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ORIGINAL RESEARCH

Factors Related to Blood Transfusions in Pregnant Women Undergoing Caesarean Sections: A 20-year Retrospective Study

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Background: The rising rates of caesarean section (CS) globally have been associated with an increase in maternal complications, including the need for blood transfusions. Maternal anaemia, uterine atony, and placenta-related disorders contribute significantly to haemorrhagic complications during CS. This study aimed to evaluate the factors associated with blood transfusions in pregnant women undergoing CS at Siriraj Hospital over a 20-year period.

Methods: This large, retrospective study enrolled 1277 pregnant women who underwent CS and received blood transfusions at Siriraj Hospital between January 1999 and December 2019. Demographic data, baseline haematocrit, underlying diseases, indications for CS, and relevant neonatal details were retrieved from medical records. Statistical analyses were performed to identify factors associated with increased transfusion rates, with a focus on maternal anaemia, uterine atony, placenta previa, and placenta accreta spectrum.

Results: Over the 20-year period, the rate of CS increased from 1.9% in 2002 to 48.5% in 2017. Concurrently, the need for blood transfusions also rose, with the highest transfusion rate recorded at 3.2% in 2019. The most common indications for transfusion were uterine atony (22.6%), placenta previa, and anaemia. Women with placenta accreta spectrum had a 6-fold higher likelihood of transfusion (aOR 6.530, 95% CI 4.056–10.510; $P < 0.001$), and those with uterine atony were 3.5 times (aOR 3.612, 95% CI 2.599–5.019; $P < 0.001$) more likely to require transfusions. Anaemic mothers also demonstrated a significantly higher risk for transfusion.

Conclusion: Blood transfusion risk in CS is strongly linked to placenta accreta spectrum, uterine atony, and maternal anaemia. Early identification of high-risk pregnancies and optimization of antenatal care are essential for reducing transfusion needs and improving maternal outcomes.

Clinical Trial Registration: Clinical trial number: TCTR20200505001 (Registered on 5 May 2020).

Plain Language Summary: Over a 20-year period, 1277 women who required blood transfusions during caesarean sections at Siriraj Hospital were studied to identify conditions that increased transfusion risk. Placenta accreta, heavy bleeding from uterine atony, and maternal anaemia were the strongest predictors of needing transfusions. Recognizing these risks early allows healthcare teams to plan safer deliveries, provide better pregnancy care, and reduce the need for transfusions.

Keywords: anaemia, blood transfusion, caesarean section, placenta accreta spectrum, pregnant women, uterine atony

Introduction

Caesarean section, a common surgical procedure, carries a low but notable risk of blood transfusion. A large prospective study found that 3.2% of women undergoing primary caesarean deliveries and 2.2% of those with repeat caesareans required transfusions, with transfusion needs ranging from 2 to 4 units.[1] Key risk factors for transfusion include general anesthesia, placenta previa, and severe preoperative anaemia, particularly in women with multiple prior caesareans.[1]

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These findings underscore the importance of optimizing maternal health, such as managing anaemia and implementing careful perioperative planning for high-risk cases. Massive blood loss remains a leading cause of maternal mortality, contributing to approximately 10% of maternal deaths worldwide.[2–5] Although global maternal mortality has decreased by 38%, postpartum hemorrhage continues to be a major cause of death.[6] Proper timing and appropriate use of blood transfusions are crucial for managing women at risk of hemorrhage, particularly those at risk of blood loss exceeding 1000 mL, who should deliver in facilities equipped with intensive care units and blood components.[7]

Pregnant women with underlying diseases or complications are at an increased risk of bleeding during delivery or the post-partum period, potentially leading to shock and necessitating blood transfusions. The reported rates of blood transfusion during pregnancy and post-partum vary from 0.16% to 2%–6%, with particularly high rates among those with abnormal deliveries.[6,8,9] Jadwin et al analyzed 6696 transfusion events across 15 hospitals and found that more than half of blood component transfusions were unnecessary, leading to longer hospital stays and increased costs due to reliance on laboratory criteria and suboptimal blood management practices.[10] Moreover, blood transfusion, though life-saving, carries risks such as infections, red blood cell allo-immunization, exposure to incorrect blood components, and increased costs.[11]

Although advancements in medical management have contributed to an overall decline in transfusion rates, obstetric transfusions remain a significant concern, particularly in the context of rising caesarean section rates worldwide. Intra-operative and post-partum hemorrhage during caesarean delivery continues to be a major contributor to maternal morbidity and mortality, accounting for approximately 10% of maternal deaths globally.[1] Post-partum hemorrhage remains the leading cause of maternal mortality despite global efforts to reduce maternal death rates.[2] Therefore, proper timing and indication of blood transfusions, particularly in cases of severe anaemia and massive blood loss, are crucial.[1]

The primary objective of this study is to analyze blood transfusion patterns and risk factors during caesarean sections over a 20-year period, aiming to identify key determinants of transfusion and outcomes. The secondary objectives are to examine the relationship between the amount of blood loss and associated risk factors, and to evaluate the use of different blood components (fresh frozen plasma, platelets, cryoprecipitate) and their related risk factors.

Materials and Methods

This was a large, retrospective, descriptive study. Before this research began, the Ethics Committee of the Faculty of Medicine Siriraj Hospital approved its protocol (approval number Si 235/2020). The work was also registered at the Thai Clinical Trials Registry (TCTR20200505001). The requirement for informed consent was waived by the Siriraj Institutional Review Board due to the retrospective nature of the study, which involved anonymized data extraction from medical records with no direct contact with patients.

A retrospective chart review was conducted of pregnant women who underwent a caesarean section and received a blood transfusion at Siriraj Hospital between 1999 and 2019. Details of the following were recorded: demographic data, maternal haemoglobin and haematocrit, number of antenatal care visits, type of caesarean section, indications for caesarean section, gestational age at caesarean section, time of delivery (regular working hours and after hours), total time of caesarean section, maternal medical complications, maternal complications arising from caesarean section, neonatal birth weight, APGAR scores, and neonatal complications.

Statistical Analysis

Statistical analyses were conducted with PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics included frequencies, percentages, means with standard deviations, and medians with ranges. Categorical data were analyzed using chi-squared or Fisher's exact tests, while quantitative variables were analyzed with the Mann–Whitney *U*-test and multiple logistic regression for univariate and multivariate analyses, respectively.

