

Determinants and Clinical Trajectories of Caesarean Section Delivery in Western Kenya: Findings from a Prospective Cohort Study, 2022–2026

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Abstract

Caesarean section (CS) rates are rising globally, yet sub-Saharan Africa records among the lowest rates despite substantial unmet obstetric need. Understanding clinical decision-making trajectories and their determinants is essential to optimize obstetric practice and address service gaps in resource-limited settings. We conducted a secondary analysis of 2,400 deliveries from a prospective cohort enrolled in the Pregnancy Risk, Infant Surveillance and Measurement Alliance (PRISMA), recruited via a population-based Health and Demographic Surveillance System in Kenya. Sankey flow visualization, observed-to-expected ratios and mixed-effects modified Poisson regression were applied to characterize clinical trajectories and identify associated factors. The overall CS prevalence was 19.4% ($n = 465$), exceeding the WHO-recommended threshold of 10–15%. Sankey analysis highlighted over-represented trajectories: previous unplanned CS transitioning to planned repeat CS (O/E ratio: 3.25; $p < 0.001$), primigravid women progressing to emergent CS for failure to progress (O/E ratio: 3.50; $p < 0.001$) and previous obstructed labour associated with planned CS for prior caesarean indication (O/E ratio: 2.89; $p < 0.001$). In multivariable regression, history of unplanned CS (RR: 4.63; 95% CI: 4.53–4.73), preeclampsia (RR: 1.97; 95% CI: 1.85–2.10), multiple pregnancy (RR: 2.23; 95% CI: 1.84–2.70), nulliparity (RR: 1.79; 95% CI: 1.58–2.03), and women with BMI ≥ 30 kg/m² (RR: 1.79; 95% CI: 1.61–1.99) were significantly associated with CS delivery. Gestational hypertension, gestational diabetes, advanced maternal age, and tertiary education were associated with higher likelihood of CS, while greater maternal height and unskilled employment were inversely associated. CS in western Kenya follows structured clinical trajectories shaped by obstetric history and intrapartum indications. Most determinants are identifiable antenatally, underscoring the value of targeted risk stratification in antenatal care. Expanding access to monitored vaginal birth after caesarean and strengthened antenatal risk profiling represent critical leverage points for rationalizing CS rates in comparable low-resource settings.

Introduction

Caesarean section (CS) is a vital, life-saving obstetric intervention when medically indicated, reducing maternal and neonatal morbidity and mortality in the context of obstructed labour, fetal compromise, and other obstetric emergencies [1]. However, CS performed without clear medical necessity exposes women and newborns to avoidable short- and long-term risks, including haemorrhage, infection, anaesthetic complications, and adverse neonatal respiratory outcomes, while simultaneously increasing financial and health system burdens [2–4]. Globally, CS rates have risen from approximately 7% in 1990 to over 21% by 2015–2018, with projections suggesting that nearly 29% of births worldwide will be delivered by CS by 2030 [5–7]. These aggregate trends, however, mask profound regional inequity: Latin America and the Caribbean report rates exceeding 40%, whereas sub-Saharan Africa averages approximately 5%—a level that likely reflects substantial unmet obstetric need in many settings [5, 8].

Within sub-Saharan Africa, CS utilization is highly heterogeneous. Population-level rates below 2% persist in the poorest quintiles of several countries, even as urban tertiary facilities report rates approaching or exceeding 20–25% [8, 9]. This dual burden of simultaneous underuse and overuse—within the same

country and often within the same health system—represents a global public health crisis requiring both indication and rate-based metrics to guide appropriate intervention [1]. The World Health Organization recommends a population-level CS rate of 10–15%, above which no further reduction in maternal or neonatal mortality is observed [10]. Eastern Africa presents a particularly dynamic picture: a recent systematic review estimated a pooled CS prevalence of 24.0% across the region, exceeding the WHO threshold, with rates highest in Ethiopia (28.3%) and lowest in Uganda (11.9%) [11]. In Kenya, the 2022 Demographic and Health Survey document a national CS rate of approximately 17%, concentrated among urban, higher-income, and more educated populations [12].

The determinants of CS delivery are multifactorial, encompassing clinical, obstetric, sociodemographic, and healthcare system factors. Established medical risk factors include previous CS, multiple pregnancy, advanced maternal age, preterm birth, malpresentation, gestational hypertension, fetal distress, and obstructed labour [13–19]. Sociodemographic determinants including higher educational attainment, greater household wealth, and urban residence are consistently associated with elevated CS rates across low- and middle-income country settings, reflecting access differentials [8, 20, 21]. Maternal anthropometric characteristics—particularly short stature as a proxy for cephalopelvic adequacy, and elevated body mass index—have been independently linked to CS risk in multiple sub-Saharan African datasets [14, 22]. Antenatal care attendance, while broadly protective of maternal outcomes, has also been associated with higher CS rates in some settings, likely reflecting increased detection of high-risk pregnancies and, in higher-income urban populations, greater opportunity for birth preference discussion with providers [7, 20, 23]

Despite growing literature on individual CS risk factors, relatively few studies have characterized the clinical decision-making trajectories through which obstetric histories and intrapartum indications interact to produce surgical delivery outcomes. The Robson Ten-Group Classification System (TGCS) has been endorsed by the WHO as a standardized framework for monitoring, auditing, and comparing CS rates within and across health facilities [24]. While Robson TGCS provides an invaluable population-level audit framework, the current work goes further, unravelling the sequential interplay between prior obstetric histories and intrapartum indications that converge to drive individual surgical delivery decision. Understanding whether CS follows structured, non-random clinical trajectories—and which pathway combinations are most over-represented—is essential for designing targeted interventions at the facility and health system level. In western Kenya, where the Pregnancy Risk, Infant Surveillance and Measurement Alliance (PRISMA) prospective cohort study is being implemented within a Health and Demographic Surveillance System (HDSS), a unique opportunity exists to examine CS rates and its determinants using high-quality, prospectively collected data.

