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Predictors of prolonged decision-to-delivery interval in emergency caesarean section in Northern Uganda: a historical cohort study

Henry Ochola[a,b,c], Ronnie Omoro[b], Paul Buga[b], Emintone Ayella Odong[b], Oscar Ocaya[b], Rogers Kajabwangu[a], Nelly Atim[b], Harriet Akello[b], Judith Praiselyn Acayo[b], Doris Ekwem[b], Jovia Namuddu[b], Derrick Mukurasi[b], Enock Lukyamuzi[b], Hudson Onen[b], Maurine Lenia[c], Martha Gimono[b], Emily Webb[c], Oona Campbell[c], Ronald Komata[c], Jerom Okot[d], Emmanuel Ochola[b] and Sande Ojara[b,d]

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ABSTRACT

Background: Delays in decision-to-delivery interval (DDI) during emergency caesarean section (CS) may increase the risk of adverse maternal and neonatal outcomes. Evidence on health-system and provider-related factors influencing DDI in low-resource settings remains limited. We examined whether surgeon cadre, operating theatre location, and the presence of intern healthcare professionals were associated with prolonged DDI in a tertiary hospital in Northern Uganda.

Methods: We conducted a historical cohort study at St. Mary's Hospital Lacor, a tertiary hospital in Northern Uganda, involving women who underwent emergency CS (6 September 2022 to 1 June 2024). Logistic regression was used to examine the association between prolonged DDI (≥60 minutes) and surgeon cadre, operating theatre location, and intern presence, adjusting for confounders. Effect modification by emergency CS indication was assessed.

Results: Of the 760 participants enrolled (median DDI was 51 minutes [IQR: 36–67]), 36.0% had prolonged DDI. Emergency CS performed by junior doctors had twice the odds of prolonged DDI compared to fully-licensed doctors (adjusted odds ratio [aOR]: 2.07; 95% CI: 1.38–3.10). Theatre location and presence of interns showed no association with prolonged DDI (aOR: 0.89; 95% CI: 0.61–1.28) and (aOR: 0.71; 95% CI: 0.50–1.02), respectively. There was no statistically significant evidence that these associations differed by the CS indication.

Conclusions: Emergency CS performed by junior doctors was associated with increased odds of prolonged DDI compared with procedures performed by fully-licensed doctors. These findings highlight the importance of strengthening supervision, mentorship and emergency obstetric training for junior doctors in resource-limited settings. Operating theatre location and the presence of intern healthcare professionals were not significantly associated with prolonged DDI.

PLAIN LANGUAGE SUMMARY

Emergency caesarean section (CS) is performed when a pregnant woman or her baby needs urgent delivery to prevent serious complications or death. Delays between the decision to perform the surgery and the actual delivery may increase the risk of poor outcomes for both the mother and baby, especially in low-resource settings. However, little is known about the hospital and healthcare worker factors that may contribute to these delays in Northern Uganda.

We conducted a study at St. Mary's Hospital Lacor, a tertiary hospital in Northern Uganda, involving 760 women who underwent emergency caesarean between September 2022 and June 2024. We examined whether the experience level of the surgeon, the location of the operating theatre, and the presence of intern healthcare professionals were associated with delays in delivery.

We found that about one in every three women experienced delays of more than one hour between the decision for surgery and delivery. Emergency CSs performed by junior doctors were more likely to experience delays compared with those performed

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Emergency caesarean section; decision-to-delivery interval; surgeon experience; obstetric care; low-resource setting

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by fully licensed doctors. In contrast, the location of the operating theatre and the presence of intern healthcare professionals were not associated with delays.
These findings suggest that improving supervision, mentorship and emergency obstetric training for junior doctors may help reduce delays in emergency CS delivery. Strengthening surgical training and emergency obstetric care systems may contribute to better maternal and newborn outcomes in resource-limited settings such as Northern Uganda.

Introduction

Emergency caesarean section (CS) is a critical intervention for preventing adverse maternal and newborn outcomes when vaginal delivery is unsafe or no longer feasible (Lucas *et al.* 2000, Black *et al.* 2016). The urgency of emergency CS varies by indication and is commonly categorised using the four-tier classification proposed by Lucas *et al.*, which reflects the immediacy with which delivery is required (Lucas *et al.* 2000). A key measure of the timeliness of emergency CS is the decision-to-delivery interval (DDI), defined as the time between the clinical decision to perform CS and the birth of the newborn (Gholitabar *et al.* 2011). Shorter DDIs are generally considered essential for optimising maternal and neonatal outcomes (Dorjey *et al.* 2023).

