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Does hospital variation in intrapartum-related perinatal mortality among caesarean births reflect differences in quality of care? Cross-sectional study in 21 hospitals in Burkina Faso

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ABSTRACT

Objectives To examine hospital variation in crude and risk-adjusted rates of intrapartum-related perinatal mortality among caesarean births.

Design Secondary analysis of data from the DECIDE (DECIsion for caesarean DElivery) cluster randomised trial postintervention phase.

Setting 21 district and regional hospitals in Burkina Faso.

Participants All 5134 women giving birth by caesarean section in a 6-month period in 2016.

Primary outcome measure Intrapartum-related perinatal mortality (fresh stillbirth or neonatal death within 24 hours of birth).

Results Almost 1 in 10 of 5134 women giving birth by caesarean experienced an intrapartum-related perinatal death. Crude mortality rates varied substantially from 21 to 189 per 1000 between hospitals. Variation was markedly reduced after adjusting for case mix differences (the median OR decreased from 1.9 (95% CI 1.5 to 2.5) to 1.3 (95% CI 1.2 to 1.7)). However, higher and more variable adjusted mortality persisted among hospitals performing fewer caesareans per month. Additionally, adjusting for caesarean care components did not further reduce variation (median OR=1.4 (95% CI 1.2 to 1.8)).

Conclusions There is a high burden of intrapartum-related perinatal deaths among caesarean births in Burkina Faso and sub-Saharan Africa more widely. Variation in adjusted mortality rates indicates likely differences in quality of caesarean care between hospitals, particularly lower volume hospitals. Improving access to and quality of emergency obstetric and newborn care is an important priority for improving survival of babies at birth.

Trial registration number ISRCTN48510263.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first study to examine hospital variation in intrapartum-related perinatal mortality among women giving birth by caesarean section in a sub-Saharan African country.
⇒ Our study benefited from inclusion of all caesarean sections performed in a 6-month period in 21 regional and district hospitals in Burkina Faso.
⇒ We used high-quality clinical data from the DECIDE cluster-randomised trial, including standardised definitions for diagnoses and indications for caesarean, although some misclassification of obstetric complication severity was likely.
⇒ More than 20% of data were missing for three risk factors (decision-to-incision interval, timing of antibiotics and referral distance); we used multiple imputation to avoid a loss of power.
⇒ Our hospital sample size and limited available information prevented us from examining hospital characteristics as risk factors for perinatal mortality.

INTRODUCTION

While facility births have increased over the past few decades in sub-Saharan Africa,[1] improvements in maternal and perinatal health have been limited, raising questions about the quality of care in health facilities.[1–3] In particular, although facility births have increased substantially, increases in population-based caesarean section rates have been small. Persisting low caesarean rates indicate that improvements in access to emergency obstetric care have been limited.[4 5] Globally, the slowest rise was observed in West and Central Africa, from 3.0% caesarean births in 2000 to 4.1% in 2015.[5] The absolute number of caesareans performed has increased more rapidly due to a rise in total number of births—threefold to fivefold in Senegal, Tanzania and Uganda over the past few decades.[4 6 7]

Increases in caesarean births raise concerns in health systems with limited resources and capacity to provide high-quality caesarean care. Caesarean sections account for one-third of all surgeries in Africa, where postoperative

morbidity and mortality is higher than in other regions.[8] A recent meta-analysis found over 1% mortality among women who deliver by caesarean in sub-Saharan Africa, 100 times higher than in the UK.[9] Perinatal mortality is also very high in sub-Saharan Africa, with 1 in 10 mothers delivering by caesarean experiencing a stillbirth or early neonatal death.[9] This high mortality is driven both by severe complications before reaching health facilities and low capacity within facilities to provide high-quality care. Indeed, low capacity to provide caesarean section care has been reported in Burkina Faso[10 11] and elsewhere in the region.[6 12 13]

In the context of rising caesareans, there is a need to better understand why perinatal mortality is so high among women giving birth by caesarean in sub-Saharan Africa. Limited evidence is available on interhospital variation in outcomes among caesarean births. Hospital type (district, regional or national) is independently associated with perinatal mortality in some studies but not others[9 14]; however, severe restrictions in material and human resources restrict capacity to provide high-quality care in lower level and rural facilities.[4 6] Comparing variation in crude and risk-adjusted outcome rates between hospitals is a commonly used approach to determine whether differences between hospitals are entirely explained by heterogeneity in case mix. Any remaining variation in risk-adjusted rates suggest differences in quality of patient care.[15–17] In this study, we examined variation in crude and adjusted rates of intrapartum-related perinatal mortality among women giving birth by caesarean in 21 district and regional hospitals in Burkina Faso for a 6-month period in 2016. We used high-quality data from the DECIDE (DECIsion for caesarean DElivery) trial to assess the evidence that differences in intrapartum-related mortality between individual hospitals and hospital types were driven in part by variation in quality of care.