This study aimed to estimate the prevalence of caesarean section deliveries, characterize the clinical trajectories leading to caesarean section, and identify the sociodemographic and clinical determinants of caesarean section among women enrolled in the PRISMA Kenya cohort between 2022 and 2026. The findings are intended to inform evidence-based clinical protocols, antenatal risk stratification strategies,

and health system quality improvement efforts aimed at optimizing safe delivery practices in Kenya and comparable settings in sub-Saharan Africa.

Methods

Study design

This study represents a secondary analysis of prospectively collected data from the PRISMA Kenya cohort. PRISMA is a longitudinal, multi-country study designed to characterize burden and determinants of adverse maternal and newborn outcomes in South Asia and sub-Saharan Africa. PRISMA study procedures have been described previously [25].

Setting

PRISMA in Kenya was conducted in Kisumu and Siaya Counties, western Kenya, within the Health and Demographic Surveillance System (HDSS) area, covering two sites: Karemo, a rural area in Siaya County with a population of approximately 90,000, and Manyatta, a peri-urban area within Kisumu city with a population of approximately 75,000.

Participant enrollment and antenatal care follow-up visits were conducted across the identified study sites spanning multiple levels of the health system within the catchment area. In Siaya County, the primary study facilities were Siaya County Referral Hospital, a Level 4 facility offering comprehensive emergency obstetric care including caesarean delivery, and Ting'wani Health Centre, a Level 3 facility providing routine antenatal and delivery services without surgical capacity. In Kisumu County, enrollment and follow-up were conducted at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), a Level 6 facility and teaching institution representing the apex of the regional referral hierarchy; Kisumu County Referral Hospital, a Level 5 facility; Lumumba Sub-County Hospital, a Level 4 facility; and Kuoyo Health Centre, a Level 3 facility.

Study population and eligibility

The study included pregnant women enrolled in the PRISMA Kenya cohort who delivered within the study period (2022–2026).

PRISMA eligibility criteria

Eligibility criteria for the parent PRISMA cohort included: confirmed pregnancy identified within the study catchment area; age 18 years or above or meeting the criteria of emancipated minors; intrauterine pregnancy of less than 20 weeks gestation verified via ultrasound; and provision of written informed consent.

Additional inclusion criteria for this analysis

For this analysis, records with missing mode of delivery were excluded. Mode of delivery was classified as caesarean section or spontaneous vaginal delivery, defined as delivery without surgical intervention or mechanical assistance. Instrumental vaginal deliveries including vacuum-assisted, forceps-assisted, and assisted vaginal breech were additionally excluded to ensure a clinically homogeneous reference category.

Data collection

Data from the enrolled women were collected by trained study staff prospectively for each visit. Each participant was assigned a unique identifier to facilitate seamless follow-up and data anonymity. The key variables of interest included maternal sociodemographic characteristics (age, marital status, education, residence, household size, weight, height, and Body Mass Index at enrolment [< 20 weeks gestation], which serves as a proxy for pre-pregnancy BMI in obstetric research, as measurements taken later in pregnancy are confounded by gestational weight gain), obstetric history (parity and history of unplanned CS), history of unplanned CS was captured as a binary variable indicating whether a participant had previously undergone an unplanned caesarean delivery, without recording the total number of prior uterine scars, antenatal factors (Antenatal Care attendance and gestational age), pregnancy characteristics (type of pregnancy – singleton vs. multiple – and gestational hypertension), and delivery outcomes (mode of delivery – vaginal or caesarean – and indication for caesarean section where applicable). Data confidentiality was enforced by allowing access only to authorized personnel and using encrypted, password-protected computers.

Data management

Data processing was done using R statistical software (version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria). The data were cleaned and prepared through a systematic wrangling process that included handling of missing values, data type conversion, removal of duplicate records, variable transformation, and outlier detection. Records with missing mode of delivery were excluded from the primary analysis. Distribution of continuous and categorical variables were explored using histograms and bar charts respectively.

Statistical Analysis

Descriptive statistics of participants' sociodemographic characteristics were summarized in tabular form, stratified by mode of delivery. Categorical variables are reported as frequencies and percentages while non-normally distributed continuous variables are expressed as medians and interquartile ranges (IQR).

For the purposes of this analysis, clinical trajectories are defined as the observed sequential progression from a woman's prior obstetric history through the documented intrapartum clinical indication to the resulting intervention type (planned or emergent caesarean section). To illustrate the multidimensional relationships between obstetric history, caesarean section indications, and intervention type, we constructed a Sankey flow diagram. Within the diagram flow thickness represented the frequency of specific pathway combinations, while node width reflected the overall frequency across trajectories. Obstetric history was categorized as primigravida, previous caesarean section, miscarriage, low birthweight, unplanned caesarean section, stillbirth, obstructed labour, or preterm birth. Clinical indications included previous caesarean section, failure to progress, non-reassuring fetal heart rate, preeclampsia/eclampsia, breech presentation, failed induction, cord prolapse, abruption or bleeding, malpresentation, fetal anomaly, post-term pregnancy, shoulder dystocia, and elective caesarean delivery. Intervention type was classified as planned or emergent caesarean section.

To determine whether observed clinical pathway combinations occurred more frequently than would be expected by chance, we calculated observed-to-expected (O/E) ratios. Expected frequencies were derived assuming independence between obstetric history, clinical indication, and intervention type; for each pathway, the expected frequency was calculated as the product of the marginal frequencies of each component divided by the square of the total sample size. Exact 95% confidence intervals (CIs) and p-values for the O/E ratios were calculated based on the Poisson distribution. To guard against Type I error inflation across the top 20 pathway combinations examined, p-values were adjusted using the Benjamini-Hochberg false discovery rate procedure.

To evaluate associations between candidate predictors and caesarean delivery, a generalized linear mixed-effects modified Poisson regression model with a log link and robust variance estimation was fitted to estimate Risk Ratios (RR) with corresponding 95% confidence intervals (CI). The model accounted for clustering by trimester through the inclusion of a random intercept. Covariates were selected and adjusted using a stepwise regression approach, guided by both statistical significance and clinical plausibility. Variables were retained in the final model if they met a significance threshold of $p < 0.05$ or were considered clinically relevant based on existing literature.