The World Health Organisation (WHO) recommends that emergency CS be completed within 30 minutes of decision-making (World Health Organization *et al.* 2009); however, this benchmark is frequently unmet in resource-constrained settings due to multiple systemic barriers (Kamotho Pertet and Ogwayo 2018, Bidon *et al.* 2019, Kinsella 2021, Boriboonhirunsarn and Sunsaneevithayakul 2022). In high-income countries, DDIs of 20 minutes or less are commonly achieved, supported by robust infrastructure, well-resourced operating theatres and coordinated multidisciplinary teams (Bidon *et al.* 2019, Kinsella 2021). In contrast, healthcare facilities in low- and middle-income countries often experience delays related to patient preparation, theatre readiness, staffing constraints and limited theatre availability (Gupta *et al.* 2017, Nelson 2017, St Mary's Hospital Lacor 2022). Effective teamwork and communication among healthcare providers have been shown to reduce delays, highlighting the importance of organisational and human resource factors in emergency obstetric care (Boriboonhirunsarn and Sunsaneevithayakul 2022).

Evidence linking prolonged DDI to maternal and neonatal outcomes remains mixed. Some studies have reported no clear association between delayed DDI and adverse outcomes (Igwe *et al.* 2021, Radhika 2021), whereas others, particularly from sub-Saharan Africa, have demonstrated increased risks of maternal complications and poor neonatal outcomes with longer DDIs (Berghella Baxter and Chauhan 2005, Draycott *et al.* 2006, Kamotho Pertet and Ogwayo 2018). In Uganda, a study at Mulago National Referral Hospital reported a mean DDI of 5.5 hours, with delayed delivery associated with unfavourable newborn outcomes, underscoring the magnitude of the problem in low-resource settings (Hughes *et al.* 2020).

The maternal mortality ratio in Uganda remains high at 189 deaths per 100,000 live births, while neonatal mortality is estimated at 22 deaths per 1000 live births (Uganda Bureau of Statistics (UBOS) and ICF 2023), with preventable obstetric complications continuing to contribute significantly to these outcomes (Ministry of Health Uganda 2017). Delays in accessing timely emergency obstetric care, including delays in obtaining emergency CS, remain important contributors to preventable maternal and neonatal morbidity and mortality in low-resource settings (Knight Self and Kennedy 2013). Northern Uganda presents a distinct healthcare context shaped by prolonged conflict, economic disadvantage and constrained health system capacity, all of which may contribute to delays in emergency obstetric care. Previous regional quality improvement initiatives within Northern Uganda have highlighted the importance of strengthening emergency referral systems, maternal and perinatal death surveillance, and timely emergency surgical care to improve maternal and newborn outcomes (Lulgi Ochola and Omona 2021). In addition, regional maternal and newborn care quality audit frameworks used within Northern Uganda monitor delivery within one hour following the decision for emergency CS as an important indicator of emergency obstetric care quality (Lulgi Ochola and Omona 2021).

Despite the importance of timely emergency CS delivery, there is limited evidence on DDI and the health system factors that influence it in post-conflict regions such as Northern Uganda. In particular, the impact of surgeon experience, operating theatre location and the presence of intern healthcare professionals on DDI remains poorly understood in low-resource settings. We hypothesised that emergency CSs performed by junior doctors, conducted in theatres located further from the labour ward, and undertaken in the absence of intern healthcare professionals would be associated with increased odds of prolonged DDI. This study therefore aimed to assess the association between surgeon cadre, operating theatre proximity to the labour ward, and intern presence with DDI among women undergoing emergency CS in a tertiary hospital in Northern Uganda. We also explored whether these associations differed according to the indication for emergency CS.

Methods

Study design and setting

We conducted a historical cohort study design at St. Mary's Hospital Lacor, a 482-bed private non-profit Catholic referral hospital located in Gulu City, Northern Uganda. This facility mainly caters to patients from the Acholi, Lango, West Nile and Karamoja subregions, plus South Sudan. The Maternity unit, within the Department of Obstetrics and Gynaecology, handles approximately 6000 births yearly, including roughly 1800 CS, with nearly 600 classified as emergency CS (St Mary's Hospital Lacor 2022).

The maternity unit employs three obstetricians, four medical officers, 28 midwives and auxiliary support staff. Emergency CS deliveries are executed by either junior doctors (interns) or fully licensed doctors (medical officers or obstetricians). A team of 14 anaesthetists with varying credentials provide both spinal and general anaesthesia in both operating theatres. Maternal and foetal monitoring during labour utilises WHO labour care guides and cardiotocography conducted by midwives and doctors. As a fee-based service, payment for emergency CS of approximately 20 US dollars is remitted by the patient or family members after completion of the procedure rather than before surgery.

Additionally, the hospital has a neonatal unit staffed by three paediatricians and four medical officers that provides care for both preterm and term newborns. The unit offers advanced neonatal services including incubator care, continuous positive airway pressure (CPAP), neonatal intubation and surfactant therapy, and manages sick and preterm neonates delivered within the hospital as well as those referred from peripheral health facilities.