METHODS

This study is a secondary analysis of the DECIDE cluster-randomised controlled trial, which assessed the effectiveness of a multicomponent intervention including provider training, caesarean audits and SMS reminders to reduce non-medically indicated caesarean sections. The trial included three phases: 6-month preintervention, 1-year intervention and 6-month postintervention. It was conducted in all 22 regional and district hospitals in Burkina Faso performing more than 200 caesareans per year in 2012; university hospitals in Ouagadougou and Bobo-Dioulasso were excluded. Detailed trial methods are described elsewhere.[18]

Health system context

Similar to other West African countries, the caesarean rate in Burkina Faso is below 5% (3.7% in 2010–2015),[19] with large urban–rural, wealth and educational differentials.[20 21] Although 85% of births take place in health facilities, 70% occur in primary care facilities without surgical capacity.[22] Women who develop complications requiring a caesarean are referred to medical centres with surgical capacity (*centres médicaux avec antenne chirurgicale,* referred to as district hospitals hereafter) or regional hospitals. Women with severe complications may be referred onwards to tertiary university hospitals in the capital Ouagadougou and second largest city Bobo-Dioulasso. Most—but not all—district and regional hospitals have at least one obstetrician or generalist doctor trained in emergency obstetric care. Task-shifting of caesarean care has been supported in Burkina Faso through additional 3-year training of nurses and midwives as non-physician providers with surgical skills (*attachés en chirurgie*) and obstetrics skills (*attachés en gynéco-obstétrique*). Most anaesthesia care is provided by nurses with additional training in anaesthesia. More than three quarters of study hospitals did not have Doppler ultrasounds, CTG monitors or ultrasound capacity, relying on Pinard stethoscopes for assessment of fetal well-being. Fetal scalp pH was only available in one hospital.[18]

Emergency obstetric care has been subsidised to improve access since 2006, initially with an 80% subsidy of the cost of caesareans, which were made free to women from 2016 onwards. Hospitals are reimbursed according to the number of caesareans and vaginal births. This policy absorbed around 3.5% of total health expenditure in 2011.[23] However, some costs (formal or informal) not included in the 'free' package continue to be borne by households and remain unaffordable for some.[24 25] Women express fears around caesarean birth related primarily to poor quality of care and economic burden.[26]

Participants

We included all 5134 women giving birth by caesarean section in the 21 study hospitals with caesarean capacity in the postintervention phase (2 May–2 November 2016). One study hospital's operating theatre was no longer functional in the postintervention phase. These 21 hospitals accounted for 45% of all caesarean sections performed nationally in 2016.[27] Women delivering by caesarean were included regardless of gestational age, whether they were referred to the study hospital before the caesarean or referred to another hospital after birth.

Data source

Patient medical records were used in the DECIDE trial, with prospective data collection in the postintervention phase using data extraction forms and standardised clinical definitions (including for labour dystocia, acute fetal distress and indications for caesarean).[18] We used postintervention data to provide the most recent description for a larger sample.

Outcome

We defined intrapartum-related perinatal mortality as the rate of fresh stillbirths and very early neonatal

deaths (within 24 hours of birth) per 1000 caesareans.[28 29] Intrapatum-related mortality is recommended by the WHO as an indicator of the quality of emergency obstetric and newborn care.[30]

Risk factors and conceptual approach

We examined two groups of risk factors for intrapartum-related mortality: individual-level clinical risk factors, and caesarean care components and hospital characteristics.

We conceptualised case mix as the hospital prevalence of clinical risk factors for intrapartum-related mortality (maternal age, parity, highest educational level achieved, previous caesarean, multiple pregnancy, number of antenatal visits, birth weight, congenital malformation, referral status and distance, labour phase, diagnosis of acute fetal distress, transverse lie/brow presentation in active labour, other severe obstetric complication or maternal death and primary indication for caesarean). 'Other severe obstetric complications' included severe pre-eclampsia or eclampsia, retroplacental haematoma, uterine (pre-) rupture and placenta praevia in active labour. Uterine prerupture was defined as women with severe dystocia and signs of prerupture, such as Bandl's ring. Acute fetal distress was defined as fetal heart rate <120 or >160 bpm, either persistent after oxygen administration and lateral decubitus position, or with IUGR, placental abruption, prolonged labour, maternal fever or meconium-stained amniotic fluid. Some women diagnosed with acute fetal distress had a primary indication for caesarean other than 'fetal distress' (eg, pre-eclampsia), while some women had a caesarean with 'fetal distress' recorded as the primary indication despite not having met the diagnostic criteria for acute fetal distress.

We conceptualised components of caesarean care (provider cadre deciding and performing the caesarean, decision-to-incision interval, anaesthesia type, skin/uterine incision type and antibiotic prophylaxis administration) and hospital characteristics (hospital type and monthly caesarean volume) as potential indicators of quality of patient care. Monthly caesarean volume was calculated as the mean number of caesareans performed per month in the study period, per hospital.