Missing data in the analytical cohort was minimal across all key variables ranging from 0.5% to 5.0%. Complete case analysis was therefore performed with minimal risk of bias.

Ethics statements

Ethical approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. The PRISMA study received approval by Kenya Medical Research Institute Scientific and Ethics Review Unit (KEMRI SERU - #4166) and relevant institutional review boards including, Liverpool School of Tropical Medicine (LSTM - 23 - 020) and Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH - 549/21). Informed consent was obtained from all participants prior to data collection.

Consent to Publish declaration

Not applicable.

Results

Of the PRISMA enrollment data, 2400 complete deliveries were eligible, Fig. 1, and considered for the analysis.

The median age was 26 years (IQR 22.0,30.0). Majority of the women 1,985(82.7%) were aged 20–34 years. At least three quarters, 1,724(72.4%) had a secondary level of education or higher, while 657(27.6%) had a primary level of education. Nulliparous women accounted for 27.6% of the cohort, whereas 130(5.4%) had previously undergone an unplanned caesarean section. In the current cohort, 19.4% (n = 465) delivered by caesarean section of which 23.0% (n = 107) had prior unplanned caesarean delivery. Regarding BMI, 105 (4.4%) of the women were underweight (< 18.5 kg/m²), 597 (25.0%) were Overweight (25-<30 kg/m²), and 296 (12.4%) were Obese (≥ 30 kg/m²). Detailed sociodemographic and obstetric characteristics stratified by mode of delivery are presented in Table 1.

Table 1

Socio demographic and Obstetric characteristics, by delivery mode in Western Kenya 2022–2026.

Characteristics	C-section	Vaginal Birth	Overall
	N = 465 (19.4%)¹	N = 1927 (80.6%)¹	N = 2,3921
Maternal age categories			
20–34 years	383 (82.4%)	1,597 (82.9%)	1,980 (82.8%)
35 years and above	54 (11.6%)	163 (8.5%)	217 (9.1%)
<=19 years	28 (6.0%)	167 (8.7%)	195 (8.2%)
Maternal age	26 (23.0, 31.0)	26 (22.0, 30.0)	26 (22.0, 30.0)
Education level			
Primary	109 (23.6%)	548 (28.6%)	657 (27.6%)
Secondary	193 (41.8%)	919 (47.9%)	1,112 (46.7%)
Tertiary	160 (34.6%)	452 (23.6%)	612 (25.7%)
Marital status			
Married/cohabitating	386 (83.0%)	1,608 (83.4%)	1,994 (83.4%)
Single/divorced/widowed	79 (17.0%)	319 (16.6%)	398 (16.6%)
Maternal height (m)	161 (157.2, 166.0)	163 (158.6, 167.0)	162 (158.3, 167.0)
Employment			
Skilled labourer	169 (38.5%)	596 (32.6%)	765 (33.8%)
Unskilled labour	270 (61.5%)	1,231 (67.4%)	1,501 (66.2%)
Type of Pregnancy			
Singleton pregnancy	444 (95.5%)	1,901 (98.7%)	2,345 (98.0%)
Multiple pregnancy	21 (4.5%)	26 (1.3%)	47 (2.0%)
Parity			
Multipara	187 (40.2%)	839 (43.6%)	1,026 (42.9%)
Primipara	142 (30.5%)	564 (29.3%)	706 (29.5%)
Nullipara	136 (29.2%)	523 (27.2%)	659 (27.6%)
History of Unplanned C-section	107 (23.0%)	23 (1.2%)	130 (5.4%)
¹ n (%); Median (Q1, Q3)			

Characteristics	C-section N = 465 (19.4%) ¹	Vaginal Birth N = 1927 (80.6%) ¹	Overall N = 2,3921
MUAC levels			
Normal (23-32cm)	366 (78.7%)	1,576 (81.8%)	1,942 (81.2%)
Low (< 23cm)	13 (2.8%)	120 (6.2%)	133 (5.6%)
High(> = 33cm)	86 (18.5%)	231 (12.0%)	317 (13.3%)
HDSS region			
Karemo	138 (29.7%)	770 (40.0%)	908 (38.0%)
Manyatta	327 (70.3%)	1,157 (60.0%)	1,484 (62.0%)
ANC Visits			
<= 3 ANC visits	21 (4.5%)	116 (6.0%)	137 (5.7%)
Four or more visits	444 (95.5%)	1,811 (94.0%)	2,255 (94.3%)
BMI levels			
Normal (18.5-<25)	229 (49.2%)	1,165 (60.5%)	1,394 (58.3%)
Underweight (< 18.5)	9 (1.9%)	96 (5.0%)	105 (4.4%)
Overweight (25-<30)	127 (27.3%)	470 (24.4%)	597 (25.0%)
Obese (> = 30)	100 (21.5%)	196 (10.2%)	296 (12.4%)
¹ n (%); Median (Q1, Q3)			

Clinical Trajectories from Obstetric History to Caesarean Section Type

The Sankey diagram (Fig. 2) illustrates the clinical trajectories leading to caesarean section across three sequential stages: obstetric history (left), current clinical indications (middle), and intervention type (right). Of the 411 caesarean deliveries with complete documentation across all stages, previous unplanned caesarean section accounted for 103 (25.1%), primigravida 90 (21.9%), previous miscarriage 79 (19.2%), previous obstructed labour 50 (12.2%), previous stillbirth 25 (6.1%), and previous preterm birth 16 (3.9%). Regarding clinical indications for caesarean section, previous caesarean section represented 180 (43.8%), failure to progress 112 (27.3%), non-reassuring fetal heart rate 59 (14.4%), breech presentation 26 (6.3%), failed induction 19 (4.6%), preeclampsia/eclampsia 29 (7.1%), and post-term pregnancy 13 (3.2%). Overall, 287 (69.8%) caesarean sections were performed as emergent procedures, while 124 (30.2%) were planned.