Results

Over the 20-year study period, the lowest birth rate was in 2001 (4780 cases/year), and the highest rate was in 2012 (9748 cases/year). The lowest caesarean section rate of 1.9% was in 2002, with the highest rate of 48% occurring in

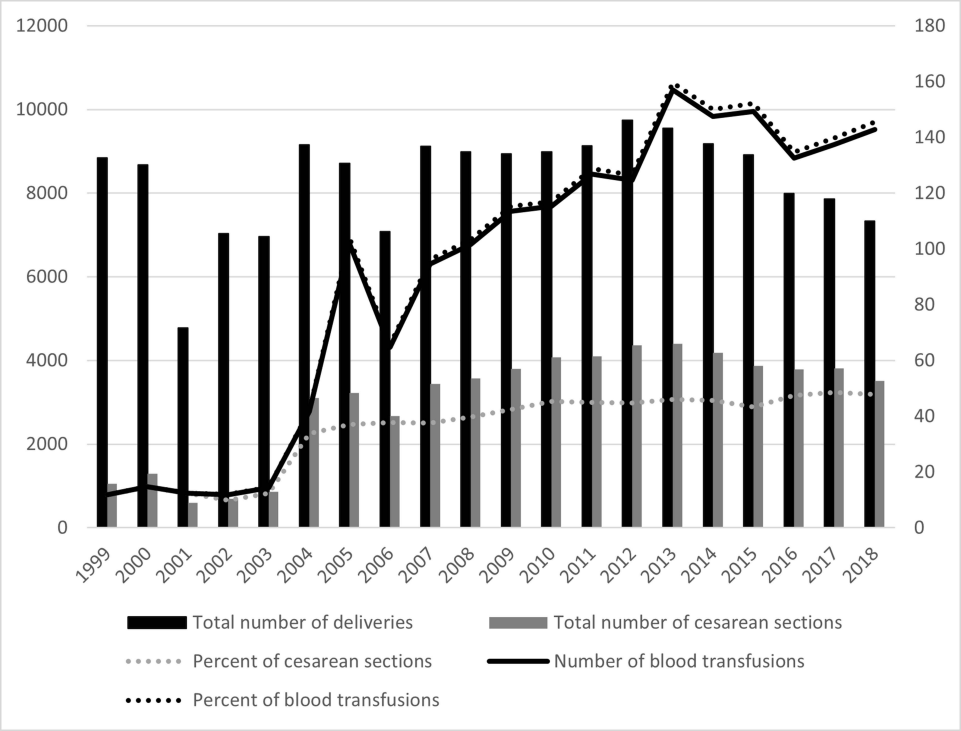

Figure 1 Number and percentage of deliveries, caesarean sections and blood transfusions.

2017. The blood transfusion rate in women undergoing caesarean section peaked at 3.2% in 2019. No blood transfusions were found between 1999 and 2001 (Figure 1).

The most common risk factors for the 1274 transfused women were maternal anaemia (523 cases; 41%), placenta previa (384 cases; 30.1%) and uterine atony (370 cases; 29.0%; Table 1). The most frequently used anaesthetic method was spinal block (607 cases; 47.6%), and most operations lasted between 45 and 60 minutes (291 cases; 22.8%; Table 1).

Table 1 Risk Factors and Quantity, Types and Blood Components of Blood Transfusion (n = 1274)

Risk Factors	Number of Cases
Maternal anaemia (Hct < 33%)	523 (41%)
Uterine atony	370 (29.0%)
Abnormal placentation	535 (42.0%)
Placenta accreta spectrum	
Placenta accreta	32 (2.5%)
Placenta increta	44 (3.5%)
Placenta percreta	22 (1.7%)
Placenta previa	384 (30.1%)
Placental abruption	45 (3.5%)
Uterine rupture	8 (0.6%)

(*Continued*)

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Table 1 (Continued).

Risk Factors	**Number of Cases**
Adjacent organ injury	218 (17.1%)
Tear lower uterine segment	117 (9.2%)
Tear bladder	41 (3.2%)
Tear uterine artery	31 (2.4%)
Other injuries	29 (2.3%)
Hypertensive disorders in pregnancy	
No	1055 (82.8%)
Gestational hypertension	33 (2.6%)
Pre-eclampsia without severe feature	40 (3.1%)
Pre-eclampsia with severe feature	117 (9.2%)
Eclampsia	8 (0.6%)
Superimpose pre-eclampsia with severe feature	21 (1.6%)
HELLP	44 (3.5%)
Thrombocytopenia	28 (2.2%)
Coagulopathy	50 (3.9%)
Gestational diabetes mellitus (GDM)	
No	1156 (90.7%)
GDM A1	102 (8.0%)
GDM A2	16 (1.3%)
Time of caesarean section	
Official time (9.00 A.M.–16.00 P.M.)	627 (49.2%)
Out of official time (16.00 P.M.–9.00 A.M.)	647 (50.8%)
Anaesthetic methods	
General anaesthesia	501 (39.3%)
Spinal block	607 (47.6%)
Spinal block with general anaesthesia	123 (9.7%)
Other	43 (3.4%)
Total operative time (minutes)	
< 30	18 (1.4%)
30–< 45	213 (16.7%)
45–< 60	291 (22.8%)
60–< 75	191 (15.0%)
75–< 90	126 (9.9%)
90–< 105	87 (6.8%)
105–< 120	69 (5.4%)
120–< 150	86 (6.8%)
150–< 180	65 (5.1%)
≥ 180	127 (10.0%)
Blood Loss, and Type of Blood and Blood Component Transfusions	**Number of Cases**
	Median (range), mean ± SD
Estimated blood loss (EBL) (mL)	1200 (100–23,500)
< 500	210 (16.5%)
500–999	288 (22.6%)
1000–1499	256 (20.1%)

(*Continued*)

Table 1 (Continued).

Blood Loss, and Type of Blood and Blood Component Transfusions	Number of Cases
	Median (range), mean ± SD
1500–1999 2000–2499 2500–4999 5000–9999 ≥ 10,000	164 (12.9%) 120 (9.4%) 185 (14.5%) 45 (3.5%) 6 (0.5%)
Packed red blood cells (units)	1163 (91.3%) 2 (1–34), 2.8 ± 3.1
Whole blood (units)	199 (15.6%) 2 (1–10), 2.3 ± 1.8
Fresh-frozen plasma (units)	267 (21.0%) 4 (1–39), 4.8 ± 3.9
Platelets (units)	196 (15.4%) 6 (1–60), 11.1 ± 11.0
Cryoprecipitate (units)	92 (7.2%) 10 (1–46), 10.8 ± 8.2

The highest volumes of blood loss were in the range of 500 to 999 mL (288 cases; 22.6%). The most common blood type used was packed red cells (1163 cases; 91.3%; Table 1).

The factors associated with maternal anaemia included maternal age under 20 years (adjusted odds ratio [aOR] 8.42; 95% CI 3.64–19.44) and age 20–29 years (aOR 3.19, 95% CI 1.97–5.18); P < 0.001. Pre-eclampsia with severe features was also a significant factor (aOR 2.69, 95% CI 1.60–4.52), as well as hypertension with superimposed pre-eclampsia (aOR 3.08, 95% CI 1.00–9.51; P = 0.002) (Table 2).