Study population

We retrospectively extracted data for women at ≥24 weeks of gestation admitted to St. Mary's Hospital Lacor's maternity unit, who required emergency CS as determined by a doctor. Indications comprised foetal distress, cord prolapse, antepartum haemorrhage (placenta previa and placental abruption), eclampsia, obstructed labour, failed vacuum extraction or previous CS scar in active labour. We excluded participants with multiple pregnancies and gestational age <24 weeks. Women with multiple pregnancies were excluded because they may require different obstetric management pathways and thus urgency profiles, which could independently influence the DDI. We included women delivering at ≥24 weeks of gestation because St. Mary's Hospital Lacor has advanced neonatal care services capable of managing selected extremely preterm newborns born from 24 weeks of gestation onwards, despite the commonly applied national threshold of viability in Uganda being approximately 26 weeks.

Data collection

Research data were obtained from the hospital emergency CS records between 6 September 2022 and 1 June 2024. Data access occurred on 2 September 2024 using a standardised extraction tool to ensure consistency across all participants, regardless of exposure status.

Variables

Our primary outcome variable was DDI (in minutes), defined as the time from the decision to perform an emergency CS to the time of delivery of the baby. DDI was categorised as prolonged (≥60 minutes) or not prolonged (<60 minutes) according to the regional quality-of-care audit guideline used to monitor emergency obstetric and newborn care in Northern Uganda, which recommends delivery within one hour following the decision for emergency CS (Lulgi Ochola and Omona 2021).

The exposure variables comprised: (1) *Surgeon cadre performing the emergency CS* – Juniors or fully licensed doctors (medical officers or obstetricians). Juniors were defined as intern doctors completing mandatory post-graduate clinical experience under a temporary practice license, before full licensure; medical officers as fully licensed general practitioners; and obstetricians as fully licensed doctors with specialist training in reproductive health. (2) *Operating theatre* – Emergency CS were carried out in either the labour-suite theatre (operating eight hours on weekdays) or a main theatre (105 m – nearly three minutes' walk from the labour-suite), functioning continuously with 1–2 tables reserved for emergency CS. The main theatre was preferred for potentially complicated CS due to its proximity to the intensive care unit. (3) *Presence of intern health professionals* – Intern doctors, midwives, nurses and pharmacists are deployed annually by Uganda's Ministry of Health to supplement St. Mary's Hospital Lacor's workforce. Given deployment inconsistencies, we identified periods of their absence (1 April 2023 to 6 August 2023) versus presence (remaining timeframe).

Covariates included maternal age, parity, residence, gestational age (determined by last normal menstrual period), referral status, emergency CS indication classified as previous CS, foetal distress, obstructed labour and others (cord prolapse, antepartum haemorrhage (placenta previa and placental abruption), eclampsia and failed vacuum extraction) to minimise sparse data across categories, operation day, staff shift and anaesthesia type.

Sample size

Using the two-proportion formula, we determined a minimum required sample size of 760 participants. Assuming that 31% of emergency CS performed by fully licensed doctors were prolonged DDI (>75 minutes) according to a previous study in Uganda (Apako *et al.* 2023). This sample size could detect a 32% relative difference in the proportion of prolonged DDI for emergency CS done by juniors compared to fully licensed doctors, with a 0.05 significance level and 80% power.

Statistical methods

We conducted statistical analyses using STATA 18 (College Station, TX). For descriptive statistics, we calculated means and standard deviations (SDs) (normally distributions), medians and interquartile ranges (skewed distributions) and frequencies with percentages (categorical variables).

Univariable analysis employed chi-squared tests and logistic regression to assess associations between exposures, covariates and prolonged DDI, presenting percentages, crude odds ratios (ORs), 95% confidence intervals (CIs) and likelihood ratio test (LRT) *p* values. We conducted a minimal model analysis to identify important confounders, treating maternal age as an *a priori* confounder. We identified specific confounders for each exposure-outcome relationship: for *surgeon cadre*, we considered work shift, operation day, presence of juniors, gestational age and parity; for *theatre location*, we included the above covariates plus area of residence; and for *presence of interns*, only maternal age was retained. Pre-operative delay point and anaesthesia type were considered mediators rather than confounders in the surgeon's cadre-DDI pathway.

For multivariable analysis, we used causal modelling and a forward modelling approach, constructed three final models, each including one primary exposure, age and identified important confounders. We assessed multicollinearity by comparing natural log standard errors. We examined effect modification by emergency CS indication using LRT, comparing final adjusted models with/without interaction terms. For missing data, we implemented complete case analysis for our primary analysis and examined the impact

of additional adjustment for the variables with >5% missing data sensitivity analysis. All statistical tests used a two-sided $p < 0.05$ significance threshold.