We used these risk factors to derive two sets of risk-adjusted mortality rates per hospital: adjusting for case mix only, and additionally adjusting for components of care and hospital characteristics, because some of these variables might capture unmeasured differences in case mix. For example, women receiving general anaesthesia are more likely to have complications requiring urgent surgery. Including these additional variables also allowed us to identify whether any care components (eg, decision-to-incision interval) were strongly associated with mortality. We included care components prior to delivery as risk factors even when they were not hypothesised to causally affect perinatal mortality, since they may be proxies for quality of care.

Multiple imputation of missing data among risk factors

Data were complete for the outcome and nine risk factors, including multiple gestation, indication for caesarean and referral status (online supplemental table 1). Eleven risk factors had <5% missing values; six risk factors had >5% missing data, including decision–incision interval (24%) and timing of antibiotic administration (23%). Overall, 68% of women had at least one risk factor missing, and 4% had at least four risk factors missing (online supplemental table 2). Missing information on previous caesarean was assumed to indicate no previous caesarean (n=40), and missing deciding provider cadre was imputed as the hospital mode for seven women.

Multiple imputation by chained equations was used for other variables to avoid a loss in efficiency, because missing values were likely to be missing at random given known risk factors, including referral status and severe obstetric complication.[31] Five imputed datasets were created using the mi package in Stata V.14.2, including all risk factors and intrapartum-related mortality in the imputation model. The same model was used for all hospitals, with hospital type included as a risk factor. Missing values for continuous risk factors (age, parity, number of antenatal care visits, referral distance, birth weight and decision-to-incision interval) were imputed from linear regression models, missing values for binary risk factors (acute fetal distress, antibiotic prophylaxis, incision type, anaesthesia type, congenital malformation and neonatal resuscitation) were imputed from logistic regression models and categorical risk factors (education, provider cadre performing the caesarean, and timing of antibiotic administration) were imputed from multinomial regression models. Gestational age at birth had >50% missing data; it was not considered as a risk factor in the analysis model, since it is highly correlated with low birth weight, which was more complete and likely to be more accurate in a setting without routine ultrasound in the first trimester. However, we included gestational age at birth in the imputation model to improve the prediction of birth weight. Distributions of imputed values were compared with observed values for variables with >5% missing data.

Hospital variation in intrapartum-related mortality rates

First, we calculated crude hospital intrapartum-related mortality rates with 95% CIs and described perinatal outcomes according to hospital type. Differences in hospital case mix were assessed by describing the prevalence of clinical risk factor for intrapartum-related mortality among women giving birth by caesarean, stratified by hospital and hospital type. We similarly described differences in components of care received. χ^2 tests accounted for clustering of women by hospital using the svyset package in Stata.

Next, we built two multivariable models for intrapartum-related death among caesarean births using multilevel logistic regression models of women, nested in hospitals to account for clustering. The first model (model 1) adjusted