Table 2 Factors Associated with Maternal Anaemia (Multivariable Analysis: Multiple Logistic Regression)

Factors	Unadjusted Odds Ratio (95% CI)	*P* value	Adjusted Odds Ratio (95% CI)	*P* value
Age		< 0.001		< 0.001
< 20 (n = 43)	8.92 (4.46–17.83)		8.42 (3.64–19.44)	
20–29 (n = 397)	3.88 (2.57–5.86)		3.19 (1.97–5.18)	
30–35 (n = 440)	1.68 (1.09–2.61)		1.54 (0.94–2.54)	
> 35 (n = 394)	1.00		1.00	
Parity		0.032		0.369
0	1.40 (0.95–2.08)		0.80 (0.48–1.33)	
1	0.92 (0.60–1.42)		0.68 (0.40–1.17)	
> 1	1.00		1.00	
Haemoglobinopathy		< 0.001		< 0.001
No	1.00		1.00	
Hb H disease	10.51 (3.14–35.19)		12.46 (3.25–47.74)	
Beta thal-trait	3.50 (1.32–9.28)		5.41 (1.90–15.44)	
Hb E trait	1.48 (0.93–2.37)		1.66 (1.01–2.73)	
Alpha thal-trait	1.84 (0.95–3.59)		2.44 (1.19–4.97)	
Others	10.59 (7.05–15.91)		13.85 (8.71–22.02)	

(*Continued*)

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Table 2 (Continued).

Factors	Unadjusted Odds Ratio (95% CI)	*P* value	Adjusted Odds Ratio (95% CI)	*P* value
Anti-HIV	4.81 (1.98–11.69)	0.001	2.95 (0.99–8.86)	0.053
Number of antenatal care visits		< 0.001		0.045
No	3.35 (1.81–6.18)		1.37 (0.19–10.08)	
1–4	1.83 (1.15–2.91)		2.00 (1.13–3.54)	
≥ 5	1.00		1.00	
Hypertension (HT)		0.001		0.002
No	1.00		1.00	
Gestational HT	1.16 (0.47–2.85)		1.06 (0.37–3.02)	
Pre-eclampsia without severe features	1.10 (0.48–2.54)		1.64 (0.63–4.27)	
Pre-eclampsia with severe features	2.50 (1.65–3.81)		2.69 (1.60–4.52)	
Superimposed pre-eclampsia	1.63 (0.59–4.50)		3.08 (1.00–9.51)	
Gestational diabetes (GDM)		0.001		0.047
No	1.00		1.00	
GDM A1	0.17 (0.06–0.47)		0.25 (0.07–0.83)	
GDM A2	0.28 (0.04–2.15)		0.32 (0.04–2.75)	

Blood loss of ≥1000 mL was significantly associated with several factors: maternal age ≥35 years (aOR 1.952, 95% CI 1.419–2.685; P < 0.001), placenta accreta spectrum (aOR 0.076, 95% CI 0.043–0.134; P < 0.001), placenta previa (aOR 2.226, 95% CI 1.577–3.142; P < 0.001), and adjacent organ injuries (aOR 4.034, 95% CI 2.062–7.890; P < 0.001) (Table 3). Blood loss volumes starting from 1000 mL and progressing through 1500 mL, 2000 mL, and 2500 mL were consistently associated with these risk factors, as detailed in Table 3.

PRC transfusion of ≥5 units was significantly associated with the following factors: maternal age ≥35 years (aOR 1.417, 95% CI 1.001–2.005; P = 0.049), placenta accreta spectrum (aOR 5.987, 95% CI 3.585–10.000; P < 0.001),

Table 3 Factors Associated with Varying Volumes of Blood Loss: a Univariable and Multivariable Logistic Regression Analysis

Factors	No (n=498)	Yes (n=776)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Blood loss ≥1000 milliliters						
Age: ≥ 35 years	120 (24.1%)	350 (45.1%)	2.588 (2.017, 3.321)	<0.001	1.952 (1.419, 2.685)	<0.001
Body mass index (kg/m^2) (n=937)						–
20 – 24.9	136 (41.7%)	318 (52%)	1.000		–	
< 20	129 (39.6%)	127 (20.8%)	0.421 (0.307, 0.578)	<0.001		
≥ 25	61 (18.7%)	166 (27.2%)	1.164 (0.816, 1.661)	0.403		
Total weight gain ≥ 10 kg (n=920)	211 (65.3%)	423 (70.9%)	1.290 (0.966, 1.723)	0.084	–	–
Parity ≥ 2	76 (15.3%)	172 (22.2%)	1.581 (1.175, 2.128)	0.002	1.416 (0.946, 2.121)	0.091
Preterm delivery	249 (50.3%)	312 (40.4%)	0.670 (0.534, 0.841)	<0.001	0.691 (0.508, 0.940)	0.019
Gestational diabetes mellitus	26 (5.2%)	92 (11.9%)	2.442 (1.556, 3.833)	<0.001	1.340 (0.794, 2.261)	0.273
Hypertension	31 (6.2%)	26 (3.4%)	0.522 (0.306, 0.891)	0.015	0.497 (0.249, 0.991)	0.047

(*Continued*)

Table 3 (Continued).

Factors	No (n=498)	Yes (n=776)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Hemoglobinopathy	197 (42.1%)	228 (30.1%)	0.593 (0.466, 0.754)	<0.001	0.980 (0.710, 1.353)	0.901
Maternal anaemia	208 (41.8%)	18 (2.3%)	0.033 (0.020, 0.055)	<0.001	0.076 (0.043, 0.134)	<0.001
Placenta accreta spectrum	4 (0.8%)	93 (12%)	16.82 (6.140, 46.06)	<0.001	11.51 (3.879, 34.13)	<0.001
Placenta previa	87 (17.5%)	297 (38.3%)	2.929 (2.230, 3.848)	<0.001	2.226 (1.577, 3.142)	<0.001
Placental abruption	20 (4%)	25 (3.2%)	0.796 (0.437, 1.448)	0.454	–	–
Uterine atony	48 (9.6%)	322 (41.5%)	6.649 (4.780, 9.250)	<0.001	5.583 (3.828, 8.144)	<0.001
Uterine rupture	1 (0.2%)	7 (0.9%)	4.524 (0.555, 36.88)	0.159	–	–
Adjacent organs injuries	12 (2.4%)	105 (13.5%)	6.338 (3.449, 11.65)	<0.001	4.034 (2.062, 7.890)	<0.001
Factors	**No (n=754)**	**Yes (n=520)**	**Univariable Analysis**		**Multivariable Analysis**	
			Crude Odds Ratio (95% CI)	**p-value**	**Adjusted Odds Ratio (95% CI)**	**p-value**
Blood loss ≥1500 milliliters						
Age: ≥ 35 years	222 (29.4%)	248 (47.7%)	2.185 (1.731, 2.757)	<0.001	1.620 (1.225, 2.142)	<0.001
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	236 (44.8%)	218 (53.2%)	1.000			
< 20	174 (33%)	82 (20%)	0.510 (0.370, 0.703)	<0.001		
≥ 25	117 (22.2%)	110 (26.8%)	1.018 (0.740, 1.400)	0.914		
Total weight gain ≥ 10 kg (n=920)	352 (68.1%)	282 (70%)	1.092 (0.824, 1.448)	0.539	–	–
Parity ≥ 2	128 (17%)	120 (23.1%)	1.467 (1.110, 1.939)	0.007	1.128 (0.796, 1.598)	0.498
Preterm delivery	358 (47.8%)	203 (39.2%)	0.704 (0.561, 0.883)	0.002	0.659 (0.492, 0.881)	0.005
Gestational diabetes mellitus	54 (7.2%)	64 (12.3%)	1.819 (1.243, 2.663)	0.002	1.233 (0.798, 1.904)	0.345
Hypertension	42 (5.6%)	15 (2.9%)	0.504 (0.276, 0.918)	0.023	0.608 (0.305, 1.215)	0.159
Hemoglobinopathy	282 (39.5%)	143 (28%)	0.595 (0.466, 0.760)	<0.001	0.815 (0.607, 1.094)	0.173
Maternal anaemia	218 (28.9%)	8 (1.5%)	0.038 (0.019, 0.079)	<0.001	0.102 (0.047, 0.219)	<0.001
Placenta accreta spectrum	13 (1.7%)	84 (16.2%)	10.98 (6.051, 19.93)	<0.001	8.919 (4.665, 17.05)	<0.001
Placenta previa	166 (22%)	218 (41.9%)	2.557 (2.001, 3.267)	<0.001	2.204 (1.606, 3.024)	<0.001
Placental abruption	31 (4.1%)	14 (2.7%)	0.645 (0.340, 1.225)	0.177	–	–
Uterine atony	138 (18.3%)	232 (44.6%)	3.596 (2.792, 4.631)	<0.001	3.629 (2.693, 4.891)	<0.001
Uterine rupture	2 (0.3%)	6 (1.2%)	4.389 (0.882, 21.83)	0.069	8.517 (1.533, 47.32)	0.014
Adjacent organs injuries	40 (5.3%)	77 (14.8%)	3.103 (2.080, 4.628)	<0.001	2.194 (1.387, 3.470)	<0.001