Ethics and informed consent

Ethical approval for this study was obtained from the St. Mary's Hospital Lacor Research Ethics Committee on 31 January 2024 (Reference number LACOR-2023-272) before commencement of data access and analysis. The permission to conduct the study at St. Mary's Hospital Lacor was obtained from the hospital administration. Given the retrospective nature of the study and the use of routinely collected clinical data, the requirement for informed consent was waived by the ethics committee. Throughout the study, strict measures were implemented to ensure patient confidentiality and data security.

Results

Study population

From a total of 772 women who underwent emergency CS between 6 September 2022 and 1 June 2024, 760 (98.4%) fulfilled our inclusion criteria and were enrolled in the analysis. We excluded women with gestational age <24 weeks (3/772, 0.4%) and those with multiple pregnancies (9/772, 1.2%). The final study cohort comprised 760 women who were followed up from the time emergency CS was indicated until delivery. All participants completed follow-up with no attrition (Figure 1).

Demographic and clinical characteristics

The study population had a mean age of 25 years (SD: 6.0), with most participants (56.7%, $n = 431$) falling within the 20–29-year age category. The women had a median parity of 1 (interquartile range, IQR: 1–3), with multiparous women constituting 35.3% ($n = 268$) of the cohort. Pregnancies had a median gestation age of 39 weeks (IQR: 38–40), and the majority of deliveries (66.5%, $n = 410$) occurred at term. Most participants (59.6%, $n = 453$) were referred from other health facilities to St. Mary's Hospital Lacor. Participants predominantly resided in non-urban districts of Uganda (70.1%, $n = 533$), and spinal anaesthesia was administered in 83.3% ($n = 633$) of emergency CS. Stillbirths occurred in 24 (3.2%) deliveries, while birth asphyxia occurred in 18.7% ($n = 142$) of the deliveries. The leading indication for emergency CS was previous scar in active labour, 37.9% ($n = 288$) of the emergency CS (Table 1).

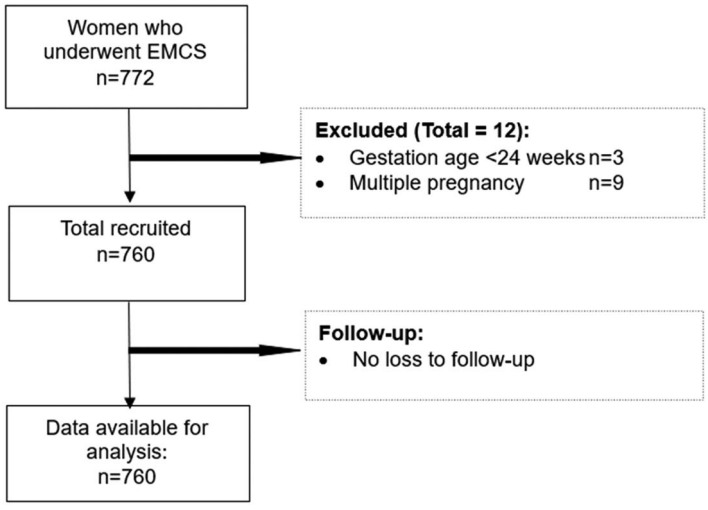

Figure 1. Flow diagram of participant selection. EMCS: emergency caesarean section.

Table 1 . Characteristics of women and their newborn outcome who underwent emergency CS (N = 760).

Characteristics	*n*	(%)[c]
Surgeon's cadre[b]		
Junior	169	25.2
Medical officer	471	70.1
Specialist	32	4.8
Theatre		
Main	582	76.6
Labour-suite	178	23.4
Presence of interns[b]		
Present	569	74.9
Absent	189	24.9
Point of pre-operative delay		
None	138	18.2
Ward	186	24.5
Theatre	186	24.5
Ward + theatre	250	32.9
DDI (minutes)		
Median (IQR)	51	36–67
<60	486	64.0
≥60	274	36.0
Maternal age (years)		
Mean (SD)	25.0	6.0
<20	153	20.1
20–29	431	56.7
≥30	176	23.2
Gestational age (weeks)[b]		
Median (IQR)	39	38–40
Preterm	95	16.9
Term	410	73.0
Post-term	57	10.1
Parity[b,a]		
Median (IQR)	1	1–3
Nulliparous	176	23.2
Primiparous	213	28.0
Multiparous	268	35.3
Grand multiparous	100	13.2
Referral status		
No	307	40.4
Yes	453	59.6
Staff shift[d]		
Morning	237	31.2
Afternoon	214	28.2
Night	309	40.7
Operation day[b]		
Weekday	488	64.2
Weekend/public holiday	270	35.5
Residence		
Urban	227	29.9
Non-urban	533	70.1
Indication of emergency CS		
Previous CS	288	37.9
Foetal distress	125	16.5
Obstructed labour	148	19.5
Others	199	26.2
Type of anaesthesia[b]		
Spinal anaesthesia	633	83.3
General anaesthesia	38	5.0
Newborn outcome		
Stillbirth	24	3.2
Birth asphyxia	142	18.7
Normal	594	78.2

