

Supplementary materials

Supplementary Figure 1. Odds ratios and 95% confidence intervals for individual-level risk factors for intrapartum-related mortality (model 1)

$$\text{median OR} = \exp[\sqrt{2 \times \tau^2 \times 0.6745}]$$

where τ^2 is the hospital-level variance.

Supplementary Table 1. Missing data for risk factors for intrapartum-related perinatal mortality among 5,134 women in sample

Variable	N total expected	N missing	% missing (whole sample)	% missing (sub-sample)
Risk factors for which all women are expected to have data				
Maternal age	5,134	102	2.0	-
Parity	5,134	10	0.2	-
Education	5,134	74	1.4	-
Previous caesarean	5,134	0	0	-
Number of antenatal visits	5,134	382	7.4	-
Multiple pregnancy	5,134	0	0	-
Malformation	5,134	396	7.7	-
Birthweight	5,134	253	4.9	-
Acute fetal distress diagnosis	5,134	496	9.7	-
Transverse lie or brow presentation	5,134	0	0	-
Other severe obstetric complication or maternal death	5,134	0	0	-
Neonatal resuscitation	5,134	242	4.7	-
Labour phase	5,134	0	0	-
Referral status	5,134	0	0	-
Primary indication for caesarean	5,134	0	0	-
Provider deciding to perform caesarean	5,134	7	0.1	-
Provider performing caesarean	5,134	71	1.4	-
Decision-incision interval	5,134	1212	23.6	-
Anaesthesia type	5,134	39	0.8	-
Skin incision type	5,134	176	3.4	-
Antibiotic prophylaxis administration	5,134	149	2.9	-
Hospital type	5,134	0	0	-
Monthly caesarean volume	5,134	0	0	-
Risk factors for which a subset of women are expected to have data				
Birthweight for second baby among multiple pregnancies	301	91	1.8	30.2
Referral distance among referred women	3,429	1039	20.2	30.3
Timing of antibiotic administration among women receiving antibiotic prophylaxis	4,918	1159	22.6	23.6
Variable used in the imputation model but not in the risk factor analysis				
Gestational age at birth	5,134	2808	54.7	-

Supplementary Table 2. Characteristics of women with missing data on risk factors among 5,134 women in sample

Risk factor	N	Missing data for 0 risk factors (row %)	Missing data for 1-3 risk factors (row %)	Missing data for 4 or more risk factors (row %)
Maternal age				
13-19	883	31	65	4
20-29	2,376	33	63	4
30-39	1,612	33	63	4
40-49	161	26	70	4
Missing	102	0	90	10
Parity				
0	1,784	33	64	4
1-3	2,358	32	64	4
4 or more	982	29	67	4
Missing	10	0	70	30
Education				
None	3,256	31	65	4
Primary	724	29	66	4
Secondary or higher	1,080	38	60	2
Missing	74	0	88	12
Previous caesarean				
No	3,776	31	65	4
Yes	1,308	33	64	3
Missing	50	24	54	22
Number of antenatal care visits				
0	42	19	76	5
1-3	1,899	32	65	3
4 or more	2,811	36	61	3
Missing	382	0	87	13
Multiple pregnancy				
No	4,833	32	64	4
Yes	301	20	71	9
Congenital malformation				
No	4,694	35	64	2
Yes	44	14	77	9
Missing	396	0	73	27
Gestational age at birth				
Preterm	286	26	69	6
Term	2,040	36	61	3
Missing	2,715	30	66	4
Birthweight				
Birthweight \geq 2,500g	4,071	35	63	2
Birthweight<2,500g	775	28	68	3
Missing	288	0	72	28
Acute fetal distress				
No	3,168	34	64	2
Yes	1,470	37	61	2
Missing	496	0	81	19
Transverse lie or brow presentation in active labour				
No	4,922	32	65	4
Yes	212	29	63	8