(*Continued*)

Table 3 (Continued).

Factors	No (n=918)	Yes (n=356)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Blood loss ≥2000 milliliters						
Age: ≥ 35 years	292 (31.8%)	178 (50%)	2.144 (1.670, 2.752)	<0.001	1.561 (1.156, 2.109)	0.004
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	308 (47%)	146 (52%)	1.000			
< 20	199 (30.3%)	57 (20.2%)	0.604 (0.424, 0.861)	0.005		
≥ 25	149 (22.7%)	78 (27.8%)	1.104 (0.788, 1.547)	0.564		
Total weight gain ≥ 10 kg (n=920)	434 (67.4%)	200 (72.5%)	1.273 (0.933, 1.738)	0.128	–	–
Parity ≥ 2	155 (16.9%)	93 (26.1%)	1.741 (1.299, 2.333)	<0.001	1.307 (0.907, 1.883)	0.151
Preterm delivery	425 (46.6%)	136 (38.3%)	0.712 (0.554, 0.914)	0.008	0.581 (0.419, 0.805)	0.001
Gestational diabetes mellitus	76 (8.3%)	42 (11.8%)	1.482 (0.995, 2.207)	0.052	1.032 (0.649, 1.640)	0.895
Hypertension	47 (5.1%)	10 (2.8%)	0.536 (0.268, 1.072)	0.073	0.764 (0.350, 1.660)	0.499
Hemoglobinopathy	330 (37.8%)	95 (27.1%)	0.612 (0.466, 0.803)	<0.001	0.821 (0.595, 1.134)	0.232
Maternal anaemia	221 (24.1%)	5 (1.4%)	0.045 (0.018, 0.110)	<0.001	0.122 (0.046, 0.325)	<0.001
Placenta accreta spectrum	15 (1.6%)	82 (23%)	18.02 (10.22, 31.75)	<0.001	17.20 (9.232, 32.03)	<0.001
Placenta previa	222 (24.2%)	162 (45.5%)	2.618 (2.024, 3.387)	<0.001	2.191 (1.553, 3.091)	<0.001
Placenta abruption	37 (4%)	8 (2.2%)	0.547 (0.252, 1.187)	0.122	–	–
Uterine atony	208 (22.7%)	162 (45.5%)	2.850 (2.199, 3.695)	<0.001	3.462 (2.519, 4.759)	<0.001
Uterine rupture	2 (0.2%)	6 (1.7%)	7.851 (1.577, 39.09)	0.008	19.64 (3.479, 110.8)	<0.001
Adjacent organs injuries	60 (6.5%)	57 (16%)	2.726 (1.854, 4.009)	<0.001	2.013 (1.274, 3.182)	0.003
Factors	**No (n=1038)**	**Yes (n=236)**	**Univariable Analysis**		**Multivariable Analysis**	
			Crude Odds Ratio (95% CI)	**p-value**	**Adjusted Odds Ratio (95% CI)**	**p-value**
Blood loss ≥2500 milliliters						
Age: ≥ 35 years	354 (34.1%)	116 (49.2%)	1.868 (1.404, 2.485)	<0.001	1.300 (0.929, 1.819)	0.126
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	355 (47.3%)	99 (53.2%)	1.000			
< 20	217 (28.9%)	39 (21%)	0.644 (0.429, 0.968)	0.034		
≥ 25	179 (23.8%)	48 (25.8%)	0.962 (0.652, 1.418)	0.843		
Total weight gain ≥ 10 kg (n=920)	502 (68.2%)	132 (71.7%)	1.183 (0.828, 1.690)	0.354	–	–
Parity ≥ 2	178 (17.1%)	70 (29.7%)	2.037 (1.476, 2.813)	<0.001	1.519 (1.027, 2.246)	0.036
Preterm delivery	460 (44.6%)	101 (43%)	0.937 (0.704, 1.248)	0.657	–	–
Gestational diabetes mellitus	89 (8.6%)	29 (12.3%)	1.494 (0.957, 2.332)	0.076	1.152 (0.688, 1.930)	0.591
Hypertension	51 (4.9%)	6 (2.5%)	0.505 (0.214, 1.191)	0.112	–	–
Hemoglobinopathy	364 (36.7%)	61 (26.2%)	0.612 (0.445, 0.842)	0.002	0.856 (0.594, 1.234)	0.404

(*Continued*)

Table 3 (Continued).

Factors	No (n=1038)	Yes (n=236)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Maternal anaemia	222 (21.4%)	4 (1.7%)	0.063 (0.023, 0.172)	<0.001	0.191 (0.064, 0.568)	0.003
Placenta accreta spectrum	30 (2.9%)	67 (28.4%)	13.32 (8.406, 21.11)	<0.001	12.43 (7.368, 20.97)	<0.001
Placenta previa	272 (26.2%)	112 (47.5%)	2.544 (1.902, 3.401)	<0.001	1.972 (1.349, 2.882)	<0.001
Placenta abruption	39 (3.8%)	6 (2.5%)	0.668 (0.280, 1.597)	0.361	–	–
Uterine atony	259 (25%)	111 (47%)	2.671 (1.995, 3.576)	<0.001	4.091 (2.835, 5.905)	<0.001
Uterine rupture	2 (0.2%)	6 (2.5%)	13.51 (2.710, 67.38)	<0.001	28.15 (5.014, 158.1)	<0.001
Adjacent organs injuries	76 (7.3%)	41 (17.4%)	2.661 (1.767, 4.009)	<0.001	2.123 (1.304, 3.456)	0.002

uterine atony (aOR 3.404, 95% CI 2.297–5.043; P < 0.001), and adjacent organ injuries (aOR 1.794, 95% CI 1.072–3.002; P = 0.026) (Table 4).

