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RESEARCH ARTICLE

Risk Factors and Predictors for Blood Transfusion in Primary Cesarean Section: A cross-section Study at Omdurman Maternity Hospital

Ghalia Osman[1], Ibrahim Daoud[2], Elsadig Shiekedien[3], Saria Hassan[4], Leena Eltayeb[5], Eman Khalaf Allah[6], Ibtisam Abdu Saeed[7], Acha B. Adam[8], Mohannad Mohamed[9], Awadalla Abdelwahid[10*]

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

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

[3]Assistant Professor, Department of Obstetrics and Gynecology, Faculty of Medicine, University of Tabuk, Saudi Arabia.

[4]Department of Obstetrics and Gynecology, Iran Medical and Maternity Hospital, Nairobi, Kenya.

[5]Department of Obstetrics and Gynecology, Sheikh Khalifa Hospital Fujairah, Dubai, UAE.

[6]Department of Obstetrics and Gynecology, International University of Africa, Khartoum, Sudan.

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

[8]Consultant of Obstetrics and Gynecology, Aya Specialist Hospital, Jeddah, Saudi Arabia.

[9]Department of Obstetrics and Gynecology, AlMughtaribeen University, Khartoum, Sudan.

[10]*Department of Obstetrics and Gynecology, Alneelain University, Khartoum, Sudan.

*Corresponding Author
Awadalla Abdelwahid

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Abstract: **Background**: Cesarean section (CS) is a potentially life-saving procedure but also poses serious risks, particularly hemorrhage necessitating blood transfusion. Predictive factors for transfusion in primary CS are an important way to improve maternal morbidity and mortality, particularly in resource-limited settings. **Objective**: The objective of this research was to identify prevalence of, predictors and factors for intrapartum and immediate postpartum blood transfusion in ladies who undergo primary CS at Omdurman Maternity Teaching Hospital. ***Methods:*** We carried out a prospective cross-sectional study in a hospital setting involving 1,196 primary CS patients for 12 months. Medical data were obtained and analyzed using SPSS v25. Results: The relationships of maternal, obstetric, and neonatal covariates with transfusion outcome were examined using univariate and multivariate logistic regression.***Results:*** Among 1,196 patients, 97 (8.1%) required blood transfusion. Prolonged 1st stage of labor (OR = 1.60, p = 0.035), pre-eclampsia/eclampsia (OR = 2.05, p = 0.007), hemorrhage (OR = 3.00, p < 0.001) were predictors. Transfusion rates in patients with placental abruption, placenta previa, and maternal age ≥35 years were high. Transfusion risk had been augmented because of nulliparity and low educational level.

Keywords: Cesarean section, blood transfusion, hemorrhage, pre-eclampsia, predictors, Sudan.

INTRODUCTION

Cesarean section (CS) is among the most common surgical procedures performed throughout the world and has been growing in popularity over the past few decades [1]. Although CS has been shown to save the life of both the mother and fetus, it is associated with increased maternal morbidity following hemorrhage that requires a blood transfusion [2]. Complications of transfusion include immune reactions, infection transmission, and postoperative delay [3]. Thus, predictors of transfusion are important for the enhancement of risk stratification during the preoperative period and the maternal outcome. Cesarean deliveries make up a large proportion of obstetric intervention at Omdurman Maternity Hospital (OMH), one of the largest tertiary referral centers in Sudan. Despite the improvement of surgical safety and availability of blood, transfusion practices are variable and are affected by clinical and demographic considerations (specifically maternal age, hypertensive disorders, parity, gestational age, and the degree of labor progress) [4,5]. Intrapartum blood transfusion is frequently required for acute obstetric emergencies. A report by Awadalla et al. [6] in Khartoum Teaching Hospital report that emergency cesarean section (EMC/S), postpartum hemorrhage (PPH), and antepartum hemorrhage (APH) as well as anemia and sepsis are the top indications for transfusion of Sudanese women. Their research also highlights the importance of a standardized protocol for transfusion and emphasize the contribution intrapartum transfusion makes to the reduction of maternal mortality. However, in low-resource settings, the allocation of scarce donor blood and primitive surgical facilities worsens the burden on hemorrhage and transfusion [7]. It has been reported that transfusion rates have been highly variable