DDI: decision to delivery interval; CS: caesarean section; SD: standard deviation; IQR: inter-quartile range.
[a]Parity refers to previous pregnancies delivered alive or dead after 24 weeks of gestation grouped into nulliparous, primiparous, multiparous and grand multiparous (0, 1, 2–4 and ≥5, respectively).
[b]*Missing data*: Gestational age 198 (26.1%), parity 3 (0.4%), type of anaesthesia 89 (11.7%), surgeon cadre 88 (11.6%), operation day 2 (0.3%) and presence of interns 2 (0.3).
[c]Percentages may not add up to 100.0% due to rounding and missing data.
[d]Staff shift – morning (08:00–13:59 hours), afternoon (14:00–19:59 hours) and night (20:00–07:59 hours).

Exposure variables and primary outcome

Emergency CS were predominantly performed by fully licensed doctors (74.9%, *n* = 503), including medical doctors (70.1%, *n* = 471) and obstetrician specialists (4.8%, *n* = 32) and took place in the hospital's main theatre (76.6%, *n* = 582). The median DDI was 51 minutes (IQR: 36–67). Approximately two-thirds of the women (64.0%, *n* = 486) delivered within 60 minutes of the decision for emergency CS, while 36.0% (*n* = 274, 95% CI: 32.6–39.6%) experienced prolonged DDI. Most emergency CS were performed during the periods when intern healthcare professionals were available (74.9%, *n* = 569) (Table 1).

Unadjusted analysis

Relationship between exposures and DDI – Junior doctors performing emergency CS were associated with higher odds of prolonged DDI compared to fully licensed doctors, with delays occurring in 51.5% (87/169) of the junior-led procedures versus 31.0% (156/503) of senior-led procedures (OR: 2.36, 95% CI: 1.65–3.37; $p < 0.0001$). Operating theatre location showed no significant association with prolonged DDI, with comparable proportions of prolonged DDI in the main theatre (36.1%; 210/582) and labour-suite theatre (36.0%; 64/178) (OR: 0.99, 95% CI: 0.70–1.41; $p = 0.98$). Concerning intern healthcare professional presence, a higher proportion of prolonged DDI was noted when interns were present (38.0%; 216/569) than absent (30.2%; 57/189), though the association was weak (OR: 0.71, 95% CI: 0.50–1.01; $p = 0.05$) (Table 2).

Association between covariates and DDI – Women experiencing both ward and theatre-related delays had a higher proportion of prolonged DDI than those with delays restricted to one area. Nulliparous participants had a higher proportion of prolonged DDI than primiparous, multiparous and grand multiparous women. Higher proportions of prolonged DDI were observed during afternoon and night shifts than during morning shifts. Emergency CS performed under spinal anaesthesia had higher proportions of prolonged DDI than those performed under general anaesthesia (Table 2).

Adjusted analysis

On accounting for confounders, emergency CS conducted by junior doctors were still significantly associated with prolonged DDI compared to fully licensed doctors, with adjusted odds just over two (OR: 2.07, 95% CI: 1.38–3.10; $p = 0.0004$). The operating theatre location showed no statistically significant association with prolonged DDI on adjusting for confounders, with women operated in the labour-suite theatre showing comparable odds of prolonged DDI as those in the main theatre (OR: 0.89, 95% CI: 0.61–1.28; $p = 0.52$). Regarding the presence of intern healthcare professionals, the adjusted analysis also showed no statistically significant association between their absence and prolonged DDI (OR: 0.71, 95% CI: 0.50–1.02; $p = 0.06$) (Table 3).

Effect modification by indication of emergency CS

There was no statistically significant evidence to suggest that the association between surgeon's cadre, choice of operating theatre, and the presence of intern healthcare professionals and the odds of prolonged DDI differed by the indications of the emergency CS ($p = 0.83$, $p = 0.47$ and $p = 0.88$, respectively) as in Table 4 (see Additional file 1).

Sensitivity analysis

Accounting for gestational age in the final model, in addition to confounders in the primary analysis, the adjusted association between surgeon's cadre and choice of operating theatre and the odds of prolonged DDI association produced comparable findings to the primary analysis (OR: 2.00, 95% CI: 1.30–3.09, $p = 0.002$, $N = 487$, and OR: 0.91, 95% CI: 0.59–1.41, $p = 0.67$, $N = 559$ respectively) as in Table 5 (see Additional file 1).

Table 2 . Factors associated with prolonged DDI in emergency caesarean sections (N = 760).