The diagram reveals distinct patterns of clinical progression. Previous caesarean section as an indication channeled predominantly toward planned caesarean delivery, consistent with elective repeat procedures, while also contributing a notable flow toward emergent caesarean. A substantial proportion of women with a history of previous unplanned caesarean section were subsequently classified under previous caesarean section as the clinical indication, reflecting the recurrence of prior surgical delivery as a determinant of subsequent caesarean need. In contrast, primigravida and other histories such as previous miscarriage and previous obstructed labour exhibited diverse flows across multiple acute indications — particularly failure to progress and non-reassuring fetal heart rate — culminating predominantly in emergent caesarean delivery.

Top Clinical pathway combinations

Table 2 presents the predominant clinical trajectories to caesarean section, delineated by obstetric history, clinical indication, and intervention type. Several combinations occurred far more frequently than expected. Women with a history of previous unplanned caesarean were frequently managed with planned repeat caesarean for the same indication (O/E Ratio: 3.25; 95% CI: 2.45–4.23). Primigravida women undergoing emergent caesarean for failure to progress were similarly overrepresented (O/E Ratio: 3.51; 95% CI: 2.6–4.62). Other notable trajectories included previous obstructed labour associated with planned caesarean for prior caesarean indication (O/E Ratio: 2.89; 95% CI: 1.85–4.3), and previous miscarriage linked to emergent caesarean for failure to progress (O/E Ratio: 1.93; 95% CI: 1.24–2.88).

Table 2

Co-occurrence of Obstetric History, Current Clinical Indication, and Intervention Type Among Caesarean Section Cases.

Obstetric History	Current clinical indication	Procedure Type	Observed	Expected	O/E Ratio (95% CI)¹	p (BH-adj)^{2,3}
Previous Unplanned CS	Previous Cesarean	Planned CS	55	16.9	3.25 (2.45–4.23)	< 0.001
Primigravida	Failure to Progress	Emergent CS	50	14.3	3.51 (2.60–4.62)	< 0.001
Previous Unplanned CS	Previous Cesarean	Emergent CS	42	33.7	1.25 (0.90–1.68)	0.167
Previous Obstructed Labour	Previous Cesarean	Planned CS	24	8.3	2.89 (1.85–4.30)	< 0.001
Previous miscarriage	Failure to Progress	Emergent CS	24	12.4	1.93 (1.24–2.88)	0.003
Primigravida	Non-Reassuring FHR	Emergent CS	24	7.6	3.14 (2.01–4.68)	< 0.001
Previous Obstructed Labour	Previous Cesarean	Emergent CS	20	16.6	1.21 (0.74–1.86)	0.388
Previous miscarriage	Previous Cesarean	Planned CS	20	14.2	1.41 (0.86–2.18)	0.141
Previous miscarriage	Non-Reassuring FHR	Emergent CS	15	6.6	2.26 (1.26–3.72)	0.005
Previous Stillbirth	Previous Cesarean	Planned CS	9	4.4	2.06 (0.94–3.9)	0.047
Previous miscarriage	Preeclampsia/Eclampsia	Emergent CS	9	3.8	2.36 (1.08–4.48)	0.016

³ *P-values adjusted for multiple comparisons (Benjamini-Hochberg)*

Obstetric History	Current clinical indication	Procedure Type	Observed	Expected	O/E Ratio (95% CI)¹	p (BH-adj)^{2,3}
Previous miscarriage	Previous Cesarean	Emergent CS	9	28.3	0.32 (0.15–0.60)	< 0.001
Primigravida	Preeclampsia/Eclampsia	Emergent CS	9	4.4	2.06 (0.94–3.9)	0.047
Previous Preterm Birth	Previous Cesarean	Planned CS	8	2.6	3.12 (1.35–6.14)	0.005
Previous Stillbirth	Previous Cesarean	Emergent CS	8	8.7	0.92 (0.40–1.8)	1.000
Previous low birthweight	Previous Cesarean	Planned CS	7	2.1	3.31 (1.33–6.82)	0.006
Previous miscarriage	Failed Induction	Emergent CS	6	2.1	2.9 (1.06–6.31)	0.019
Primigravida	Failed Induction	Emergent CS	6	2.4	2.52 (0.93–5.49)	0.034
Previous Unplanned CS	elective cesarean delivery	Planned CS	5	0.9	5.49 (1.78–12.81)	0.002
Previous Preterm Birth	Preeclampsia/Eclampsia	Emergent CS	4	0.7	5.8 (1.58–14.86)	0.005
¹ Confidence Intervals (CI) for O/E ratios calculated using the exact Poisson method.						
² Significance levels: $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***)						
³ P-values adjusted for multiple comparisons (Benjamini-Hochberg)						

Emergent caesarean for non-reassuring fetal heart rate was also disproportionately observed among primigravida women (O/E Ratio: 3.14; 95% CI: 2.01–4.68) and among women with previous miscarriage (O/E Ratio: 2.26; 95% CI: 1.26–3.72). Preeclampsia/eclampsia leading to emergent caesarean was significantly overrepresented among women with previous miscarriage (O/E Ratio: 2.36; 95% CI: 1.08–4.48).

Previous preterm birth was disproportionately associated with planned caesarean for prior caesarean indication (O/E Ratio: 3.12; 95% CI: 1.35–6.14), as was previous low birthweight (O/E Ratio: 3.31; 95% CI: 1.33–6.82). Failed induction leading to emergent caesarean was also overrepresented among women with previous miscarriage (O/E Ratio: 2.9; 95% CI: 1.06–6.31). Conversely, women with previous miscarriage undergoing emergent caesarean for prior caesarean indication were markedly underrepresented (O/E Ratio: 0.32; 95% CI: 0.15–0.6).