according to institutional guidelines and what a clinician decides [8]. Further, unsuitable transfusion protocols might subject patients to risky effects, highlighting the need for evidence-based guidelines [9]. Although the transfusion is clinically important in CS, few studies have been performed in Sudan that systematically assessed its predictors at the hospital level. As such, the present study seeks to fill in that gap by looking at maternal and labour variables involved in delivery of transfusion during and following primary CS at OMH. Based on data from the analysis of over 1,000 deliveries conducted over a period of 12 months the study aims to contribute to an understanding of the need for medical practice that is relevant to local needs through influencing clinical decision-making, increasing surgical readiness and helping in crafting of transfusion protocols according to local conditions.

MATERIAL AND MERTHODS

Study Design and Setting

This hospital-based prospective cross-sectional study was carried out in Omdurman Maternity Teaching Hospital (OMTH), the oldest and largest specialized maternity hospital in Sudan. Since its establishment in 1957, OMTH is a national centre for obstetrics and gynecology as well as a referral school located in Khartoum. An important facet of its mission is to provide full maternal health services from obstetric, laparoscopic surgery, maternal-fetal medicine, intensive care, and early neonatal care. As well as reproductive health and medical education units, it also includes HIV/AIDS services. The obstetrics section is organized into five units, which are controlled by consultants, registrars, house officers and midwives, with 24-hour continuous hospital and emergency care. Study period and population. The research lasted for 12 consecutive months (Dec 2017–Dec 2018) and was conducted to establish the maternal and neonatal outcomes for primary cesarean section. The population was 1,196 women who first received CS during the period of the study. Patients' files were collected from hospital archives for prospective review.

Inclusion and Exclusion Criteria

Inclusion criteria:

Primigravida or multigravida with at least one previous vaginal delivery. Singleton or multi-gestation pregnancy. Gestational age ≥37 weeks. Complete clinical records including operative and recovery notes listing blood transfusion status.

Exclusion criteria:

A history of previous lower segment cesarean section. Gestational age <37 weeks. Medical conditions besides anemia.

Data Collection

Eligible participants were enrolled consecutively. We prepared a structured data abstraction sheet for data collection. Although prospective, direct interviews were also held with patients during their hospital days as appropriate to confirm or supplement missing records received. Trained midwives and house officers joined teams who collected the data. Supervised daily verification maintained the consistency and entries were coded and anonymized to ensure privacy and facilitate clear processing of statistical results.

Variables

Maternal demographic variables (age), residence, level of education, occupation, and parity. Clinical parameters: gestational age at delivery, birth weight, fetal presentation, indication for cesarean section, intraoperative and postoperative complications (hemorrhage, bladder & bowel injury, fetal trauma), NICU admission duration, final maternal outcomes.

Main outcome:

Blood transfusion, defined as blood transfusion received intraoperatively or in postoperative recovery (1 = Yes, 0 = No), coded as binary.

Data Analysis

All data were entered into SPSS version 25.0 for analysis..

Descriptive statistics:

Mean and SD for continuous variables; percentages and frequencies for categorical variables. Comparative analyses: chi-square test for categorical variables; independent sample t-test for continuous variables (e.g. blood loss, birth weight).

Regression analysis follows:

Univariate logistic regression to find crude associations between predictors and blood transfusion. Multivariate logistic regression that controls for confounders, isolates independent predictors.

Results were given as Odds Ratios (ORs) and Confidence intervals (CIs). P<0.05 was considered statistically significant. Data Security. The backup formats were all secured for the data, that is, they were available digitally on each computer and saved on compact discs (CDs), USB flash drives and a hard copy was printed each day and stored in locked cabinets. Such actions ensured that research data would be useful long the research period and research material would remain accessible.