Variable	N (%)[d]	Prolonged DDI, n (%)[d]	OR (95% CI)	p Value
Surgeon's cadre[c]				
Fully-licensed doctor	503 (74.9)	156 (31.0)	1	<0.0001
Junior	169 (25.2)	87 (51.5)	2.36 (1.65–3.37)	
Theatre				
Main	582 (76.6)	210 (36.1)	1	0.98
Labour-suite	178 (23.4)	64 (36.0)	0.99 (0.70–1.41)	
Presence of interns[c]				
Present	569 (74.9)	216 (38.0)	1	0.05
Absent	189 (24.9)	57 (30.2)	0.71 (0.50–1.01)	
Point of pre-operative delay[a]				
Theatre-related	186 (24.5)	62 (33.3)	1	<0.0001
Ward-related	186 (24.5)	69 (37.1)	1.18 (0.77–1.81)	
Ward + theatre	250 (32.9)	143 (57.2)	2.67 (1.80–3.97)	
Maternal age (years)				
<20	153 (20.1)	57 (37.3)	1.01 (0.69–1.47)	0.51
20–29	431 (56.7)	160 (37.1)	1	
≥30	176 (23.2)	57 (32.4)	0.81 (0.56–1.18)	
Gestational age (weeks)[c]				
Preterm	95 (12.5)	42 (44.2)	1.37 (0.87–2.16)	0.39
Term	410 (66.5)	150 (36.6)	1	
Post-term	57 (7.5)	21 (36.8)	1.01 (0.57–1.80)	
Parity[c,b]				
Nulliparous	176 (23.2)	80 (45.5)	1	0.005
Primiparous	213 (28.0)	66 (31.0)	0.54 (0.36–0.82)	
Multiparous	268 (35.3)	100 (37.3)	0.71 (0.49–1.05)	
Grand multiparous	100 (13.2)	27 (27.0)	0.44 (0.26–0.76)	
Referral status				
No	307 (40.4)	111 (36.2)	1	0.96
Yes	453 (59.5)	163 (36.0)	0.99 (0.73–1.34)	
Staff shift[e]				
Morning	237 (31.2)	70 (29.5)	1	0.02
Afternoon	214 (28.2)	78 (36.5)	1.37 (0.92–2.03)	
Night	309 (40.7)	126 (40.8)	1.64 (1.15–2.35)	
Operation day[c]				
Weekday	488 (64.2)	170 (34.8)	1	0.36
Weekend/public holiday	270 (35.5)	103 (38.2)	1.15 (0.85–1.57)	
Residence				
Urban	227 (29.9)	88 (38.8)	1	0.31
Non-urban	533 (70.1)	186 (34.9)	0.85 (0.61–1.17)	
Indication of emergency CS				
Previous CS	288 (37.9)	105 (36.5)	1	0.48
Foetal distress	125 (16.5)	52 (41.6)	1.24 (0.81–1.91)	
Obstructed labour	148 (19.5)	50 (33.8)	0.89 (0.59–1.35)	
Others	199 (26.2)	67 (33.7)	0.88 (0.61–1.29)	
Type of anaesthesia[c]				
Spinal	633 (83.3)	235 (37.1)	1	0.04
General	38 (5.0)	8 (21.1)	0.45 (0.20–1.00)	

DDI: decision to delivery interval; CS: caesarean section; OR: odds ratio; CI: confidence interval.
[a]Women without any delays documented 138 (18.2%) excluded to overcome zero cells when assessing point of delay-prolonged DDI association
[b]Parity refers to previous pregnancies delivered alive or dead after 24 weeks of gestation grouped into nulliparous, primiparous, multiparous and grand multiparous (0, 1, 2–4 and ≥5, respectively).
[c]*Missing data*: Gestational age 198 (26.1%), parity 3 (0.4%), type of anaesthesia 89 (11.7%), and surgeon cadre 88 (11.6%).
[d]Percentages may not add up to 100.0% due to rounding and missing data.
[e]*Staff shift* – Morning (08:00–13:59 hours), afternoon (14:00–19:59 hours) and night (20:00–07:59 hours).

Discussion

In this historical cohort study conducted in a tertiary hospital in Northern Uganda, emergency CSs performed by junior doctors were associated with significantly increased odds of prolonged DDI compared with procedures performed by fully licensed doctors. In contrast, operating theatre location and the presence of intern healthcare professionals were not significantly associated with prolonged DDI. Additionally, we found no evidence that these associations differed by indication for emergency CS.

The observed association between emergency CS performed by junior doctors and prolonged DDI underscores the critical role of surgical expertise in delivering prompt emergency obstetric interventions. This finding is consistent with previous studies reporting that inexperienced surgeons are more prone to procedural delays during emergencies (Nelson 2017, Apako *et al.* 2023). Junior doctors may require

Table 3 . Adjusted associations between surgeons' cadre, theatre location, and interns' presence and prolonged DDI.