Factors associated with Caesarean Section

After multivariable adjustment (Table 3), several clinical, obstetric, and sociodemographic factors remained significantly associated with caesarean delivery. A history of unplanned caesarean delivery was a significant predictor of subsequent caesarean section (RR: 4.06; 95% CI: 4.03–4.09). Compared with singleton pregnancy, multiple pregnancy was also associated with an elevated risk (RR: 2.24; 95% CI: 1.86–2.69). Preeclampsia was independently associated with a higher likelihood of caesarean delivery (RR: 1.85; 95% CI: 1.73–1.98). Gestational hypertension (RR: 1.15; 95% CI: 1.02–1.33) and gestational diabetes (RR: 1.54; 95% CI: 1.21–1.94) were also independently associated with a higher likelihood of caesarean delivery. Previous stillbirth (RR: 1.43; 95% CI: 1.20–1.69) and previous obstructed labour (RR: 1.22; 95% CI: 1.04–1.43) similarly emerged as significant obstetric history predictors.

Table 3

Factors Associated with Caesarean Section Delivery: Estimates from a Generalized Linear Mixed-Effects Modified Poisson Regression Model.

Characteristic ¹	Crude estimates			Adjusted estimates		
	RR ²	95% CI	p-value	RR ²	95% CI	p-value
Age categories						
20–34 years	Ref	—		Ref	—	
35 years and above	1.29	1.15, 1.45	< 0.001	1.18	1.02, 1.36	0.025
<=19 years	0.73	0.63, 0.86	< 0.001	0.86	0.72, 1.02	0.091
Education						
Primary	Ref	—		Ref	—	
Secondary	1.05	0.95, 1.15	0.3	0.93	0.83, 1.03	0.2
Tertiary	1.57	1.42, 1.74	< 0.001	1.26	1.11, 1.43	< 0.001
Maternal height	0.96	0.96, 0.97	< 0.001	0.97	0.96, 0.98	< 0.001
Employment						
Skilled laborer	Ref	—		Ref	—	
Unskilled labor	0.82	0.76, 0.89	< 0.001	Ref	0.81, 0.96	0.004
BMI levels						
Normal (18.5-<25)	Ref	—		Ref	—	
Underweight (< 18.5)	0.54	0.41, 0.71	< 0.001	0.55	0.40, 0.75	< 0.001
Overweight (25-<30)	1.3	1.19, 1.42	< 0.001	1.21	1.10, 1.33	< 0.001
Obese (≥ 30)	2.06	1.87, 2.27	< 0.001	1.75	1.57, 1.95	< 0.001
HDSS region						
Karemo	Ref	—		Ref	—	
Manyatta	1.42	1.31, 1.54	< 0.001	1.03	0.92, 1.16	0.6
Facility level						
Level 2 3	Ref	—		Ref	—	
Level 4	4.69	3.63, 6.05	< 0.001	3.31	2.51, 4.36	< 0.001
Level 5	7.29	5.67, 9.36	< 0.001	5.39	4.14, 7.02	< 0.001
² RR = Risk Ratio, Abbreviation: CI = Confidence Interval						

Characteristic ¹	Crude estimates			Adjusted estimates		
	RR ²	95% CI	p-value	RR ²	95% CI	p-value
Level 6	9.54	7.41, 12.3	< 0.001	5.95	4.52, 7.85	< 0.001
Parity						
Multipara	Ref	—		Ref	—	
Primipara	1.1	1.00, 1.20	0.041	1.26	1.14, 1.41	< 0.001
Nullipara	1.14	1.04, 1.24	0.006	1.68	1.48, 1.91	< 0.001
Gestational hypertension☒	1.7	1.51, 1.90	< 0.001	1.15	1.02, 1.33	0.034
Preeclampsia☒	2.91	2.51, 3.38	< 0.001	1.85	1.73, 1.98	< 0.001
Gestational diabetes☒	1.27	1.02, 1.58	0.032	1.54	1.21, 1.94	< 0.001
History of unplanned C-section☒	5.22	4.77, 5.71	< 0.001	4.06	4.03, 4.09	< 0.001
Type of pregnancy☒						
Singleton pregnancy	Ref	—		Ref	—	
Multiple pregnancy	2.49	2.10, 2.95	< 0.001	2.24	1.86, 2.69	< 0.001
Antenatal care visits☒						
<= 3 ANC visits	Ref	—		Ref	—	
Four or more visits	1.24	1.03, 1.50	0.022	1.14	0.93, 1.40	0.2
Previous stillbirth☒	1.58	1.35, 1.85	< 0.001	1.43	1.20, 1.69	< 0.001
Previous obstructed labor☒	3.67	3.26, 4.13	< 0.001	1.22	1.04, 1.43	0.013
¹ ☒ Baseline characteristics measured at enrollment, ☒ Variables captured across ANC visits, ☒ Obstetric history variables,						
² RR = Risk Ratio, Abbreviation: CI = Confidence Interval						

Compared to multiparous women, both nulliparous (RR: 1.68; 95% CI: 1.48–1.91) and primiparous women (RR: 1.26; 95% CI: 1.14–1.41) were significantly more likely to undergo caesarean section delivery.

Maternal BMI demonstrated a dose–response relationship with caesarean delivery. Obese women (BMI ≥ 30) were substantially more likely to undergo caesarean delivery compared to women with normal BMI (RR: 1.75; 95% CI: 1.57–1.95), while overweight women (BMI 25–<30) also showed a moderately elevated likelihood (RR: 1.21; 95% CI: 1.10–1.33). Underweight women were significantly less likely to undergo caesarean delivery compared to those with normal BMI (RR: 0.55; 95% CI: 0.40–0.75).

Compared to women in the Karemo HDSS region, those in Manyatta did not differ significantly in their likelihood of caesarean delivery after multivariable adjustment (RR: 1.03; 95% CI: 0.92–1.16). Although women attending four or more antenatal care visits had a higher estimated likelihood of caesarean delivery compared to those attending three or fewer visits, this association did not reach statistical significance (RR: 1.14; 95% CI: 0.93–1.40)

Compared to Level 2/3 facilities, the likelihood of caesarean section increased progressively with facility level. Deliveries at Level 4 facilities were more than three times as likely to be by caesarean section (RR: 3.31; 95% CI: 2.51–4.36). Level 5 and Level 6 facilities both showed over five times the likelihood of caesarean delivery (RR: 5.39; 95% CI: 4.14–7.02 and RR: 5.95; 95% CI: 4.52–7.85, respectively).