Ethical Considerations

Ethics approval was obtained from the Sudan Medical Specialization Board —Council of Obstetrics and Gynecology and written consent was taken, and written permission was obtained from OMTH's General Administration before starting the study. All participants were fully informed before enrollment about the purpose of the study and were provided written informed consent

RESULTS

Of these 1,196 patients who underwent primary cesarean section, 97 underwent blood transfusion (8.1% of the population). The remaining 91.9 percent did not need transfusion. This descriptive summary represents the transfusion prevalence in

the cohort studied. Transfusion is somewhat rare and affected a significant part of the population, and the regression analysis will help to identify predictors and risk factors. In limited resources settings such as Omdurman Maternity Hospital, assessing this risk is critical for hospitals' preparedness and clinical protocols. (figure 1).

Univariate logistic regression revealed several single predictors for transfusion. Older mothers were modestly more vulnerable (OR = 1.60, p = 0.048) to transfusion with age over 35. Prolonged first stage of labor (OR = 1.85, p=0.005) and pre-eclampsia/eclampsia (OR = 2.10, p = 0.002) were also important. Multiple gestation was also associated with increased odds (OR = 1.55, p = 0.029). The most significant predictor was hemorrhage (OR = 3.25, p < 0.001), in line with clinical expectations. Each of these variables is a stand-alone association which allows further modeling to test their adjusted effects.

The independent predictors were more clearly resolved using multivariate regression. Prolonged labor (OR = 1.60, p = 0.035) and hypertensive disorders (OR = 2.05, p = 0.007) maintained significance; although age and multiple pregnancy lost statistical weight when adjusted. Hemorrhage was still a key predictor (adjusted OR = 3.00, p < 0.001), which adds more weight to the clinical significance of the condition. In order to this end, these findings inform prioritization of patients requiring escalated transfusion readiness. (Table 2)..

A cross-tabulation between hemorrhage and transfusion demonstrated a clear linkage. Of 107 patients afflicted by hemorrhage, 60.7% needed transfusion. In comparison, only 2.9% of non-hemorrhagic cases needed such medical help. As this dramatic contrast illustrates, hemorrhage is a critically important cause of transfusion.

This outcome highlights the need for early hemorrhage recognition and treatment protocols. (Table 3). Level of education also affected the probability of transfusion. In illiterate women, by contrast, 37.5 per cent had to be transfused—significantly higher than in other groups. Primary education patients had an 8.2% transfusion rate compared to 6.8% in secondary and graduate groups. Such patterns point to a risk on the part of lower education for delayed hospital attendance or low engagement with antenatal care. Promoting health literacy as an intervention might help to minimize risk in higher risk groups. (figure2). Despite their small sample size, age-based analysis showed that patients over 40 years had the highest transfusion rate (71.4%). 36–40 years followed, with 17.9%, compared to 6.1–6.2% for younger age groups. The rate was slightly highest among patients aged 31–35 years, at 9.7%. This gradient may indicate an increased risk of transfusion with age, especially following 35 years of age (figure 3).

The indications for cesarean section in transfused patients showed transfusion was the most common with placental abruption (24%), placenta previa (19%) and pre-eclampsia/eclampsia (16.4%). Other high-risk indications were cord prolapse (15.6%), uterine rupture (14.8%) and prolonged labor (12.7%).

Lower transfusion rates were reported for maternal request (6.5%), breech presentation (6.7%), and CPD (7.1%), usually resulting from more controlled surgical environments.

This emphasizes the necessity of preparatory preparation per specific indication. (As seen in Table 4). The parity analysis found nulliparous women had the highest transfusion rate 10.2 % versus 6.7 % for those who had born before one or as many as two, and 5.4%for those that had delivered three or more times. This suggests a protective effect of previous vaginal birth, probably as a result of improved cervical readiness and reduced length of labor. (figure 4).