Other severe obstetric complication or maternal death				
No	4,125	32	64	3
Yes	1,009	29	66	5
Neonatal resuscitation				
No	4,273	34	63	2
Yes	619	27	70	3
Missing	242	0	70	30
Labour phase				
Pre-labour	1,031	29	67	4
Latent phase	1,577	36	61	3
Active phase	2,526	30	66	4
Referral status				
Not referred before caesarean	1,705	39	58	3
Referred before caesarean	3,429	28	68	4
Referral distance				
<20km	911	43	55	3
20-450km	1,479	39	58	4
Distance unknown	1,039	0	94	6
Primary indication for caesarean				
Fetal distress	1,125	36	61	3
Prolonged labour	1,695	31	66	4
Previous caesarean	830	30	66	3
Pre-eclampsia	193	28	67	5
Other	1,291	31	64	5
Provider cadre deciding to perform caesarean				
Obstetrician	3,129	37	60	3
Generalist doctor with emergency surgical training	936	27	68	4
Generalist doctor	446	21	74	5
Midwife	500	24	73	3
Non-physician provider with surgical skills	116	7	86	7
Missing	7	0	71	29
Provider cadre performing caesarean				
Obstetrician	1,905	32	63	5
Generalist doctor	895	28	67	5
Non-physician provider with obstetrics skills	224	18	81	0
Non-physician provider with surgical skills	2,039	36	62	3
Missing	71	0	92	8
Decision-to-incision interval				
<60min	878	36	61	2
≥60min	3,044	43	56	1
Missing	1,212	0	89	11
Anaesthesia type				
Spinal	4,505	32	64	3
General/other	590	29	66	5
Missing	39	0	46	54
Skin incision type				
Joel-Cohen	4,128	34	63	3
Pfannenstiel	730	27	70	4
Midline/other	100	25	72	3
Missing	176	0	78	22
Uterine incision type				
Lower segment	4,921	33	64	3
Other	161	11	86	2
Missing	52	0	60	40

Antibiotic prophylaxis administration				
Antibiotics before incision	1,434	43	56	1
Antibiotics after incision	2,325	43	56	1
Antibiotics, timing unclear	1,159	0	90	10
No recorded antibiotics	67	24	75	1
Missing	149	0	74	26
Hospital type				
Regional hospital	2,693	39	58	2
Urban district hospital	1,659	26	70	4
Rural district hospital	782	18	75	7
Mean monthly caesarean volume				
<30	923	25	70	4
30-60	1,717	20	74	5
60-105	2,494	42	56	2

Supplementary Table 3. Maternal and perinatal outcomes among women giving birth by caesarean section in 21 hospitals – Burkina Faso, 2016

	N women	Perinatal outcomes						
		Macerated stillbirths (per 1,000)	Fresh stillbirths (per 1,000)	Apgar score <3, live birth (per 1,000)	Neonatal death within 24 hrs of birth (per 1,000)	Neonatal death after 24 hrs, before discharge (per 1,000)	Intrapartum-related perinatal death (per 1,000)	Total perinatal death before discharge (per 1,000)
Total	5,134	7 [5-9]	65 [58-72]	24 [20-29]	23 [20-28]	3 [2-5]	88 [81-96]	98 [90-107]
Range across hospitals	5,134	0-23	16-135	0-90	0-90	0-32	21-189	32-243
Facility type								
Regional hospital	2,693	9 [6-14]	78 [68-89]	32 [26-39]	30 [24-37]	4 [2-7]	108 [97-120]	121 [109-134]
Urban district hospital	1,659	3 [1-7]	36 [28-46]	9 [5-15]	10 [06-16]	2 [1-6]	46 [37-57]	51 [42-63]
Rural district hospital	782	5 [2-14]	81 [63-102]	31 [21-45]	29 [20-44]	4 [1-12]	110 [90-134]	119 [98-144]
P-value	-	0.08	<0.001	0.029	0.016	0.793	0.001	0.001

Supplementary table 4. Risk factors for intrapartum-related deaths among 5,134 women giving birth by caesarean section in 21 hospitals – Burkina Faso, 2016

Risk factor	Unadjusted OR (95% CI)	Model 1 ^a (95% CI)	Model 2 ^b (95% CI)
Individual-level clinical risk factors			
Maternal age			
13-19	1 [ref]	-	-
20-29	1.31 (0.98-1.76)	-	-
30-39	1.56 (1.15-2.10)	-	-
40-54	2.09 (1.21-3.58)	-	-
Parity			
0	1 [ref]	1 [ref]	1 [ref]
1-3	1.15 (0.90-1.47)	0.80 (0.56-1.13)	1.30 (0.99-1.71)
4 or more	2.46 (1.91-3.18)	0.52 (0.34-0.78)	1.84 (1.38-2.46)
Education			
None	1 [ref]	1 [ref]	1 [ref]
Primary	0.64 (0.46-0.89)	0.89 (0.61-1.31)	0.79 (0.56-1.13)
Secondary or higher	0.31 (0.21-0.46)	0.53 (0.34-0.85)	0.55 (0.36-0.83)
Number of previous caesareans			
0	1 [ref]	-	-
1 or more	0.39 (0.29-0.52)	-	-
Number of ANC visits			
0	1 [ref]	1 [ref]	-
1-3	0.58 (0.24-1.36)	0.54 (0.19-1.48)	-
4 or more	0.35 (0.15-0.81)	0.43 (0.16-1.18)	-
Multiple pregnancy			
No	1 [ref]	-	-
Yes	1.43 (0.99-2.07)	-	-
Malformation			
No	1 [ref]	1 [ref]	1 [ref]
Yes	7.15 (3.75-13.64)	6.01 (2.95-12.23)	5.67 (2.79-11.55)
Birthweight			
Birthweight ≥2,500g	1 [ref]	1 [ref]	1 [ref]
Birthweight <2,500g	1.77 (1.39-2.25)	1.50 (1.14-1.97)	1.45 (1.10-1.92)
Diagnosis of acute fetal distress			
No	1 [ref]	1 [ref]	1 [ref]
Yes	2.26 (1.79-2.86)	2.42 (1.80-3.26)	2.34 (1.72-3.17)
Transverse lie or brow presentation in active labour			
No	1 [ref]	1 [ref]	1 [ref]
Yes	3.69 (2.65-5.13)	3.56 (2.43-5.22)	3.81 (2.59-5.59)
Other severe obstetric complication or maternal death			
No	1 [ref]	1 [ref]	1 [ref]
Yes	3.49 (2.84-4.29)	3.88 (3.04-4.95)	3.50 (2.73-4.49)
Labour phase			
Pre-labour	1 [ref]	-	-
Latent phase	1.20 (0.84-1.71)	-	-
Active phase	2.12 (1.53-2.92)	-	-