Among sociodemographic factors, advanced maternal age (≥ 35 years) was associated with a higher likelihood of caesarean delivery after multivariable adjustment (RR: 1.18; 95% CI: 1.02–1.36), while adolescent women aged 19 years and below were less likely to undergo caesarean delivery compared to the reference group of women aged 20–34 years, though this association did not reach statistical significance (RR: 0.86; 95% CI: 0.72–1.02). Tertiary education was associated with a higher likelihood of caesarean delivery compared to primary education (RR: 1.26; 95% CI: 1.11–1.43), whereas women employed in unskilled labour were less likely to undergo caesarean delivery compared to those in skilled labour (RR: 0.88; 95% CI: 0.81–0.96). Greater maternal height was inversely associated with likelihood of caesarean delivery (RR: 0.97; 95% CI: 0.96–0.98)

Discussion

This study examined clinical decision-making trajectories and determinants of CS within a prospective cohort study in western Kenya. Using Sankey flow analysis and generalized linear mixed-effects modified Poisson regression, we demonstrate that CS in this setting follows structured, non-random clinical trajectories driven by overlapping obstetric histories and current clinical indications. The overall CS prevalence of 19.4% exceeds the WHO-recommended range of 10–15% [4] and substantially surpasses the projected sub-Saharan Africa rate of 7.1% by 2030 [26].

While the association between prior CS and subsequent repeat CS is clinically intuitive and well-established in the literature, the value of the Sankey analysis in this context lies not in the novelty of the finding itself, but in quantifying its magnitude, confirming it as the single dominant clinical trajectory in this cohort, and demonstrating that this pathway occurs at a frequency far exceeding what chance alone would predict. Women with a history of previous unplanned caesarean were most frequently managed with planned repeat caesarean, and history of previous unplanned CS remained the strongest independent predictor of subsequent caesarean delivery in the regression model. This pattern reflects the persistent influence of the “once a caesarean, always a caesarean” paradigm [27], in which prior surgical delivery becomes a self-perpetuating indication for subsequent surgery. This association is likely mediated by both clinical and patient-level concerns surrounding vaginal birth after caesarean (VBAC) [28, 29], particularly the risk of uterine rupture. In settings with limited capacity for continuous

fetal monitoring and inability to perform emergency CS within 30 minutes, repeat CS may represent the safest and most contextually appropriate clinical decision [30, 31]. Nevertheless, where infrastructure permits, expanding access to monitored VBAC for women with a single prior uterine scar represents a critical and potentially modifiable leverage point for interrupting the self-perpetuating cycle of repeat CS in this setting.

Primigravid women experiencing failure to progress leading to emergent caesarean delivery represented the second most over-represented pathway. This finding is reinforced by our regression model, in which nulliparous women were substantially more likely to undergo caesarean delivery compared to multiparous women as were primiparous women, consistent with evidence from sub-Saharan Africa [32] where obstructed labour, predominantly driven by cephalopelvic disproportion has been identified to account for the majority of emergency caesarean deliveries among nulliparous women [33]. Emergent caesarean for non-reassuring fetal heart rate was also disproportionately observed among primigravida women further underscoring the vulnerability of this group to acute intrapartum complications.

Hypertensive disorders of pregnancy, encompassing gestational hypertension and pre-eclampsia, were associated with increased likelihood of caesarean delivery, reinforcing findings from other studies [34–37]. In the present cohort, preeclampsia/eclampsia accounted for 7.1% of all caesarean indications, predominantly channeling toward emergent over planned delivery, reflecting the acute and unpredictable clinical trajectory characteristic of severe hypertensive disease. Preeclampsia/eclampsia leading to emergent caesarean was additionally overrepresented among women with previous miscarriage, suggesting that this subgroup may carry compounded obstetric vulnerability. Elevated blood pressure reduces placental perfusion, potentially leading to fetal growth restriction and non-reassuring fetal heart rate [38, 39] —both of which increase the likelihood of caesarean delivery [40, 41]

Gestational diabetes mellitus (GDM) in our cohort significantly elevated the likelihood of caesarean delivery. In many settings, pregnancies complicated by GDM necessitate surgical delivery and clinical guidelines recommend elective caesarean section for fetuses with estimated weights exceeding 4,500g [42]. Our findings align with evidence from sub-Saharan Africa and globally, where GDM has consistently been associated with increased caesarean rates [43, 44]. The persistence of this association after multivariable adjustment underscores the independent contribution of GDM to caesarean risk, highlighting early screening and optimized glycemic management as potential targets for reducing avoidable caesarean deliveries.

Facility level showed a progressive gradient of increasing caesarean delivery rates with higher-level facilities demonstrating substantially greater likelihood. A scoping review of health systems in sub-Saharan Africa found that CS rates varied widely across the region, with key drivers of both underuse and overuse being inequalities in access to maternity care, poor referral systems, and inadequate facility infrastructure [45]. Similarly global evidence demonstrates that population-level Caesarean section estimates mask substantial within-country equity differences, with facility type and level of care

representing critical determinants of CS rates [21]. Our findings are consistent with this evidence, underscoring the role of facility-level factors in shaping caesarean delivery patterns in this setting.

Advanced maternal age (≥ 35 years) was independently associated with a higher likelihood of caesarean delivery, consistent with findings from other studies [19, 46, 47]. The association is likely multifactorial: older women have higher prevalences of chronic hypertension, gestational diabetes, and preeclampsia [16], conditions that contributed to caesarean delivery in the present cohort and have been similarly implicated in other settings [34].

Women with tertiary education demonstrated significantly higher CS incidence than those with primary education, consistent with evidence from Kenya and Tanzania [48], a demographic and health survey based meta-analysis across 34 sub-Saharan Africa [49] and a systematic review across Eastern Africa [11], all demonstrating a positive gradient between educational attainment and caesarean delivery. This association may reflect the fact that higher educational attainment is linked to more frequent and timely antenatal care attendance [50], which increases women's exposure to clinical risk information and counselling on delivery options.