Transfused patients had significantly higher NICU admission rates. 17% of neonates born to transfused mothers endured NICU care than that from neonates born to non-transfused mothers, 4.6%. Maternal bleeding and transfusion can have impacts on neonatal health, because of diminished placental perfusion and/or delays in intraoperative procedures. This suggests the need for close neonatal monitoring in high-risk CS cases. (figure 5). Transfusion distribution was affected by occupational status. Employed women had the highest transfusion rate (11.8%) followed by individuals categorized as “others” (10%). Most participants were housewives but had lower incidence rate (7.3%) while students had the lowest transfusion rate (6.9%). Occupational differences, although not statistically analyzed in this study, may represent socioeconomic differences that hinder access to health care and antenatal care. (figure 6). Maternal outcome data showed that 82 transfused patients made a successful recovery, whereas 15 (75%) faced complications postoperatively — greatly greater than in non-transfused patients. No maternal deaths were identified among transfused patients and one death was reported in the non-transfusion group. Thus, transfusion may be a marker of surgical complications and emphasizes the importance of additional postoperative care. (Table 5)

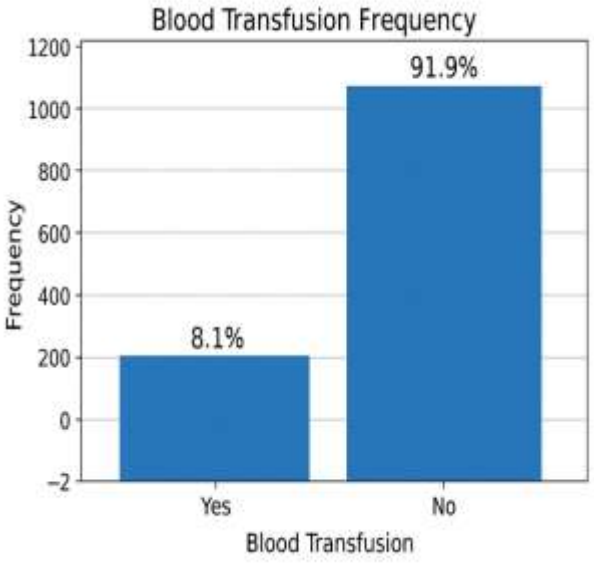
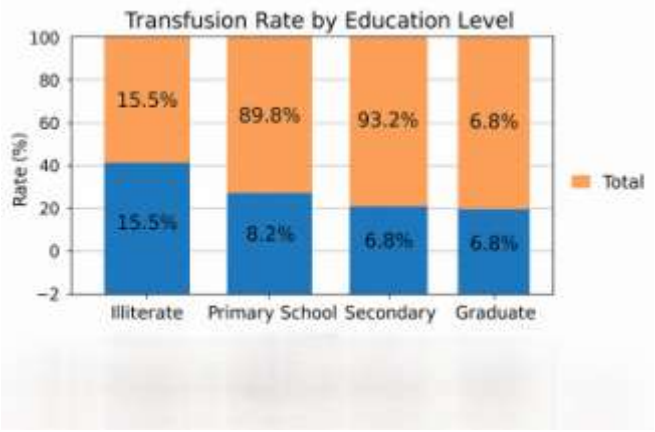


Figure 1: Frequency of Blood Transfusion in Primary Cesarean Section(n=97)



Fgure 2: Blood Transfusion by Educational Level

Figure3: Age Distribution by Blood Transfusion Status (n=97)