Variable	OR (95% CI)	*p* Value	OR (95% CI)	*p* Value[a]
Surgeon's cadre[a]				
Fully-licensed doctor	1	<0.0001	1	0.0004
Junior	2.35 (1.64–3.36)[b]		2.07 (1.38–3.10)[d]	
Theatre				
Main	1	0.91	1	0.52
Labour-suite	0.98 (0.69–1.39)[b]		0.89 (0.61–1.28)[e]	
Presence of interns				
Present	1	0.05	1	0.06
Absent	0.71 (0.50–1.01)[c]		0.71 (0.50–1.02)[f]	

DDI: decision-to-delivery interval; OR: odds ratio; CI: confidence interval.
[a]Likelihood ratio *p* values.
[b]OR adjusted for maternal age.
[c]Crude OR.
[d]OR adjusted for maternal age, parity group, presence of juniors, operation day of the week, and staff shift ($N = 667$).
[e]OR adjusted for maternal age, parity group, indication of emergency caesarean section, area of residence, and calendar day of the week ($N = 755$).
[f]OR adjusted for age ($N = 670$).

additional time for clinical assessment, surgical preparation, obtaining supervision or intra-operative decision-making, particularly in complex obstetric emergencies. These findings emphasise the importance of structured mentorship, supervision and simulation-based emergency obstetric training to strengthen the capacity of junior doctors and improve timely access to emergency CS (Mannella *et al.* 2023).

The absence of a significant association between operating theatre location and prolonged DDI represents a potentially important finding. Despite the main theatre at St. Mary's Hospital Lacor being situated 105 m away from the labour suite, this spatial separation did not appear to adversely affect DDI. This may suggest that efficient coordination systems, rapid mobilisation of theatre teams, timely anaesthetic support and clear communication pathways may mitigate the impact of physical distance between the labour ward and operating theatre. Previous studies examining DDI have primarily focused on staffing, anaesthesia and theatre readiness rather than theatre proximity itself, limiting direct comparison with our findings (Gupta *et al.* 2017, Kamotho Pertet and Ogwayo 2018, Bidon *et al.* 2019). Further multicentre studies are therefore needed to better understand how organisational efficiency may offset infrastructural constraints in resource-limited settings.

Similarly, the presence of intern healthcare professionals was not significantly associated with prolonged DDI. This finding may suggest that the mere presence of interns alone is insufficient to influence the timeliness of emergency CS. Instead, this finding may imply that factors such as supervision quality, task allocation, team coordination and institutional workflow efficiency may play more important roles in determining surgical timeliness. Given the substantial reliance on intern healthcare professionals within Uganda's healthcare system due to workforce shortages, this finding contributes important preliminary evidence to an underexplored area of obstetric systems research. However, no previous studies have specifically evaluated the relationship between intern staffing and DDI in low-resource settings, limiting direct comparison.

In addition, we found no evidence that the associations between surgeon cadre, operating theatre location or presence of intern healthcare professionals and DDI varied according to the indication for emergency CS. This may suggest that the factors influencing delays are broadly similar across different clinical scenarios. Nevertheless, it remains possible that subtle differences by indication could exist but were not detected due to limited statistical power for some subgroups. Future studies with larger sample sizes could explore this further to clarify whether certain indications may be more susceptible to DDI delays in specific contexts.

Our study median DDI of 51 minutes was shorter than the mean DDI of 5.5 hours previously reported at Mulago National Referral Hospital in Uganda (Hughes *et al.* 2020), but remained above the 30-minute benchmark recommended by the World Health Organization for emergency CS (World Health Organization *et al.* 2009). Similar challenges in achieving recommended DDI targets have been widely reported across sub-Saharan Africa and other low-resource settings due to delays related to staffing shortages, operating theatre access, anaesthesia availability and referral systems (Bloom *et al.* 2006, Gupta *et al.* 2017, Kamotho

Pertet and Ogwayo 2018). Nevertheless, the clinical significance of specific DDI thresholds remains debated, as some studies have not demonstrated a consistent association between prolonged DDI and adverse neonatal outcomes (Igwe *et al.* 2021, Radhika 2021), while others have reported increased maternal and perinatal complications with delayed delivery (Berghella Baxter and Chauhan 2005, Draycott *et al.* 2006, Kamotho Pertet and Ogwayo 2018).