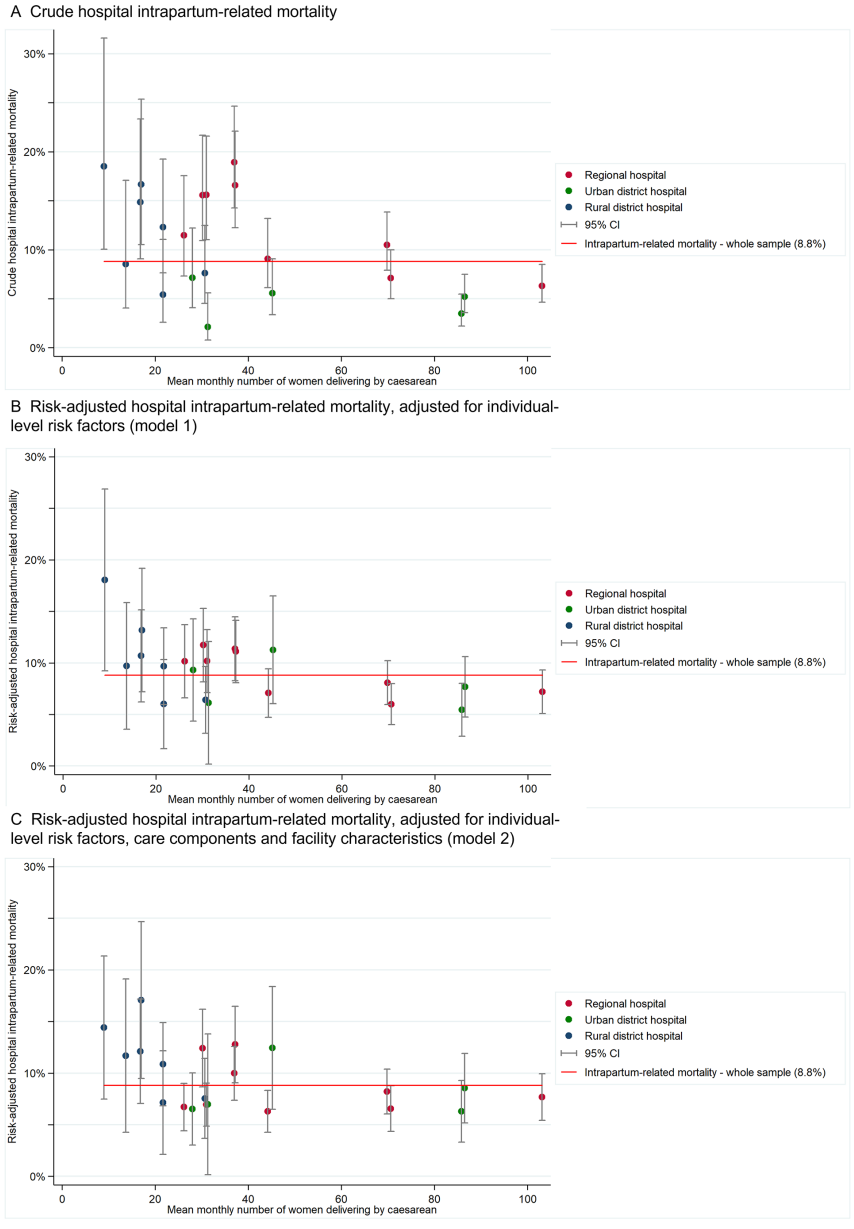

Figure 1 Crude and risk-adjusted hospital intrapartum-related mortality rates among women giving birth by caesarean section in 21 hospitals, according to mean monthly number of caesareans – Burkina Faso, 2016.

for case mix only and included all individual-level clinical risk factors for intrapartum-related mortality with Wald test p value ≤0.25 in bivariate associations, using manual backward selection to retain only variables with p values <0.1. The second model (model 2) built on model 1 by additionally including all care components and hospital characteristics with bivariate Wald test p value ≤0.25 and similarly using backward selection to retain only p values <0.1. Multicollinearity was examined by reviewing Spearman correlations and model SEs. In building model 2, provider cadre deciding the caesarean met the criteria for inclusion; however, its inclusion reduced the hospital-level estimate almost to zero, indicating that this variable acted as a proxy for broader differences between hospitals. Further inspection showed that deciding providing cadre was highly clustered within hospitals, with one category accounting for >90% of women in 13 of 21 hospitals. We therefore removed it from risk factors considered for model 2.

We calculated the median OR for models 1 and 2 as a measure of interhospital variation in mortality that is not explained by the model covariates, expressed on the OR scale (see formula in online supplemental figure 1).[32] For a multilevel model, the median OR is defined as the median of the ORs that could be calculated by comparing two patients with identical individual-level characteristics from two, randomly chosen, different hospitals.[33 34]

Risk-adjusted mortality enables comparisons in hospital outcomes taking into account differences in case mix.[15–17] Risk-adjusted intrapartum-related mortality rates were calculated for each hospital by multiplying the intrapartum-related mortality rate across the study sample

Table 1 Perinatal mortality among women giving birth by caesarean according to hospital type – Burkina Faso, 2016

		Fresh stillbirths (per 1000)	Neonatal death within 24 hours of births (live babies, per 1000)	Intrapartum-related perinatal death (per 1000)*	Intrapartum-related perinatal death – range across hospitals
Total	5134	65	23	88	21–189
Hospital type					
Regional hospital	2693	78	30	108	63–189
Urban district hospital	1659	36	10	46	21–71
Rural district hospital	782	81	29	110	54–185
P value	–	<0.001	0.016	<0.001	–

Note: CIs and additional outcomes are reported in online supplemental table 3.
*Fresh stillbirth or neonatal death within 24 hours of birth.

by the ratio of the number of observed deaths to predicted deaths based on models 1 and 2 in each hospital. Bootstrapping with 1000 iterations was used to calculate 95% CIs around both sets of risk-adjusted hospital mortality rates and found to produce stable estimates. We used the Boot MI percentile method to produce CIs with nominal coverage.[35] We constructed graphs showing risk-adjusted mortality and CIs for each hospital, according to the mean monthly number of caesareans in each hospital, to visually assess any associations between risk-adjusted mortality and caesarean volume (figure 1A–C).

The DECIDE trial found a reduction in avoidable caesareans,[36] suggesting changes in caesarean decision making that may affect intrapartum-related mortality. As a secondary analysis, we added trial group as a risk factor to model 2 to determine whether it was associated with mortality after adjusting for other covariates.

Patient and public involvement

No patients were involved in the design, conducting, reporting or dissemination of this study.

RESULTS

Our analysis included 5134 women giving birth by caesarean in the 21 study hospitals. Women with multiple pregnancies, congenital malformation, transverse lie/brow presentation in active labour, whose caesarean was decided by a non-physician provider with surgical skills and delivering in a rural district hospital were more likely to have missing data for four or more risk factors (online supplemental table 2).

Hospital variation in intrapartum-related perinatal mortality among caesarean births

Intrapartum-related perinatal mortality was high among caesarean births at 88 per 1000 (95% CI 81 to 96), including 65 per 1000 fresh stillbirths and 23 per 1000 deaths within 24 hours of birth (table 1). Crude mortality rates varied substantially across hospitals, from 21 to 189 per 1000. Intrapartum-related mortality tended to be higher in hospitals performing fewer caesarean sections (figure 1A). Intrapartum-related mortality was higher in regional and rural district hospitals than in urban district hospitals (108-110 vs 46 per 1000, p=0.001). Other perinatal outcomes showed similar patterns (online supplemental table 3).