Factors associated with fresh frozen plasma transfusion include maternal anaemia (aOR 0.369, 95% CI 0.189–0.719; P = 0.003), placenta accreta spectrum (aOR 6.530, 95% CI 4.056–10.510; P < 0.001), uterine atony (aOR 3.612, 95% CI

Table 4 Factors Associated with Transfusion of 5 or More Units of Packed Red Blood Cells: a Univariable and Multivariable Logistic Regression Analysis

Factors	No (n=1097)	Yes (n=177)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age: ≥ 35 years	384 (35%)	86 (48.6%)	1.755 (1.274, 2.416)	<0.001	1.417 (1.001, 2.005)	0.049
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	394 (48.7%)	60 (46.9%)	1.000			
< 20	220 (27.2%)	36 (28.1%)	1.075 (0.689, 1.677)	0.751		
≥ 25	195 (24.1%)	32 (25%)	1.078 (0.679, 1.711)	0.751		
Total weight gain ≥ 10 kg (n=920)	551 (69.1%)	83 (67.5%)	0.926 (0.617, 1.390)	0.712		
Parity ≥ 2	199 (18.1%)	49 (27.7%)	1.727 (1.201, 2.484)	0.003	1.341 (0.901, 1.997)	0.149
Preterm delivery	465 (42.7%)	96 (54.2%)	1.593 (1.158, 2.192)	0.004	1.769 (1.233, 2.537)	0.002
Gestational diabetes mellitus	98 (8.9%)	20 (11.3%)	1.299 (0.780, 2.161)	0.314	–	–
Hypertension	50 (4.6%)	7 (4%)	0.862 (0.385, 1.933)	0.719	–	–
Hemoglobinopathy	374 (35.6%)	51 (29.5%)	0.758 (0.534, 1.076)	0.120	–	–
Maternal anaemia	210 (19.1%)	16 (9%)	0.420 (0.246, 0.717)	0.001	0.982 (0.531, 1.816)	0.955
Placenta accreta spectrum	54 (4.9%)	43 (24.3%)	6.198 (3.995, 9.615)	<0.001	5.987 (3.585, 10.00)	<0.001
Placenta previa	311 (28.4%)	73 (41.2%)	1.774 (1.279, 2.460)	<0.001	1.282 (0.848, 1.937)	0.238
Placental abruption	40 (3.6%)	5 (2.8%)	0.768 (0.299, 1.974)	0.583	–	–
Uterine atony	291 (26.5%)	79 (44.6%)	2.233 (1.613, 3.091)	<0.001	3.404 (2.297, 5.043)	<0.001
Uterine rupture	5 (0.5%)	3 (1.7%)	3.766 (0.892, 15.90)	0.087	4.091 (0.806, 20.77)	0.089
Adjacent organs injuries	89 (8.1%)	28 (15.8%)	2.128 (1.346, 3.365)	<0.001	1.794 (1.072, 3.002)	0.026

2.599–5.019; P < 0.001), uterine rupture (aOR 6.698, 95% CI 1.452–30.900; P = 0.015), and adjacent organ injuries (aOR 1.678, 95% CI 1.061–2.653; P = 0.027) (Table 5).

Factors associated with platelet transfusion include maternal hemoglobinopathy (aOR 0.630, 95% CI 0.431–0.919; P = 0.016), placenta accreta spectrum (aOR 3.575, 95% CI 2.205–5.797, P < 0.001), and uterine atony (aOR 1.995, 95% CI 1.393–2.856; P < 0.001) (Table 6).

Table 5 Factor Associated with Fresh Frozen Plasma Transfusion: a Univariable and Multivariable Logistic Regression Analysis

Factors	No (n=1007)	Yes (n=267)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age: ≥ 35 years	352 (35%)	118 (44.2%)	1.474 (1.120, 1.938)	0.005	1.160 (0.854, 1.576)	0.343
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	353 (47.9%)	101 (50.5%)	1.000			
< 20	202 (27.4%)	54 (27%)	0.934 (0.643, 1.357)	0.721		
≥ 25	182 (24.7%)	45 (22.5%)	0.864 (0.583, 1.282)	0.468		
Total weight gain ≥ 10 kg (n=920)	502 (69.3%)	132 (67.3%)	0.912 (0.651, 1.279)	0.593	–	–
Parity ≥ 2	179 (17.8%)	69 (25.8%)	1.612 (1.173, 2.216)	0.003	1.312 (0.911, 1.889)	0.145
Preterm delivery	427 (42.7%)	134 (50.4%)	1.365 (1.041, 1.789)	0.024	1.585 (1.152, 2.181)	0.005
Gestational diabetes mellitus	89 (8.8%)	29 (10.9%)	1.257 (0.807, 1.957)	0.311	–	–
Hypertension	45 (4.5%)	12 (4.5%)	1.006 (0.524, 1.930)	0.986	–	–
Hemoglobinopathy	358 (37.1%)	67 (25.9%)	0.593 (0.436, 0.806)	<0.001	0.770 (0.549, 1.078)	0.128
Maternal anaemia	215 (21.4%)	11 (4.1%)	0.158 (0.085, 0.295)	<0.001	0.369 (0.189, 0.719)	0.003
Placenta accreta spectrum	42 (4.2%)	55 (20.6%)	5.961 (3.884, 9.147)	<0.001	6.530 (4.056, 10.51)	<0.001
Placenta previa	299 (29.7%)	85 (31.8%)	1.106 (0.827, 1.479)	0.497	–	–
Placental abruption	30 (3.0%)	15 (5.6%)	1.938 (1.027, 3.658)	0.038	1.545 (0.744, 3.205)	0.243
Uterine atony	242 (24%)	128 (47.9%)	2.911 (2.200, 3.853)	<0.001	3.612 (2.599, 5.019)	<0.001
Uterine rupture	3 (0.3%)	5 (1.9%)	6.387 (1.517, 26.89)	0.013	6.698 (1.452, 30.90)	0.015
Adjacent organs injuries	77 (7.6%)	40 (15%)	2.128 (1.414, 3.203)	<0.001	1.678 (1.061, 2.653)	0.027

Table 6 Factors Associated with Platelet Transfusion: a Univariable and Multivariable Logistic Regression Analysis

Factors	No (n=1078)	Yes (n=196)	Univariable Analysis		Multivariable Analysis	
			Crude odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age: ≥ 35 years	386 (35.8%)	84 (42.9%)	1.345 (0.987, 1.832)	0.060	1.147 (0.824, 1.597)	0.417
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	380 (47.4%)	74 (54.4%)	1.000			
< 20	226 (28.2%)	30 (22.1%)	0.682 (0.432, 1.074)	0.099		
≥ 25	195 (24.4%)	32 (23.5%)	0.843 (0.538, 1.321)	0.455		

(*Continued*)

Table 6 (Continued).