Referral status			
Not referred	1 [ref]	1 [ref]	1 [ref]
Referred from <20km	2.17 (1.51-3.11)	1.52 (1.04-2.21)	1.46 (1.01-2.13)
Referred from 20-450km	4.24 (3.10-5.80)	2.17 (1.55-3.04)	2.18 (1.55-3.06)
Decision-to-delivery interval			
<60 minutes	1 [ref]	-	-
≥60 minutes	0.85 (0.65-1.11)	-	-
Primary indication for caesarean			
Fetal distress	1 [ref]	1 [ref]	1 [ref]
Prolonged labour	1.10 (0.85-1.43)	1.14 (0.81-1.59)	1.04 (0.74-1.46)
Previous caesarean	0.23 (0.13-0.39)	0.51 (0.28-0.92)	0.49 (0.27-0.90)
Pre-eclampsia	0.59 (0.31-1.13)	0.38 (0.19-0.80)	0.35 (0.17-0.74)
Other	1.37 (1.04-1.80)	2.08 (1.44-3.00)	1.90 (1.31-2.74)
Caesarean care components and hospital characteristics			
Provider cadre deciding the caesarean			
Obstetrician	1 [ref]		-
Generalist doctor with emergency surgical training	1.20 (0.84-1.73)		-
Generalist doctor	1.20 (0.73-1.96)		-
Midwife	1.78 (1.07-2.96)		-
Non-physician provider with surgical skills ^c	1.87 (0.82-4.28)		-
Provider cadre performing the caesarean			
Obstetrician	1 [ref]		-
Generalist doctor	0.94 (0.62-1.44)		-
Non-physician provider with obstetrics skills ^d	1.47 (0.81-2.68)		-
Non-physician provider with surgical skills ^c	1.01 (0.68-1.49)		-
Type of anaesthesia			
Spinal	1 [ref]		1 [ref]
General/other	4.46 (3.41-5.84)		2.60 (1.94-3.47)
Type of skin incision			
Joel-Cohen	1 [ref]		-
Other	0.89 (0.62-1.28)		-
Type of uterine incision			
Lower segment	1 [ref]		-
Other	1.23 (0.69-2.19)		-
Antibiotics administration			
Antibiotics before incision	1 [ref]		1 [ref]
Antibiotics after incision	0.99 (0.74-1.31)		0.94 (0.72-1.23)
No recorded antibiotics	2.31 (1.25-4.25)		2.91 (1.46-5.81)
Neonatal resuscitation			
No	1 [ref]		-
Yes	1.71 (1.31-2.24)		-
Hospital type			
Regional hospital	1 [ref]		-
Urban district hospital	0.36 (0.23-0.58)		-
Rural district hospital	0.96 (0.62-1.47)		-
Hospital caesarean volume (per month)			

<30	1 [ref]		-
30-60	0.93 (0.55-1.57)		-
60-105	0.53 (0.30-0.94)		-

^aModel 1 was built by manual backward elimination of individual-level risk factors with p>0.1 in a model including all variables with p<0.25 in the unadjusted model, with the exception of maternal age which had p<0.25 in the unadjusted model but was removed due to collinearity with parity

^bModel 2 was built by adding all care components and hospital characteristics with p<0.25 to model 1, followed by manual backward selection until all remaining variables had p<0.1

^cNurses or midwives with additional 3-year training in surgery

^dMidwives with additional 3-year training in obstetrics and gynaecology, including performing caesareans