify the physiological and psychological effects of stress beyond those observed in non-conflict settings. This reinforces our conclusion that the lived experience of displacement, and the subsequent psychological burden it imposes, is a critical determinant of surgical delivery (18). Collectively, these findings align with the “stress as mediator” model, which proposes that adverse life events influence health outcomes primarily through increased psychological stress. In the context of displacement, women may experience loss of housing, separation from family and social networks, uncertainty about the future, and limited access to essential resources. Together, these stressors contribute to increased psychological burden, which in turn affects physical health and obstetric outcomes.

# Research and Clinical Implications

Our findings suggest that interventions targeting psychological stress among displaced pregnant women may improve birth outcomes more effectively than approaches focusing solely on material or logistical support, indicating that addressing the emotional and psychological consequences of displacement is as critical as meeting basic physical needs. These implications are supported by a systematic review showing that stress-reduction interventions are associated with significantly lower Cesarean delivery rates (19). Together, these findings reinforce the importance of integrating psychosocial support into humanitarian obstetric care, as displacement appears to influence delivery mode primarily through psychological distress.

ROC curve analysis identified a PSS score of ≥ 27.5 as the optimal cut-off in this dataset (sensitivity 65.4%, specificity 54.1%). However, its modest discriminatory performance suggests that the PSS-10 should not be considered a standalone predictive tool for Cesarean delivery, and further validation in larger prospective studies is warranted before its routine clinical application.

The observed CD rate (41.8%), comparable to those reported in Yemen (48.3%) and Syria (51%), suggests that conflict-affected settings share a common trajectory of substantially elevated Cesarean delivery rates, underscoring the need for policy shifts toward holistic maternal healthcare that integrates mental and physical health (9, 12). In Sudan, workforce shortages, disrupted health services, and the psychological trauma associated with conflict and displacement further highlight the need for conflict-sensitive obstetric protocols that integrate both surgical capacity and psychosocial support, consistent with experiences reported in Syria, Yemen, and the Democratic Republic of the Congo (1).

# Strengths and Limitations

This study has several strengths that enhance the credibility of its findings. First, it is among the few studies to investigate the relationship between war-related psychological stress and Cesarean delivery in a conflict setting, addressing a significant gap in literature. Second, the use of the validated PSS-10 scale

strengthens the reliability of stress measurement. Another important strength is the application of mediation analysis to explore the potential pathway linking displacement, psychological stress, and Cesarean delivery. To our knowledge, this is among the first studies conducted in an active armed conflict setting to statistically examine whether maternal psychological stress may explain the association between displacement and delivery mode.

Third, advanced statistical analyses—including multivariable logistic regression, mediation analysis, and ROC curve analysis—provided a comprehensive understanding of the underlying mechanisms.

Nevertheless, several limitations should be acknowledged. The cross-sectional design restricts causal inference, as psychological stress and mode of delivery were assessed at a single postpartum time point. Although mediation analysis suggests a potential causal pathway, reverse causality cannot be ruled out. Additionally, since stress was assessed postnatally, the responses might be subject to recall bias, where the mode of delivery itself could influence the mother's retrospective perception of her prenatal stress. Missing data led to the exclusion of 16 participants (9.0%) from the multivariable regression analysis, which may have introduced selection bias if the missingness was not random. Recruitment challenges in a conflict environment also limited final enrollment and necessitated the use of convenience sampling, potentially affecting the gene

ralizability of the findings. While the overall sample size was adequate to detect the main effects, some subgroup analyses were constrained by small numbers, which may have reduced statistical power for detecting smaller effect sizes. In addition, although the PSS score demonstrated a statistically significant association, its discriminatory ability was moderate, suggesting that psychological stress represents only one of several factors influencing cesarean delivery decisions. Consistent with this, the final multivariable model explained approximately 26% of the variance, indicating that other clinical and contextual determinants—such as social support and quality of antenatal care—may also play important roles. Nevertheless, the cross-sectional design represents a pragmatic methodological approach in unstable conflict settings where longitudinal research is often difficult to implement, as reported in similar studies from Sudan, Yemen, and Sri Lanka (1, 4).

# Recommendations

Future longitudinal studies following women from early pregnancy through delivery are needed to better establish causal relationships and examine changes in stress over time. (19). Future studies should also investigate protective factors such as resilience and coping strategies, as well as the long-term effects of prenatal stress on child neurodevelopment and behavioral outcomes. Given the established association between prenatal stress and adverse neurodevelopmental outcomes, longitudinal studies are needed to examine the potential intergenerational consequences of war-related maternal stress (20, 21).

## Conclusion

This study provides compelling evidence that the armed conflict in Sudan has significantly altered obstetric outcomes, driven largely by the psychological toll on expectant mothers. Our findings demonstrate that war-induced stress was independently associated with an increased likelihood of Cesarean delivery. The surge in Cesarean rates (41.8%) reflects a "conflict pattern" observed in other global crises, where systemic healthcare collapse and acute maternal anxiety converge to favor surgical outcomes.

A key finding of this study is that the association between displacement and delivery mode appeared to be partially accounted for by psychological stress. This suggests that while physical security and logistical support are vital, they are insufficient if the underlying trauma remains unaddressed. To protect maternal and child health in Sudan, healthcare policies should adopt a holistic approach that integrates low-cost psychological screening and evidence-based psychosocial interventions into routine antenatal care in conflict settings. Addressing the psychological consequences of war should be considered an essential component of maternal healthcare, alongside ensuring adequate obstetric services, to promote safer birth outcomes and reduce the long-term impact of conflict on mothers and their children. psychological "wounds of war" during pregnancy is as essential as providing surgical kits; it is a necessary step to breaking the cycle of trauma and ensuring safer birth experiences for women in the most challenging of circumstances.

# Declarations

### Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval for this study was obtained from the Al-Neelain University Institutional Review Board (IRB) and the Sudan Ministry of Health. Written informed consent was obtained from all participants prior to their inclusion. Participant confidentiality was ensured by using study identification numbers instead of personal names. All data were used solely for research purposes.

### Consent for Publication

Not applicable.

### Availability of Data

The datasets that support the findings of this study are available from the corresponding author, Eilaf Altahir, upon reasonable request. Access to the data is subject to ethical approval and confidentiality agreements to protect participant privacy.

### Competing of interests

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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**Authors' Contribution**

EEI (Eilaf Eltahir Mohamed Idris) designed and led the study, collected and analyzed the data, performed the literature review, drafted the manuscript, proofread, and coordinated the research.
DOM (Dina Abdelrahim Obeid), SNS (Sara Hamza Nurelhuda Sulieman), YAM (Yusra Abdelmoneim Mohammed Ahmed), MAM (Malaz Abdalgabar Jibreel Mohammed), TZM (Turteel ZeinElabdin Hassan Mahjob), SSW (Shahd Shawgi Mohammed WidatAlla), MMM (Meiad Mohammed Awad Mohammed), AGR (Ahazeej Gurashi Rahmatalla Gurashi), SHK (Salsabeel Hussain Khader Mohamed), and RHE (Rana Hamdan Elmamoon Elsheikh), DEA (Duaa Eljack Abdullah) collected data, performed literature review, and contributed to manuscript writing.
All authors read and approved the final manuscript.

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