Factors	No (n=1078)	Yes (n=196)	Univariable Analysis		Multivariable Analysis	
			Crude odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Total weight gain ≥ 10 kg (n=920)	542 (69%)	92 (68.7%)	0.986 (0.664, 1.464)	0.945	–	–
Parity ≥ 2	196 (18.2%)	52 (26.5%)	1.625 (1.142, 2.313)	0.007	1.386 (0.946, 2.030)	0.094
Preterm delivery	453 (42.3%)	108 (55.4%)	1.696 (1.248, 2.306)	<0.001	1.699 (1.213, 2.378)	0.002
Gestational diabetes mellitus	95 (8.8%)	23 (11.7%)	1.376 (0.848, 2.230)	0.194	–	–
Hypertension	44 (4.1%)	13 (6.6%)	1.669 (0.882, 3.161)	0.112	–	–
Hemoglobinopathy	381 (36.8%)	44 (23.3%)	0.522 (0.364, 0.748)	<0.001	0.630 (0.431, 0.919)	0.016
Maternal anaemia	209 (19.4%)	17 (8.7%)	0.395 (0.235, 0.664)	<0.001	0.736 (0.418, 1.294)	0.287
Placenta accrete spectrum	60 (5.6%)	37 (18.9%)	3.948 (2.537, 6.146)	<0.001	3.575 (2.205, 5.797)	<0.001
Placenta previa	331 (30.7%)	53 (27%)	0.836 (0.595, 1.176)	0.304	–	–
Placental abruption	32 (3%)	13 (6.6%)	2.322 (1.196, 4.508)	0.011	1.586 (0.747, 3.368)	0.230
Uterine atony	295 (27.4%)	75 (38.3%)	1.645 (1.197, 2.260)	0.002	1.995 (1.393, 2.856)	<0.001
Uterine rupture	5 (0.5%)	3 (1.5%)	3.336 (0.791, 14.07)	0.111	–	–
Adjacent organs injuries	94 (8.7%)	23 (11.7%)	1.392 (0.858, 2.258)	0.180	–	–

Factors associated with cryoprecipitate transfusion include maternal anaemia (aOR 0.258, 95% CI 0.078–0.852; P = 0.026), placenta accreta spectrum (aOR 4.928, 95% CI 2.751–8.826; P < 0.001), and uterine atony (aOR 2.943, 95% CI 1.810–4.784; P < 0.001) (Table 7).

Table 7 Factor Associated with Cryoprecipitate Transfusion: a Univariable and Multivariable Logistic Regression Analysis

Factors	No (n=1182)	Yes (n=92)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Age: ≥ 35 years	425 (36%)	45 (48.9%)	1.705 (1.114, 2.610)	0.013	1.295 (0.829, 2.023)	0.256
Body mass index (kg/m^2) (n=937)					–	–
20–24.9	416 (48%)	38 (54.1%)	1.000			
< 20	240 (27.7%)	16 (22.9%)	0.730 (0.398, 1.337)	0.308		
≥ 25	211 (24.3%)	16 (22.9%)	0.830 (0.452, 1.523)	0.548		
Total weight gain ≥ 10 kg (n=920)	588 (69.1%)	46 (66.7%)	0.895 (0.531, 1.507)	0.675	–	–
Parity ≥ 2	228 (19.3%)	20 (21.7%)	1.162 (0.694, 1.947)	0.568	–	–
Preterm delivery	508 (43.2%)	53 (57.6%)	1.784 (1.162, 2.741)	0.008	2.069 (1.299, 3.294)	0.002
Gestational diabetes mellitus	106 (9%)	12 (13%)	1.523 (0.804, 2.884)	0.194	–	–
Hypertension	54 (4.6%)	3 (3.3%)	0.704 (0.216, 2.297)	0.793	–	–
Hemoglobinopathy	398 (35.1%)	27 (30%)	0.794 (0.497, 1.266)	0.331	–	–

(*Continued*)

Table 7 (Continued).

Factors	No (n=1182)	Yes (n=92)	Univariable Analysis		Multivariable Analysis	
			Crude Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Maternal anaemia	223 (18.9%)	3 (3.3%)	0.145 (0.045, 0.462)	<0.001	0.258 (0.078, 0.852)	0.026
Placenta accrete spectrum	74 (6.3%)	23 (25%)	4.991 (2.946, 8.457)	<0.001	4.928 (2.751, 8.826)	<0.001
Placenta previa	353 (29.9%)	31 (33.7%)	1.193 (0.761, 1.872)	0.441	–	–
Placental abruption	40 (3.4%)	5 (5.4%)	1.641 (0.631, 4.264)	0.370	–	–
Uterine atony	327 (27.7%)	43 (46.7%)	2.295 (1.494, 3.523)	<0.001	2.943 (1.810, 4.784)	<0.001
Uterine rupture	6 (0.5%)	2 (2.2%)	4.356 (0.867, 21.89)	0.109	–	–
Adjacent organs injuries	104 (8.8%)	13 (14.1%)	1.706 (0.917, 3.171)	0.088	1.319 (0.687, 2.530)	0.406

Discussion

This 20-year review provides valuable insights into blood transfusion patterns during caesarean section (CS) at Siriraj Hospital, revealing significant associations between transfusion needs and specific maternal and obstetric risk factors.[12] The increasing CS rate, which rose from 1.9% in 2002 to 48.5% in 2017, reflects global trends of rising operative deliveries and underscores the growing burden of perioperative complications.[13,14] Parallel to this trend, our findings show that the transfusion rate also increased, peaking at 3.2% in 2019, which emphasizes the importance of identifying women at highest risk and implementing targeted preventive measures. The majority of blood losses were between 500 and 999 mL, consistent with other studies but with increased risks associated with underlying anaemia.[15,16]

Among all risk factors, placenta accreta spectrum emerged as the strongest predictor of transfusion, with a more than sixfold increased likelihood of requiring multiple blood components. This aligns with global evidence showing that abnormal placentation is one of the leading causes of massive obstetric haemorrhage, maternal morbidity, and peripartum hysterectomy.[17] The rising prevalence of placenta accreta spectrum has been linked to increasing CS rates, which create uterine scarring and predispose women to abnormal placental attachment in subsequent pregnancies.[17,18] Our findings reinforce the critical need for early antenatal diagnosis through ultrasound and MRI, multidisciplinary delivery planning, and blood bank preparedness in tertiary care settings to reduce morbidity and optimize outcomes. Obstetric haemorrhage remains a leading cause of maternal mortality in many countries, including Thailand, where it ranks as a major cause of direct maternal mortality.[19,20]

Uterine atony, another significant predictor, was present in nearly one-third of cases requiring transfusion. Despite advances in uterotonic protocols, uterine atony remains the leading cause of postpartum haemorrhage worldwide and is a common reason for escalation to transfusion.[3,4,17] Our data support the importance of early recognition and aggressive management of atony, including the use of second-line uterotonics, tranexamic acid, and surgical interventions where needed. Given its high prevalence, training delivery teams in atony management through simulation-based education and standardized protocols may reduce transfusion requirements and improve safety outcomes.