Hospital variation in clinical risk factors among women giving birth by caesarean section

Case mix varied substantially across hospitals, with a range of 5%–37% for parity of four or more, 2%–29% for birth weight <2500 g and 1%–11% for transverse lie or brow presentation in active labour (table 2). Regional hospitals and rural district hospitals had higher risk populations of women giving birth by caesarean than urban district hospitals, with higher proportions of intrapartum caesareans, women with high parity and referred to the study hospital immediately prior to the caesarean (p<0.01 for all).

Hospital variation in caesarean care received

Caesarean care differed between hospitals (table 3). We found large differences in the type of provider (cadre) deciding for or conducting the caesarean between hospitals, with obstetricians deciding and performing 100% of caesareans in some hospitals and non-physician providers deciding and performing over 90% of caesareans in others. Rural district hospitals relied primarily on generalist doctors and non-physician providers, while urban district hospitals relied primarily on obstetricians.

Hospitals reported up to 54% of caesareans performed more than 1 hour after decision. Almost 90% of all caesareans were performed under spinal anaesthesia; however, in some hospitals, 70% of caesareans were performed under general anaesthesia. General anaesthesia was more common in regional hospitals. Incision technique also showed important variation between hospitals, less so between hospital type. Antibiotic use was almost universal, recorded in 96% of women, but administered after skin incision in at least 41% of caesareans (62% estimated with imputed data and up to 94% in individual hospitals).

Table 2 Characteristics of women giving birth by caesarean section, across hospitals and hospital types (n=5134)

	Range across hospitals	Regional hospital	Urban district hospital*	Rural district hospital	Total
N facilities		9	5	7	21
Monthly caesarean volume (median)	9–103	37	45	17	31
N women giving birth by caesarean	54–619	2693	1659	782	5134
Age (%)					
13–19	6–31	20.2	10.1	22	17.2
20–29	37–53	44.8	49.8	43.9	46.3
30–39	22–38	30.1	35.2	27.9	31.4
40–49	0–6	3.2	3.3	2.7	3.1
Missing	0–8	1.7	1.6	3.6	2.0
Educational level (%)					
None	33–88	73.6	41.8	74.0	63.4
Primary	1–38	7.7	24.1	15.0	14.1
Secondary or higher	3–45	17.9	31.2	10.2	21.0
Missing	0–9	0.7	3.0	0.8	1.4
Parity (%)					
0	30–43	34.4	35.2	35.0	34.7
1–3	31–64	42.9	53.8	39.5	45.9
4 or more	5–37	22.5	10.9	25.1	19.1
Missing	0–2	0.2	0.1	0.4	0.2
Number of previous caesarean sections (%)					
0	60–89	76.3	66.9	78.3	73.5
1	6–31	17.9	22.4	14.8	18.9
2–4	2–13	4.9	9.8	5.8	6.6
Missing	0–4	0.9	1.0	1.2	1.0
Number of antenatal visits (%)					
0	0–6	0.9	0.4	1.3	0.8
1–3	19–74	36.5	36.4	40.0	37.0
4 or more	21–71	53.5	58.1	52.0	54.8
Missing	1–24	9.1	5.1	6.6	7.4
Multiple pregnancy (%)					
Yes	2–10	5.8	6.1	5.8	5.9
Congenital malformation (%)					
No	30–100	91.3	92.7	89.1	91.4
Yes	0–4	1.2	0.4	0.6	0.9
Missing	0–69	7.5	6.9	10.2	7.7
Birth weight (%)					
Birth weight ≥2500 g	65–95	77.8	80.6	81.8	79.3
Birth weight <2500 g	2–29	17.2	13.2	11.9	15.1
Missing	1–16	5.1	6.2	6.3	5.6
Referral for antepartum complications or during labour (%)					
Yes	26–89	74.7	50.7	73.7	66.8
Distance from referring facility (%)					
<20 km	0–85	18.7	47.4	23.4	26.6
20–450 km	0–86	48.7	11.8	69.6	43.1

Continued

Table 2 Continued

	Range across hospitals	Regional hospital	Urban district hospital*	Rural district hospital	Total
Distance unknown	0–99	32.6	40.8	6.9	30.3
Caesarean during labour (%)					
No	2–49	15	34.1	8.1	20.1
Yes	51–98	85	65.9	91.9	79.9
Primary indication for caesarean (%)					
Fetal distress	7–36	24.5	17.0	23.3	21.9
Prolonged labour	23–67	33.1	28.6	42.1	33.0
Previous caesarean	7–33	12.1	24.3	12.8	16.2
Pre-eclampsia	0–8	4.2	4.1	1.7	3.8
Other	15–37	26.1	26	20.2	25.1
Diagnosis of acute fetal distress (%)	12–43	32.3	22.8	28.5	28.6
Transverse lie/brow presentation in active labour (%)	1–11	4.8	2.6	5.0	4.1
Other severe obstetric complication or maternal death (%)	6–38	22.6	14.3	19.6	19.5
Severe pre-eclampsia/eclampsia	2–13	6.4	6.1	3.2	5.8
Retroplacental haematoma	0–5	2.8	1.5	1.4	2.2
Placenta praevia in active labour	0–5	2	0.7	0.9	1.4
Uterine (pre)-rupture	2–24	12.3	6.4	15.0	10.8
Maternal mortality (per 100 000)	0–637	297	241	256	273

*In two largest cities (Ouagadougou and Bobo-Dioulasso).