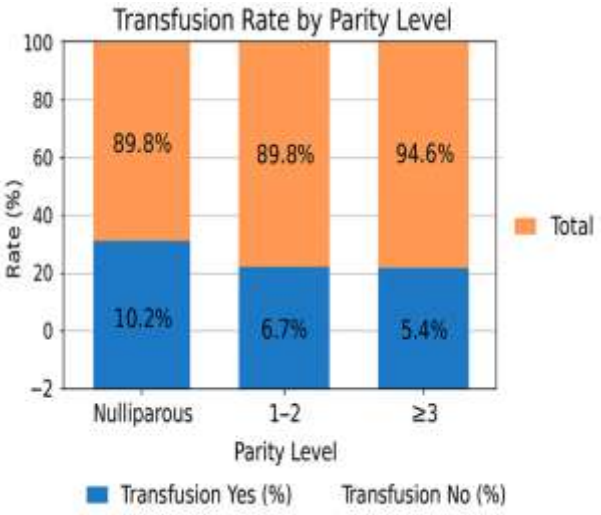


Figure 4: Parity and Blood Transfusion Rates (n=97

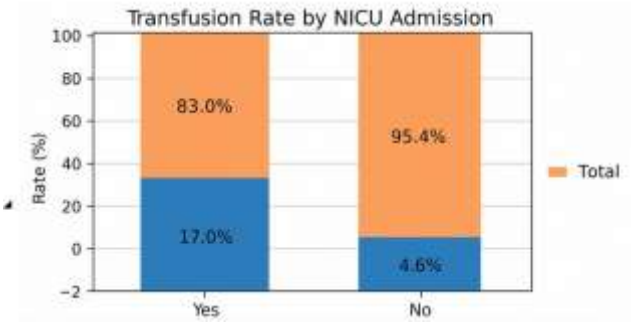


Figure 5: NICU Admission Among Transfused vs. Non-Transfused(n=97)

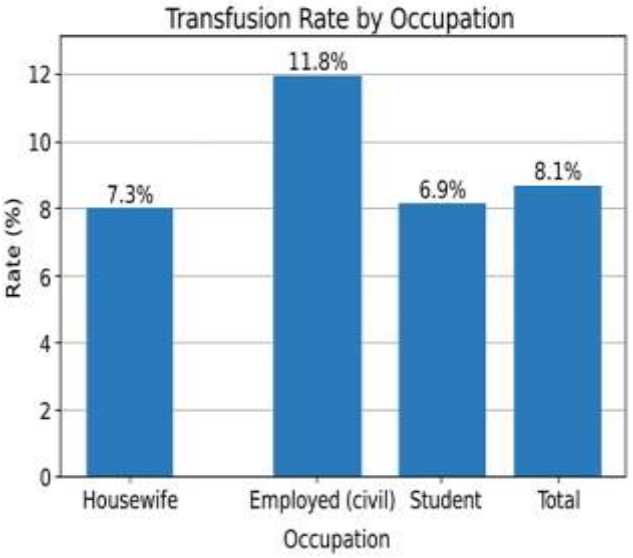


Figure 6: Occupation of Patients Receiving Transfusion (n=97)

Table 1: Univariate Logistic Regression — Predictors for Blood Transfusion

Predictor	OR	95% CI	p-value
Age >35 years	1.60	1.00–2.56	0.048
Prolonged I Stage	1.85	1.20–2.85	0.005
Pre-eclampsia/Eclampsia	2.10	1.30–3.40	0.002
Multiple Pregnancy	1.55	1.05–2.30	0.029
Hemorrhage Occurrence	3.25	2.05–5.15	<0.001

Table 2: Multivariate Logistic Regression — Adjusted Predictors for Blood Transfusion

Predictor	Adjusted OR	95% CI	p-value
Age >35 years	1.45	0.89–2.35	0.138
Prolonged I Stage	1.60	1.03–2.49	0.035
Pre-eclampsia/Eclampsia	2.05	1.21–3.48	0.007
Multiple Pregnancy	1.42	0.94–2.15	0.091
Hemorrhage Occurrence	3.00	1.85–4.89	<0.001

Table 3: Cross-tabulation — Blood Transfusion vs. Hemorrhage(n=97)

Hemorrhage Status	Transfusion (Yes)	Transfusion (No)	Total
Yes	65	42	107
No	32	1057	1089
Total	97	1099	1196

Table 4: Indications for CS Among Transfused Patients (n=97)