Maternal anaemia was also strongly associated with transfusion, particularly in women under 30 years old, those with a low BMI, and those with fewer antenatal visits. These findings are consistent with studies from other low- and middle-income countries where iron deficiency anaemia remains a persistent contributor to obstetric morbidity.[21,22] We observed that anaemia was more common in women with a BMI < 18.5, those under 30, and those with fewer antenatal visits.[23,24] Anaemia can lead to severe complications such as post-partum infection, uterine atony, and the need for blood transfusions, even with moderate blood loss.[25,26] Anaemia reduces maternal reserve, leading to a greater likelihood of transfusion even with moderate blood loss. Strengthening antenatal care, increasing access to iron and folic acid supplementation, and routine haemoglobin monitoring are critical strategies to improve maternal outcomes.[27] Public

health initiatives targeting nutritional deficiencies and anaemia screening could substantially reduce transfusion demand in obstetric populations.

In addition to these primary risk factors, placenta previa, uterine rupture, and adjacent organ injury were also significantly associated with blood loss ≥1000 mL and high transfusion volumes. These conditions, often linked to emergency CS and delayed presentation, highlight the importance of early referral systems, appropriate surgical expertise, and readily available blood products in tertiary centers. Our findings underscore that while CS is a life-saving procedure, its increasing use necessitates proactive planning to address the rising risk of obstetric haemorrhage and transfusion dependence. Blood transfusions, while lifesaving, carry risks such as infections, electrolyte imbalances, and increased mortality in massive transfusions.[28,29]

Although this study did not specifically evaluate massive transfusion protocols,[30,31] our results demonstrate that certain risk factors; particularly placenta accreta spectrum and uterine atony are closely tied to high transfusion volumes, placing patients at greater risk of complications associated with massive transfusion.[32,33] These complications include coagulopathy, hypothermia, electrolyte imbalance, and multi-organ failure, which contribute to poor maternal outcomes and increased resource utilization. Proactive measures such as standardized massive transfusion protocols, early hemorrhage risk scoring, and multidisciplinary planning for high-risk pregnancies are essential. Furthermore, optimizing antenatal care and encouraging delivery in well-equipped tertiary centers could reduce the need for massive transfusions and improve maternal safety.

Our findings also have implications for blood management strategies. Variability in transfusion practices among clinicians has been well documented,[30,31] and while our study did not directly measure provider-level variation, the high rates of transfusion observed in association with specific obstetric risk factors highlight the need for standardized, evidence-based guidelines. Implementing patient blood management (PBM) programs, which emphasize minimizing unnecessary transfusions and optimizing hemoglobin levels pre-delivery, has been shown to reduce transfusion rates and improve outcomes.[16] Education, audit, and feedback interventions could enhance adherence to PBM principles and reduce variability in transfusion decisions.[34]

Finally, this study emphasizes the importance of prevention-focused approaches. Addressing maternal anaemia through early screening and supplementation programs is an achievable strategy, particularly in resource-limited settings where blood supplies are constrained. Efforts to reduce primary caesarean section rates could indirectly lower placenta accreta spectrum prevalence, thereby decreasing the likelihood of severe hemorrhage and transfusion requirements in future pregnancies. Strengthening obstetric emergency preparedness, especially in rural and referral hospitals, will also be crucial to reducing maternal morbidity and mortality.

Importantly, while similar studies have been conducted in both the Global North and South, our analysis provides one of the largest datasets from Southeast Asia, covering a 20-year period at Thailand's largest tertiary referral center. This regional context is unique, as patterns of maternal risk factors, caesarean delivery rates, and availability of blood products differ substantially from high-income and other low- and middle-income countries. Our findings therefore add value by offering locally relevant evidence to guide clinical practice and inform national health system planning. By identifying key predictors of transfusion, our study highlights opportunities for targeted interventions to improve maternal outcomes and reduce reliance on blood products. Future research could explore predictive models integrating antenatal and intrapartum factors to better stratify risk and guide blood bank resource allocation.

Strengths of the Study

This study draws on two decades of data from a large tertiary referral center, providing a comprehensive overview of transfusion patterns and risk factors during caesarean section. The large sample size and detailed clinical information strengthen the validity of the findings. The use of multivariable analyses allowed us to adjust for multiple confounders and identify independent predictors of transfusion, offering insights that can inform clinical practice and resource planning.

Limitations of the Study

As a retrospective single-center study, the findings are subject to limitations inherent to chart reviews, including missing data and potential coding errors. The study population primarily reflects women receiving care at a tertiary center in Thailand, which may limit generalizability to other healthcare settings or ethnic populations. Additionally, while we examined transfusion volumes and component use, we did not assess maternal outcomes beyond the delivery admission period or evaluate long-term effects of transfusion. Future multicenter or prospective studies are needed to validate these findings across diverse populations and healthcare systems.

Conclusions

This 20-year retrospective review identified placenta accreta spectrum, uterine atony, placenta previa, and maternal anaemia as the strongest predictors of blood transfusion during caesarean section. Women with placenta accreta spectrum had a more than sixfold increased likelihood of transfusion, and those with uterine atony were over three times more likely to require blood products. Rising caesarean section rates were associated with an increased transfusion burden, highlighting the need for preventive strategies. Improving antenatal care to address maternal anaemia, early diagnosis of abnormal placentation, and careful delivery planning for high-risk pregnancies are critical steps to reduce transfusion requirements and improve maternal outcomes. Development and implementation of standardized transfusion protocols and massive transfusion readiness may further enhance safety and optimize resource use in obstetric care.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The Ethics Committee of the Faculty of Medicine Siriraj Hospital approved its protocol. All procedures were conducted in accordance with the ethical standards of the institutional research committee (Si 235/2020) and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The work was also registered at the Thai Clinical Trials Registry (TCTR20200505001). This study is retrospective; therefore, informed consent was not required.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