Risk factors for intrapartum-related mortality and risk-adjusted hospital mortality rates

The median OR for crude intrapartum-related mortality was 1.9 (95% CI 1.5 to 2.5), indicating that if a woman moved to another, randomly selected, hospital with higher mortality, the median increase in her odds of intrapartum-related mortality would be almost twofold.

In model 1, congenital malformation, diagnosis of acute fetal distress, transverse lie or brow presentation in active labour and other severe obstetric complication or maternal death were strongly associated with intrapartum-related mortality (online supplemental table 4). Other risk factors retained in the model were parity, education, number of antenatal visits, primary caesarean indication, referral immediately prior to caesarean and birth weight. The median OR was 1.3 (95% CI 1.2 to 1.7), indicating that a woman moving to a different hospital with higher mortality would experience a 1.3-fold increase in odds of intrapartum-related mortality on average, a modest effect compared with individual-level clinical risk factors. Inter-hospital variation in mortality rates was reduced, but not eliminated, after adjusting for individual-level risk factors, with larger variation among hospitals performing less than 50 caesareans per month (figure 1B).

In model 2, all clinical risk factors except for number of antenatal visits were retained in the model with similar effect sizes, and two care component risk factors were identified: general anaesthesia and not receiving antibiotic prophylaxis (figure 2, online supplemental table 4). Decision-to-incision interval, hospital type and monthly caesarean volume were not independently associated with intrapartum-related mortality. There was no meaningful change in interhospital variation after adding care components, compared with model 1 (median OR=1.4 (95% CI 1.2 to 1.8), figure 1C).

There was no evidence that adding trial arm improved the fit of model 2 (p=0.78).

DISCUSSION

Our study fills an important gap in the evidence by examining hospital variation in intrapartum-related perinatal mortality among caesarean births in sub-Saharan Africa, a region with a high burden of perinatal deaths. Almost 1 in 10 women giving birth by caesarean in regional and district hospitals in Burkina Faso experienced an intrapartum-related perinatal death. The substantial hospital variation in crude mortality rates, ranging between 21 and 189 per 1000, was markedly reduced after adjusting for individual-level differences in case mix between hospitals. However, important variation remained, with lower volume hospitals tending to have higher and more variable adjusted mortality than hospitals performing more caesareans per month. Additionally adjusting for caesarean care components did not further reduce variation. Remaining variation in adjusted rates indicate likely differences in quality

Table 3 Caesarean care received by women, across hospitals and hospital types (n=5134)

	Range across hospitals	Regional hospital	Urban district hospital	Rural district hospital	Total
N women	54–619	2693	1659	782	5134
Cadre of provider deciding to perform caesarean					
Obstetrician	0–100	69.6	75.5	0.4	60.9
Generalist doctor with emergency surgical training	0–96	5.0	23.5	52.7	18.2
Generalist doctor	0–68	9.0	0.4	26.0	8.7
Midwife	0–100	16.1	0.4	7.5	9.7
Non-physician provider with surgical skills*	0–94	0.3	0.1	13.0	2.3
Missing	0–2	0.1	–	0.4	0.1
Cadre of provider who performed caesarean					
Obstetrician	0–100	28.3	68.9	0.1	37.1
Generalist doctor	0–88	13.0	11.8	44.6	17.4
Non-physician provider with obstetrics skills†	0–65	8.0	0.2	0.6	4.4
Non-physician provider with surgical skills*	0–94	48.3	18.9	54.2	39.7
Missing	0–8	2.4	0.2	0.4	1.4
Decision-to-incision interval					
<60 min	3–84	64.1	61.2	31.6	60.3
≥60 min	1–54	18.7	11.4	17.0	16.1
Missing	3–97	13.2	27.4	51.4	23.6
Type of anaesthesia					
Spinal	30–100	83.8	91	94.5	87.7
General/other	0–70	16.0	7.7	4.2	11.5
Missing	0–4	0.3	1.3	1.3	0.8
Type of skin incision					
Joel-Cohen	9–100	79.6	83.1	77.5	80.4
Pfannenstiel	0–84	16.8	12.1	9.7	14.2
Midline/other	0–11	2.8	1.1	0.9	1.9
Missing	0–39	0.8	3.7	11.9	3.4
Type of uterine incision					
Lower segment	45–100	94.7	98.3	94.8	95.9
Other	0–55	5.2	0.6	1.3	3.1
Missing	0–12	0.1	1.1	4.0	1.0
Antibiotic administration					
Antibiotics before incision	0–87	32.5	26.6	15.0	27.9
Antibiotics after incision	0–94	49.1	39.0	45.7	45.3
Antibiotics, timing unclear	2–95	12.6	32.9	35.2	22.6
No recorded antibiotics	0–10	2.0	0.5	0.4	1.3
Missing	0–22	3.9	0.9	3.8	2.9

*Nurses or midwives with additional 3-year training in surgery;
†Midwives with additional 3-year training in obstetrics and gynaecology, including performing caesareans.

of caesarean care between hospitals, particularly those with low or moderate monthly caesarean volumes.