A clear dose-response relationship was observed between increasing maternal BMI and likelihood of caesarean delivery, with overweight women experiencing moderately elevated likelihood and obese women demonstrating a substantially higher likelihood compared with normal BMI. Conversely, underweight women were less likely to undergo caesarean delivery. This pattern is consistent with systematic review evidence from sub-Saharan Africa [22]. Mechanistically, obesity is associated with cephalopelvic disproportion from increased fat deposition in the pelvis, impaired uterine contractility, greater rates of gestational diabetes and hypertensive disorders of pregnancy [51, 52], all of which independently increase the likelihood of caesarean delivery.

Although women attending four or more antenatal care visits had a higher estimated likelihood of caesarean delivery compared to those attending three or fewer visits, this association did not reach statistical significance. The observed trend is nonetheless consistent with patterns reported from Ghana [7], Bangladesh [20] and Brazil [23], and is most parsimoniously explained by reverse causation and surveillance bias. Women with high-risk pregnancies complicated by hypertensive disorders, preeclampsia, gestational diabetes or multiple gestation are systematically referred for more frequent antenatal surveillance, increasing the likelihood that complications are identified and acted upon clinically; the association therefore reflects the disproportionate concentration of such women within both the highest ANC utilization and CS Strata.

Greater maternal height was inversely associated with the likelihood of caesarean delivery. This finding corroborates with evidence from a large-scale survey in India [53]. The mechanistic basis for this association lies in the well-established correlation between maternal height and pelvic dimensions: women with narrower pelvic architecture are at greater risk of cephalopelvic disproportion and obstructed labour, both of which are recognized indications for caesarean delivery [54].

Limitations

Obstetric history was limited to a binary indicator of prior unplanned CS, without capturing planned prior CS or total uterine scar count. This precludes estimation of total CS burden and stratification by scar number – clinically important given that two or more prior scars constitute a near-absolute indication for repeat CS in most protocols – and limits characterization of VBAC candidacy. Among primigravid women undergoing emergent CS, the majority were attributed to failure to progress rather than cephalopelvic disproportion, suggesting that structural disproportion does not account for most cases in this cohort. The residual heterogeneity within this category, which was not further sub-classified, precludes determination of what proportion reflects genuine labour dystocia versus potentially modifiable intrapartum management decisions. Furthermore, the study utilized a marginal independence assumption to derive expected frequencies, which may not fully account for inherent clinical correlations between obstetric history and surgical indications. We mitigated the risk of false discoveries in these multiple comparisons by applying the Benjamini-Hochberg adjustment. Finally, although facility level was adjusted for in the multivariable model, within-level structural heterogeneity including comprehensive emergency obstetric and newborn care readiness, specialist availability, and institutional caesarean section policies could not be accounted for. These systemic factors represent a residual source of confounding that facility-level classification alone cannot fully capture.

Conclusion

Collectively, these findings demonstrate that CS utilization in the western Kenya cohort is neither arbitrary nor solely driven by acute clinical necessity; rather, it is shaped by a constellation of structured, largely anticipatable determinants spanning obstetric history, maternal sociodemographic characteristics, and clinical risk profiles. The overall CS prevalence of 19.4% – exceeding the WHO-recommended threshold of 10–15% – underscores the urgency of understanding and addressing the drivers of surgical delivery in this setting. The convergence of Sankey pathway analysis and modified Poisson regression results highlights the value of employing complementary analytical approaches to illuminate both the directionality and magnitude of clinical decision-making in obstetric care. Several key determinants—including previous CS, nulliparity, advanced maternal age, obesity, and short maternal stature—are identifiable antenatally, underscoring that targeted risk stratification during antenatal care could inform more proactive and evidence-based intrapartum planning. Addressing the self-perpetuating cycle of repeat CS, through expanded access to monitored VBAC where clinically appropriate, and strengthening antenatal risk profiling for high-risk groups, represents a critical leverage point for rationalizing CS rates in this and similar settings. As sub-Saharan Africa continues to grapple with the dual challenge of CS overutilization in some facilities and critical unmet need in others, these findings provide an essential foundation for rationalizing obstetric decision-making and shaping policies that align with the realities of care in low-resource settings.

Declarations

Conflicts of interest

The authors declare no conflict of interests.

Author disclaimer

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Author Contribution

EK contributed to the conceptualization, methods development, formal analysis and original draft, VA, HM, HO, RO, FA: contributed to manuscript critical review. EK, JW, FO, BA, DG: contributed to data retrieval, data analysis and interpretation. KO contributed to Lab result generation. CS, VO, DA spearheaded pregnancy surveillance activities.

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Data Availability

The dataset collected and analyzed in the context of this research are not publicly accessible owing to the confidentiality, ethical obligations and governing institutional regulations, but can be obtained from the corresponding author upon request.