Our study had many strengths. First, the relatively high completeness of data for most key variables strengthens the internal validity of our findings. Second, the cohort design enabled examination of multiple exposure variables and adjustment for potential confounders in the assessment of factors associated with DDI. Importantly, our study addresses an underexplored area by investigating whether the proximity of the operating theatre to the labour suite and the presence of intern healthcare professionals influence DDI, aspects not examined in previous research. However, some limitations must be acknowledged. First, our study may have lacked sufficient power to identify nuanced effect modification, and the absence of statistically significant interactions could reflect a type II error rather than a true lack of differential effects. Second, as a single-centre investigation conducted in a private tertiary hospital, the generalisability of our findings to primary healthcare facilities or public sector hospitals may be limited. Third, women with multiple pregnancies were excluded; therefore, our findings may not be generalisable to multifetal gestations, which often involve different obstetric management pathways and operative urgency. Fourth, we did not assess the duration or stage of obstetrics and gynaecology training among intern doctors. Differences in procedural experience between interns at earlier versus later stages of training may therefore have contributed to variability in DDIs. Fifth, we were unable to retrospectively classify emergency CSs according to the Lucas urgency classification because the routinely collected clinical records did not consistently capture sufficient detail regarding immediacy of maternal or foetal compromise. Future prospective studies should incorporate standardised urgency classification at the time of decision-making. Sixth, while DDI is a critical clinical metric, we did not directly evaluate maternal or neonatal outcomes in relation to the intervals observed. Lastly, although previous studies in sub-Saharan Africa have used alternative DDI thresholds such as 30 or 75 minutes (Gupta *et al.* 2017, Hughes *et al.* 2020, Apako *et al.* 2023), we used a ≥60-minute threshold based on the regional obstetric quality audit guideline applied in our setting, which may limit direct comparability with some studies.

Our findings highlight the need to strengthen emergency obstetric care in resource-limited settings through structured mentorship, supervision and simulation-based training for junior doctors (Berghella Baxter and Chauhan 2005, Draycott *et al.* 2006). Future research should explore the direct relationship between prolonged DDI and maternal and neonatal outcomes and evaluate interventions such as mentorship or simulation training aimed at reducing DDI delays in this setting.

Conclusions

Our study demonstrates that emergency CSs performed by junior doctors were associated with significantly increased odds of a prolonged DDI compared with procedures performed by fully licensed doctors in a tertiary hospital in Northern Uganda. In contrast, operating theatre location and the presence of intern healthcare professionals were not significantly associated with prolonged DDI. These findings highlight the important role of surgical experience, supervision and organisational efficiency in achieving timely emergency obstetric care in resource-limited settings. Strengthened mentorship, supervision and emergency obstetric training for junior doctors may help improve the timeliness of emergency CS. Although the spatial separation between labour wards and operating theatres did not appear to adversely affect DDI in this setting, further multicentre studies are needed to evaluate whether similar findings are observed in other low-resource healthcare environments. Overall, strengthening emergency surgical capacity across all levels of obstetric care remains essential for improving maternal and newborn health outcomes in low-resource settings.

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Author contributions

CRediT: **Henry Ochola**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Ronnie Omoro**: Conceptualization, Investigation, Project administration, Supervision, Writing – review & editing; **Paul Buga**: Conceptualization, Investigation, Project administration, Supervision, Writing – review & editing; **Emintone Ayella Odong**: Conceptualization, Investigation, Project administration, Resources, Supervision, Writing – review & editing; **Oscar Ocaya**: Conceptualization, Investigation, Project administration, Validation, Writing – review & editing; **Rogers Kajabwangu**: Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing; **Nelly Atim**: Investigation, Project administration, Validation, Writing – review & editing; **Harriet Akello**: Methodology, Project administration, Validation, Writing – review & editing; **Judith Praiselyn Acayo**: Conceptualization, Investigation, Project administration, Resources, Writing – review & editing; **Doris Ekwem**: Investigation, Methodology, Project administration, Validation, Writing – review & editing; **Jovia Namuddu**: Investigation, Project administration, Validation, Writing – review & editing; **Derrick Mukurasi**: Investigation, Project administration, Validation, Writing – review & editing; **Enock Lukyamuzi**: Investigation, Project administration, Validation, Writing – review & editing; **Hudson Onen**: Investigation, Project administration, Validation, Writing – review & editing; **Maurine Lenia**: Conceptualization, Investigation, Project administration, Supervision, Validation, Writing – review & editing; **Martha Gimono**: Investigation, Methodology, Project administration, Validation, Writing – review & editing; **Emily Webb**: Formal analysis, Methodology, Software, Validation, Visualization, Writing – review & editing; **Oona Campbell**: Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – review & editing; **Ronald Komata**: Data curation, Formal analysis, Methodology, Software, Visualization, Writing – review & editing; **Jerom Okot**: Data curation, Investigation, Methodology, Project administration, Writing – review & editing; **Emmanuel Ochola**: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – review & editing; **Sande Ojara**: Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing – review & editing.

Ethical approval

The study protocol adheres to the principles outlined in the Declaration of Helsinki and has received approval from the hospital's ethics committee (Reference number LACOR-2023-272).

Consent form

The requirement for informed consent was waived by the St. Mary's Hospital Lacor Research Ethics Committee because this was a retrospective study based on routinely collected clinical data.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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The datasets generated and analysed for this study are available from the corresponding author upon request.

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