Some of the remaining differences in risk-adjusted mortality rates between hospitals may be due to unmeasured confounding by case mix, since the accuracy of obstetric complication measurement using hospital records was likely limited. However, this is unlikely to explain all the variation in adjusted mortality between lower volume hospitals. Caesarean volume and hospital type were not independently associated with intrapartum-related mortality in our study, although the number of hospitals in our analysis (n=21) was too small to detect

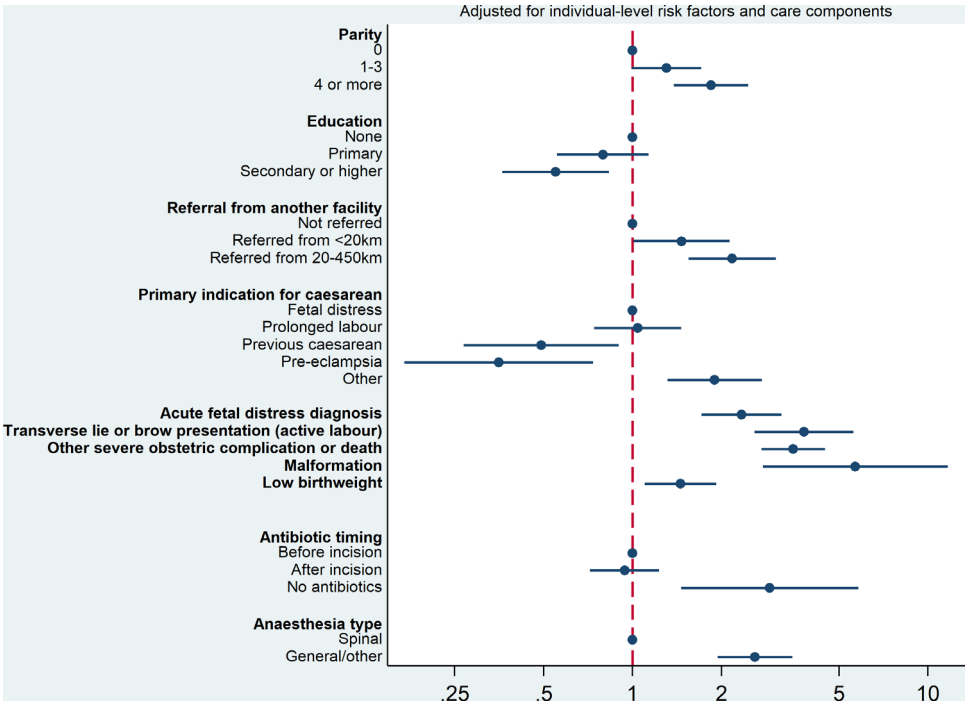

Figure 2 ORs and 95% CIs for risk factors for intrapartum-related mortality among women giving birth by caesarean section in 21 hospitals (model 2) – Burkina Faso, 2016.

such effects. Hospitals performing more caesareans likely differ from lower volume hospitals in multiple ways affecting quality of perinatal care, including presence of obstetricians or paediatricians, resources available for care of small and sick newborns, as well as differences in access to care for the population they serve.

We identified two care components associated with intrapartum-related mortality: general anaesthesia and not receiving antibiotic prophylaxis, each associated with a doubling of mortality, compared with spinal anaesthesia and receiving antibiotics before incision. These ORs may reflect unmeasured confounding by complication severity in the association with intrapartum-related mortality, or differences in quality of care. Indeed, although general anaesthesia is independently associated with perinatal mortality,[37] women undergoing general anaesthesia are also likely to be in poorer clinical condition at the time of the caesarean, with independently higher risk of perinatal death. Antibiotics may indicate very urgent caesareans without sufficient time to administer antibiotics, or poor organisation of care, with up to 10% of women not receiving antibiotics in some hospitals. Maternal antibiotic prophylaxis is unlikely to affect intrapartum-related survival.[38 39] It is not possible to disentangle the relative contributions of unmeasured confounding and quality of care for these two care components with our data.