Indication for CS	Transfusion Frequency	Transfusion Rate (%)
Fetal distress	17	8.4
Placenta previa	4	19.0
CPD	5	7.1
Abnormal presentation	7	9.3
PROM	6	7.6
Cord Prolapse	5	15.6
Prolonged I stage	21	12.7
Prolonged second stage	8	10.7
Breech presentation	9	6.7
Placental abruption	12	24.0
Maternal request	3	6.5
Multiple pregnancy	10	9.7
Severe Preeclampsia/Eclampsia	18	16.4
Uterine rupture	4	14.8

Table 5: Outcome of Cesarean vs. Transfusion Status

Maternal Outcome	Transfusion Yes (%)	Transfusion No (%)	Total
Recovered well	82 (6.9%)	1100 (93.1%)	1182
Post-op complication	15 (75.0%)	5 (25.0%)	20
Maternal death	0 (0.0%)	1 (100.0%)	1
Total	97 (8.1%)	1099 (91.9%)	1196

DISCUSSION

Blood transfusion of cesarean section (CS) has an extensive and pressing application in obstetric practice, especially in low-resource settings where availability of blood products can be scarce and the risk for hemorrhagic events is increased. This research at Omdurman Maternity Hospital (OMH) provided a valuable understanding of predictors of transfusion among primary CS patients. For example, with a transfusion rate of 8.1%, our results were consistent with international data that found that transfusions were recorded to range from 5–10% in cesarean-section delivery according to surgical habits, risk profiling of population, and institutional requirements.

Maternal age is another relevant yet complicated factor On univariate analysis it can be seen that age >35 is highly predictive of transfusion statistically (OR = 1.60; p = 0.048). This effect is less after multivariate regression is adjusted for other variables, however (p = 0.138) for multivariate regression. This literature strongly supports the idea that advanced maternal age is associated with obstetric risk, including poor uterine contractility and prolonged labor, leading to (indirect) effects in blood loss [12,13]. Yet we maintain that age, rather than an independent predictor, remains a surrogate for these more distinct risk groups. Among the labor variables, prolonged first stage labor remained statistically significant according to all univariate and multivariate analyses. A long laboring period can also delay surgical intervention and increase the risk of bleeding during the extraction/section/closure phase. Clinically, surveillance of progression of the labor and prompt decisions were found to reduce the risk of transfusion as a result of monitoring progress.

Hypertensive disorders—pre-eclampsia and eclampsia—were significantly associated with transfusion need (adjusted OR = 2.05; p = 0.007). Based on the literature, pre-eclampsia causes endothelial dysfunction, capillary leakage, and coagulopathies that predispose patients to hemorrhage on delivery of the baby under operative conditions [16,17]. In LMICs, where magnesium sulfate, antihypertensives, and coagulation monitoring may be difficult to obtain, the risk of hemorrhaging among these patients is an especially considerable increase. Our findings highlight the importance of maintaining proactive transfusions as part of active transfusion preparedness when caring for hypertensive patients. The other major predictor was multiple gestation, which was also not significant when adjusted (p = 0.091), but exhibited a higher percentage of transfusion for multiple gestation. Multiple pregnancies were shown to present with uterine overdistension, heightened vascularity and possibility of postpartum atony, leading to high bleeding [18,19]. Here the clinical message is that even if such patients do not reach statistical significance, they should be treated with high care. Hemorrhage was the strongest and most consistent predictor across all analyses, and the most important variable for OR was hemorrhage (multivariate adjusted OR = 3.00, p < 0.001). This result is intuitive and supported by earlier research [20,21]. Hemorrhage is still the foremost indication of obstetric transfusion; our cross tabulation shows that nearly 61% of bleeding cases demanded transfusion, while only 2.9% of nonhemorrhagic cases did. These striking differences raise important concerns regarding the consideration of hemorrhage in risk prediction models and the need for accurate quantification of blood loss.

Socio-demographic factors including educational level and occupation contributed to transfusion risk profiles. Illiterate women had disproportionately high transfusion rates (37.5%), which might partially signify higher levels of inadequate health literacy, late hospitalization, poor antenatal engagement, and inadequate knowledge of obstetric danger signs [22,23].