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Figures

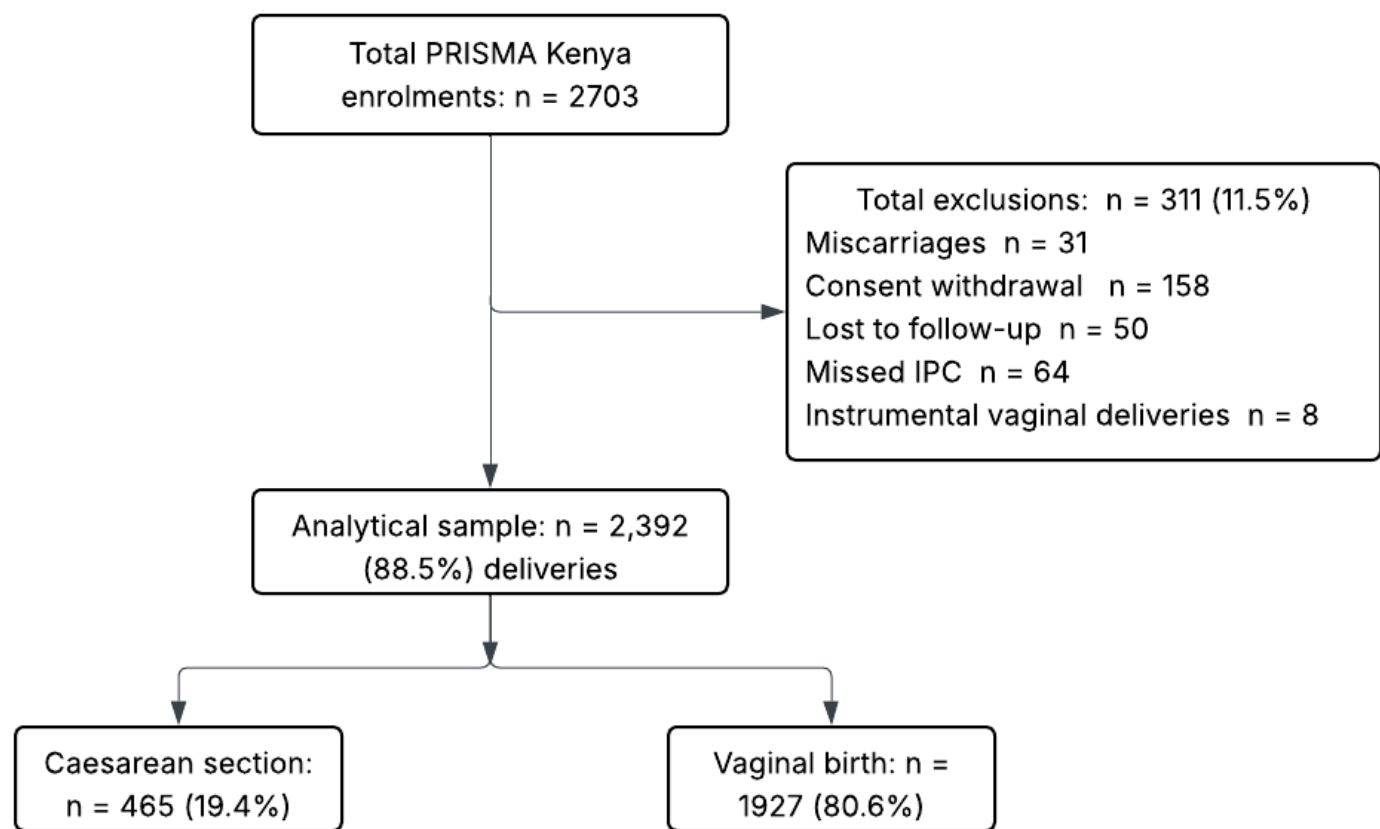


Figure 1

Flow diagram showing enrolment, exclusions, and final analytic sample from the PRISMA Kenya cohort, 2022–2026

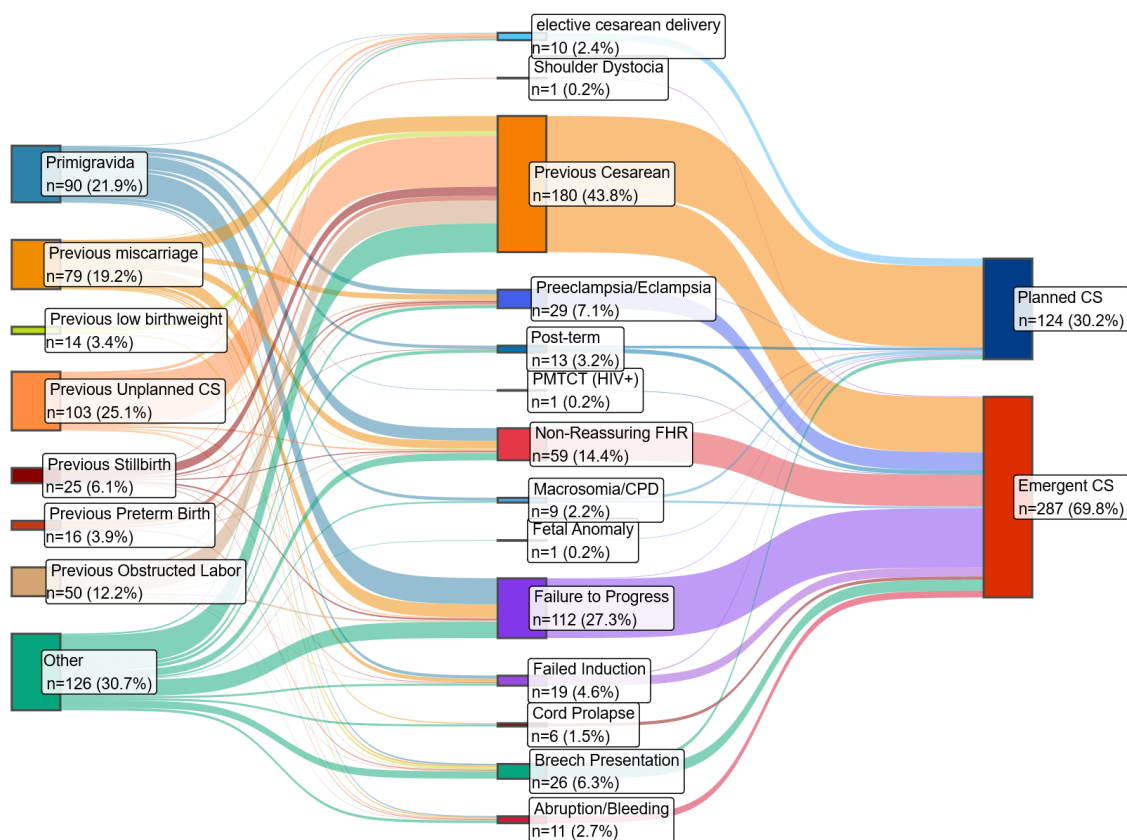


Figure 2

Flow of Caesarean Section Cases: Obstetric Histories (left) → Current Clinical Indications (middle) → Intervention Type (right).