High rates of fresh stillbirths among caesarean births—65 per 1000 in our study, 60 per 1000 total stillbirths in a previous systematic review[9]—indicate that many caesareans are performed too late in Burkina Faso. Limited access to caesarean section contributes to these poor outcomes: a higher proportion of women in sub-Saharan Africa arrive at the surgical hospital with severe complications and more caesareans are performed in the second stage of labour, with higher associated complications.[9] Some babies may die before arrival at the hospital, but nonetheless are delivered by caesarean. Indeed, our data suggest poor identification of stillbirths using the Pinard stethoscope in this setting: one-third of babies with no audible fetal heart rate were born alive, while one-quarter of macerated stillbirths had a recorded audible fetal heart rate. Other babies die in utero after arrival at the hospital, due to delayed diagnosis of fetal distress or long waiting times between decision and caesarean. We estimated a median decision-to-incision interval of 81 min for caesareans for fetal distress, based on imputed data.

To our knowledge, this is the first study to examine hospital variation in crude and risk-adjusted perinatal mortality in sub-Saharan Africa. A major strength of our study was the use of a novel dataset with high-quality, detailed clinical information on all women delivering by caesarean section in a 6-month period in all Burkinabe regional and district hospitals with >200 caesareans per year. Our 21 study hospitals accounted for 45% of all caesareans performed in Burkina Faso in 2016. University hospitals and lower volume district hospitals accounted for 26% each, with only 3% in the private sector.[27] While our results cannot be generalised to tertiary or private hospitals in Burkina Faso, higher and more variable perinatal mortality is also likely to occur in lower caesarean volume hospitals in other West African countries.

Some data limitations are worth noting. Missing data were common for several risk factors. We used multiple

imputation to preserve statistical power, and the distribution of imputed variables was similar to non-missing data. Moreover, like other studies using hospital records, some misclassification in obstetric complication severity was likely, leading to residual unmeasured confounding in case mix between hospitals. Indeed, limited granularity was available for severity (within pre-eclampsia, for example), and previous studies indicate obstetric complications may be incompletely recorded or overestimated in caesarean indications.[40–42] As a result, reported ORs for risk factors should be interpreted as measures of association within our study population, rather than causal effects. The number of hospitals in our sample was too small to enable us to examine hospital characteristics as risk factors. We were also unable to examine hospital variation in maternal outcomes since postcaesarean morbidity was not collected. Nonetheless, these prospectively collected trial data likely represent the best available clinical data for caesarean sections in sub-Saharan Africa, and it would have been difficult to further reduce complication misclassification.

Several recommendations for improving the quality of caesarean care stem from our findings. Two-thirds of women were referred immediately prior to the caesarean, and those referred from further away had higher rates of perinatal mortality. There is an urgent need to strengthen emergency referral systems by minimising delays in women reaching surgical facilities, through shared ambulances and maternity waiting homes, for example.[43] Delays in receiving treatment after arrival should also be reduced, including through prereferral notification and patient referral notes.[43] Improved antenatal care would help identify women needing an elective caesarean before labour. Monitoring of labour should be improved for all women, including those with risk factors for intrapartum-related mortality, to enable early intervention and prevent perinatal deaths among vaginal and caesarean births. Provider training in fetal monitoring, supportive supervision and making low-cost Doppler ultrasounds widely available in hospitals would help improve identification of fetal distress and stillbirths.[44] Many stillbirths can be delivered vaginally at lower risk of maternal complications[9]; however, suspected stillbirths should be confirmed with ultrasound scans, where available, to avoid misdiagnosis. The decision-to-incision interval was not associated with intrapartum-related mortality in our study, likely because of successful prioritisation of higher risk women and delayed decision to perform some caesareans. This mirrors the mixed results reported in the literature, which is based on limited observational data only.[45] Nonetheless, the estimated median 81 min interval for caesareans for fetal distress should be reduced closer to the 30 min recommended in the UK and USA,[46 47] wherever possible. Lastly, improving care for small and sick newborns—including neonatal resuscitation and intensive care through the Helping Babies Breathe[48] programme and Every Newborn Action Plan[49]—is essential to increase survival after birth. Provider training in newborn care has been shown to be cost-effective in other African countries.[50 51]

Our data also suggest suboptimal surgical technique that may affect maternal outcomes: although the Joel-Cohen incision has advantages over the Pfannenstiel technique,[52] the latter was used in at least 14% of caesareans. An estimated 62% of women received antibiotics only after incision based on imputed data, contrary to WHO recommendations.[53] Universal administration of antibiotic prophylaxis before incision could help reduce the incidence of surgical site infection and sepsis, which accounts for 10% of maternal deaths in sub-Saharan Africa.[54] The Lancet Global Surgery commission recommendations for improving access to and the safety of essential surgical services in low-resource settings should be followed,[55] first and foremost the creation of a national surgical plan including provisions for healthcare delivery, human resources, financing and information management.

Conclusions

Women giving birth by caesarean section in Burkina Faso face a high risk of perinatal death. Our study found variation in intrapartum-related perinatal mortality between hospitals remained after adjustment for case mix, indicating that differences in quality of care contribute to variation in perinatal mortality. Improving access to caesareans and the quality of caesarean care in the region is a considerable challenge for Ministries of Health and reproductive health partners in West Africa; improving training and resources for fetal distress monitoring, reducing decision-to-incision intervals and improving resuscitation and care of newborns seem important priorities to enable more babies to survive at birth.

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