References

1. Rouse DJ, MacPherson C, Landon M, et al. Blood transfusion and caesarean delivery. *Obstet Gynecol*. 2006;108(4):891–897. doi:10.1097/01.AOG.0000236547.35234.8c
2. Knight BP, Kenyon S, Shakespeare J, Kurinczuk JJ; MBRRACE-UK. Saving lives, improving mothers' care: lessons learned to inform future maternity care from the UK and Ireland confidential enquiries into maternal deaths and morbidity 2009–12. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2014.
3. Driessen M, Bouvier-Colle MH, Dupont C, Khoshnood B, Rudigoz RC, Deneux-Tharaux C. Postpartum hemorrhage resulting from uterine atony after vaginal delivery: factors associated with severity. *Obstet Gynecol*. 2011;117(1):21–31. doi:10.1097/AOG.0b013e318202c845
4. Dupont C, Touzet S, Colin C, et al. Incidence and management of postpartum haemorrhage following the dissemination of guidelines in a network of 16 maternity units in France. *Int J Obstet Anesth*. 2009;18(4):320–327. doi:10.1016/j.ijoa.2009.02.017
5. Upadhyay K, Scholefield H. Risk management and medicolegal issues related to postpartum haemorrhage. *Best Pract Res Clin Obstet Gynaecol*. 2008;22(6):1149–1169. doi:10.1016/j.bpobgyn.2008.08.007
6. Balki M, Dhumne S, Kasodekar S, Seaward G, Carvalho JC. Blood transfusion for primary postpartum hemorrhage: a tertiary care hospital review. *J Obstet Gynaecol Can*. 2008;30(11):1002–1007. doi:10.1016/S1701-2163(16)32994-2
7. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving mothers' lives: reviewing maternal deaths to make motherhood safer: 2006–2008. The eighth report of the confidential enquiries into maternal deaths in the United Kingdom. *BJOG*. 2011;118(Suppl 1):1–203.
8. Bates I, Chapotera GK, McKew S, van den Broek N. Maternal mortality in sub-Saharan Africa: the contribution of ineffective blood transfusion services. *BJOG*. 2008;115(11):1331–1339. doi:10.1111/j.1471-0528.2008.01866.x
9. Eyelade OR, Adesina OA, Adewole IF, Akinyemi JO. Blood transfusion requirement during caesarean delivery: risk factors. *Ann Ib Postgrad Med*. 2015;13(1):29–35.
10. Jadwin DF, McCarty JM, Marks DC, Vassallo RR, Yazer MH. Determination of unnecessary blood transfusion by comprehensive 15-hospital record review. *Jt Comm J Qual Patient Saf*. 2023;49(1):42–52. doi:10.1016/j.jcjq.2022.10.006
11. Serious Hazards of Transfusion Steering Group. Serious hazards of transfusion annual report 2013. Manchester: SHOT; 2013.
12. Mylonas I, Friese K. Indications for and risks of elective cesarean section. *Dtsch Arztebl Int*. 2015;112(29–30):489–495. doi:10.3238/arztebl.2015.0489
13. World Health Organization Human Reproduction Programme. WHO statement on caesarean section rates. *Reprod Health Matters*. 2015;23(45):149–150. doi:10.1016/j.rhm.2015.07.007
14. Boerma T, Ronsmans C, Melesse DY, et al. Global epidemiology of use of and disparities in caesarean sections. *Lancet*. 2018;392(10155):1341–1348. doi:10.1016/S0140-6736(18)31928-7
15. Goundan A, Grube S, Fitzmaurice G, Bateman BT, Gopal D. Descriptive study of blood transfusion practices in women undergoing caesarean delivery. *J Obstet Gynaecol Res*. 2011;37(10):1277–1282. doi:10.1111/j.1447-0756.2010.01511.x
16. Matot I, Einav S, Goodman S, Zeldin A, Weissman C, Elchalal U. A survey of physicians' attitudes toward blood transfusion in patients undergoing cesarean section. *Am J Obstet Gynecol*. 2004;190(2):462–467. doi:10.1016/j.ajog.2003.07.028
17. Escobar MF, Weiner E, Clark SL, et al. FIGO recommendations on the management of postpartum hemorrhage 2022. *Int J Gynaecol Obstet*. 2022;157(Suppl 1):S3–50. doi:10.1002/ijgo.14116
18. Sucak A, Dumanli H, Yucel O, et al. Comparison of nulliparas undergoing cesarean section in first and second stages of labour: a prospective study in a tertiary teaching hospital. *Obstet Gynecol Int*. 2011;2011:986506. doi:10.1155/2011/986506
19. American College of Obstetricians and Gynecologists. Practice bulletin no. 183: postpartum hemorrhage. *Obstet Gynecol*. 2017;130(4):e168–86. doi:10.1097/AOG.0000000000002351
20. Onah HE, Okaro JM, Umeh U, Chigbu CO. Decision–delivery interval and perinatal outcome in emergency caesarean sections. *J Obstet Gynaecol*. 2005;25(4):342–346. doi:10.1080/01443610500119671
21. Edmonds JK, Hruschka D, Sibley LM. A comparison of excessive postpartum blood loss estimates among three subgroups of women attending births in Matlab, Bangladesh. *J Midwifery Womens Health*. 2010;55(4):378–382. doi:10.1016/j.jmwh.2009.08.003
22. Nair M, Choudhury MK, Choudhury SS, et al. Association between maternal anaemia and pregnancy outcomes: a cohort study in Assam, India. *BMJ Glob Health*. 2016;1(1):e000026. doi:10.1136/bmjgh-2015-000026
23. Geller SE, Goudar SS, Adams MG, et al. Postpartum hemorrhage in resource-poor settings. *Int J Gynaecol Obstet*. 2006;92(3):202–211. doi:10.1016/j.ijgo.2005.12.009
24. Sheldon WR, Blum J, Vogel JP, et al. Postpartum haemorrhage management, risks, and maternal outcomes: findings from the World Health Organization multicountry survey on maternal and newborn health. *BJOG*. 2014;121(Suppl 1):5–13. doi:10.1111/1471-0528.12636
25. Conroy K, Koenig AF, Yu YH, Courtney A, Lee HJ, Norwitz ER. Infectious morbidity after cesarean delivery: 10 strategies to reduce risk. *Rev Obstet Gynecol*. 2012;5(2):69–77.
26. Deneux-Tharaux C, Carmona E, Bouvier-Colle MH, Bréart G. Postpartum maternal mortality and cesarean delivery. *Obstet Gynecol*. 2006;108(3 Pt 1):541–548.
27. Young MW, Lupafya E, Kapenda E, Bobrow EA. The effectiveness of weekly iron supplementation in pregnant women of rural northern Malawi. *Trop Doct*. 2000;30(2):84–88. doi:10.1177/004947550003000210
28. Stephen G, Mgongo M, Hussein Hashim T, Katanga J, Stray-Pedersen B, Msuya SE. Anemia in pregnancy: prevalence, risk factors, and adverse perinatal outcomes in northern Tanzania. *Anaemia*. 2018;2018:1846280.
29. Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. *Lancet Glob Health*. 2013;1(1):e16–25. doi:10.1016/S2214-109X(13)70001-9
30. Makhoul Z, Taren D, Duncan B, Pandey P, Thomson C, Winzerling J. Risk factors associated with anemia, iron deficiency and iron deficiency anemia in rural Nepali pregnant women. *Southeast Asian J Trop Med Public Health*. 2012;43(3):735–746.
31. Azhar BS, Islam MS, Karim MR. Prevalence of anemia and associated risk factors among pregnant women attending antenatal care in Bangladesh: a cross-sectional study. *Prim Health Care Res Dev*. 2021;22:e61. doi:10.1017/S146342362100061X
32. Rawn J. The silent risks of blood transfusion. *Curr Opin Anaesthesiol*. 2008;21(5):664–668. doi:10.1097/ACO.0b013e32830f1fd1

33. Thurn L, Wikman A, Westgren M, Lindqvist PG. Massive blood transfusion in relation to delivery: incidence, trends and risk factors: a population-based cohort study. *BJOG*. 2019;126(13):1577–1586. doi:10.1111/1471-0528.15927
34. Indelen C, Cimenoglu B, Celik E, Gunay E, Temel S, Dincer S. The cost of one unit blood transfusion components and cost-effectiveness analysis results of transfusion improvement program. *Turk Gogus Kalp Damar Cerrahisi Derg*. 2021;29(2):150–157. doi:10.5606/tgkdc.dergisi.2021.20886