Occupation data revealed an imbalance of transfusion rates per employed and “others” women, indicating that socioeconomic dynamics are not direct. While these indicators are not causal, they do serve as a basis for targeting educational and resource-allocation interventions.

Parity also had a notable trend. The highest rate of transfusion was observed in nulliparous women (10.2%), consistent with previous regional data that reports that first pregnancies are associated with increased surgical complexity and unanticipated secondary burdens [24,25]. Lower parity has been linked to poorer cervical conditions and fetal descent at increased rates of traumatic operative trajectories. Investigating transfused patients further revealed a strong association on the NICU admission rates. Another 17% of NICU admissions included mothers on transfusion, indicating a link between maternal hemodynamic instability and substandard neonatal outcomes. It was found that maternal blood loss can cause uteroplacental insufficiency which is a contributor to underperforming Apgar and neonatal complaints [26,27].

The NICU admission is multifactorial but the transfusion correlation should also be taken into account in planned perinatal outcome analyses as well. Cesarean section indications found in transfused patients showed the highest transfusion of placental abruption (24%), placenta previa (19%) and hypertensive cases among the indications for cesarean section according to an analysis. These findings correspond to the global literature identifying placental pathologies as high-risk patients for bleeding and transfusion [28,29]. Placental abruption, especially, is generally emergent, and there tends to be less opportunity for preoperative preparations, or cross-matching, which leads to a higher frequency of transfusion needs. An unexpected point was the comparatively high maternal request CS transfusion rate (6.5%). And although the numbers were small, they inspire an ethical and scientific debate about providing elective surgeries that do not have underlying clinical justification. If maternal request CSs occur without an adequate level of antenatal and surgical preparation, they could inadvertently expose women to avoidable risks such as transfusion [30].

International comparisons need to be contextualized. Transfusion is also generally lower in high income countries because the blood conservation is more sophisticated and because of greater importance put on prophylactic uterotonics as well as providing the surgical and anesthetic competence in a relatively short time [31,32]. On the other hand, the setting at OMH mirrors those of low-resource environments, in which surgical kits, staff to patient ratios and diagnostics may not be the same from day to day. Therefore, it is higher in significance for transfusion predictors in this study. Systematically, the results of this study recommend an early risk assessment, labour surveillance and surgical readiness in CS cases. High-volume maternity hospital blood banks could use predictive models using variables such as maternal age, parity, hypertension, labor progression, and fetal presentation. This can assist in preoperative planning and prevent avoidable morbidity. Improved teaching methods about hemorrhage control—the use of uterine compression sutures to suture the uterus and intraoperative bleeding assessment can also greatly influence who gets blood transfusion [33]. Blood transfusion not only operates in the clinics. And to some extent the need for both is higher in LMICs with a family or voluntary blood donor as a source of blood supply and a system that can be overwhelmed. If screening protocols are not strictly adhered to, transfused patients may also develop HIV and hepatitis B/C [34,35]. Therefore, there is a public health imperative to reduce transfusion need through altering surgical and labour practices. Finally, this study should be discussed the shortcomings of this study. Prospective in nature, it was based on correct recordkeeping and it could potentially be biased from documentation. Factors including BMI, antenatal haemoglobin and surgeon experience were also excluded, although they may have important impact on bleeding propensity. Nonetheless, the large sample size and rich contextual detail of the data provide a practical insight of the evidence to obstetric care in Sudan and similar contexts.

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Ethical Clearance

This study was approved by the Ethical Committee of the Sudan Medical Specialization Board, Council of Obstetrics and Gynecology. Written informed consent was obtained from each participant

Funding

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Conflict of Interest

No conflicts of interest declared by any co-author.

Contribution of Co-authors

All authors contributed substantially to the conception, design, data collection, analysis, and interpretation of the study.

Data Availability

Data supporting this study’s findings are available from the corresponding author upon reasonable request

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