

## Supplementary material

Table S1. International Classification of Diseases and Related Health Problems Tenth Revision, Canadian version (ICD-10-CA), and Canadian Classification of Health Interventions (CCI) codes used for population selection and to classify determinants, outcomes, and confounders

<b>Diagnosis/Procedure</b>	<b>ICD-10-CA</b>	<b>CCI</b>	<b>Study use</b>
Single live birth	BCPDR data element		
Midcavity forceps delivery		5.MD.53	
Midcavity vacuum delivery		5.MD.54	
Midcavity sequential instrumental delivery		5.MD.55	
Failed forceps delivery			
Failed instrument	O66.5		
Caesarean delivery with forceps		5.MD.60.RC, 5.MD.60.JZ, 5.MD.60.KC, 5.MD.60.RA, 5.MD.60.RE, 5.MD.60.JW, 5.MD.60.RG	
Failed vacuum delivery			
Failed instrument	O66.5		
Caesarean delivery with vacuum		5.MD.60.RD, 5.MD.60.KA, 5.MD.60.KD, 5.MD.60.RB, 5.MD.60.RF, 5.MD.60.JX, 5.MD.60.RH	Inclusion criteria
Failed sequential instrumental delivery			
Failed instrument	O66.5		
Caesarean delivery with sequential instruments		5.MD.60.C	
Caesarean delivery in second stage of labour		5.MD.60.KE, 5.MD.60.JY, 5.MD.60.KB, 5.MD.60.KG, 5.MD.60.KF, 5.MD.60.AA, 5.MD.60.KT + BCPDR element for duration of second stage of labour (only deliveries with value > 0 included)	
Gestational age 37–41 weeks	BCPDR data element		
Therapeutic abortions	O04	5.CA.20, 5.CA.24, 5.CA.88, 5.CA.89, 5.CA.90	
Non-vertex presentation	O32.1, O64.1	5.MD.56 + BCPDR indicator variable for baby presentation during labour	
Chronic hypertension	O10, O11		Exclusion criteria
Preeclampsia	O14		
Eclampsia	O15		
Diabetes	O24		
Placenta praevia	O44		
Placental abruption	O45		
Congenital anomalies	Q		

Table S1 (cont'd). International Classification of Diseases and Related Health Problems Tenth Revision, Canadian version (ICD-10-CA), and Canadian Classification of Health Interventions (CCI) codes used for population selection and to classify determinants, outcomes, and confounders

<b>Diagnosis/Procedure</b>	<b>ICD-10-CA</b>	<b>CCI</b>	<b>Study use</b>
Dystocia	O32, O33, O34.0, O34.1, O34.3–O34.9, O62.0, O62.1, O62.2, O62.4, O62.8, O62.9, O63, O66		Cohort definition
Fetal distress	O68, O69.0		
Maternal age	BCPDR element		
Parity	BCPDR element		
Pre-pregnancy weight	BCPDR element		
Previous caesarean delivery	O34.20, O66.40, O75.7		Potential confounder/ effect modifier
Birth weight	BCPDR element		
Fiscal year	BCPDR element		
Practitioner	BCPDR element		
Prolonged second stage	O63.1		
Position of the fetal head	BCPDR element		
Stillbirth	BCPDR element		
Neonatal death	BCPDR element		
Neonatal convulsions	P90		
Assisted ventilation by endotracheal intubation	BCPDR element	1.GZ.31.CA-ND	Primary perinatal composite outcome
5-minute Apgar < 4	BCPDR element		
Severe birth trauma	P10, P11.0–P11.2, P11.4–P11.5 P12.2, P13.0, P13.2, P13.30, P13.38, P14.0, P14.1, P14.3, P15.0, P15.1		
Respiratory distress	P22		Secondary perinatal outcome
Severe postpartum haemorrhage	O72 + BCPDR element (blood transfusion indicator variable)		
Shock	O75.1, T80.5, T886, R57		Primary maternal composite outcome
Sepsis	O85		
Cardiac complications	O89.1, O74.2, O75.4, I21, I22, I46, I50, J81		
Acute renal failure	O90.4, N99.0, N17, N19		
Obstetric embolism	O88		
Obstetric trauma	O70.2, O70.3, O71.3–O71.9	5.PC.80.JQ, 5.PC.80.JH	
3 <sup>rd</sup> /4 <sup>th</sup> degree perineal lacerations	O70.2, O70.3 + BCPDR element	5.PC.80.JQ	
Postpartum haemorrhage	O72		Secondary maternal outcome
Postpartum haemorrhage – retained placenta	O72.0		
Postpartum haemorrhage – atonic	O72.1		
Postpartum haemorrhage – delayed	O72.2		

Table S2. Numbers and rates of all components of perinatal and maternal outcomes by attempted mode of delivery, British Columbia, 2004–2014

Outcome	Caesarean delivery		Midcavity forceps		Midcavity vacuum		Sequential midcavity OVD	
	n	%	n	%	n	%	n	%
<b>Dystocia</b>								
Severe perinatal morbidity/mortality	20	0.83	30	1.70	15	2.17	7	3.52
Stillbirth <sup>a</sup>	<5	<0.21	<5	<0.28	0	0.00	0	0.00
Neonatal death	0	0.00	0	0.00	0	0.00	<5	<2.51
Convulsions	<5	<0.21	<5	<0.28	<5	<0.72	0	0.00
Assisted ventilation by endotracheal tube	6	0.25	9	0.51	<5	<0.72	<5	<2.51
5-min Apgar <4	7	0.29	6	0.34	<5	<0.72	0	0.00
Severe birth trauma <sup>b</sup>	7	0.29	17	0.96	7	1.01	<5	<2.51
Respiratory distress <sup>c</sup>	60	1.49	64	3.63	33	4.78	9	4.52
Birth trauma	28	1.16	71	4.03	53	7.68	23	11.6
Severe maternal morbidity	19	0.79	21	1.19	10	1.45	<5	<2.51
Severe postpartum haemorrhage <sup>d</sup>	12	0.50	17	0.96	9	1.30	<5	<2.51
Shock	<5	<0.21	<5	<0.28	0	0.00	0	0.00
Sepsis	5	0.21	<5	<0.28	0	0.00	<5	<2.51
Obstetric embolism	<5	<0.21	0	0.00	<5	<0.72	0	0.00
Cardiac complication <sup>e</sup>	<5	<0.21	<5	<0.28	0	0.00	0	0.00
Acute renal failure	0	0.00	0	0.00	0	0.00	0	0.00
Postpartum haemorrhage <sup>f</sup>	111	4.62	374	21.2	96	13.9	35	17.6
Obstetric trauma <sup>g</sup>	92	3.83	465	26.4	80	11.6	45	22.6
Severe perineal laceration (3 <sup>rd</sup> /4 <sup>th</sup> degree)	0	0.00	405	23.0	71	10.3	42	21.1
<b>Fetal distress</b>								
Severe perinatal morbidity/mortality	40	1.89	59	2.66	32	2.62	6	2.09
Stillbirth <sup>a</sup>	0	0.00	<5	<0.23	0	0.00	0	0.00
Neonatal death	0	0.00	<5	<0.23	0	0.00	0	0.00
Convulsions	9	0.42	7	0.32	6	0.49	<5	<1.74
Assisted ventilation by endotracheal tube	24	1.13	24	1.08	19	1.55	<5	<1.74
5-min Apgar <4	7	0.33	7	0.32	6	0.49	<5	<1.74
Severe birth trauma <sup>b</sup>	5	0.24	25	1.13	8	0.65	<5	<1.74
Respiratory distress <sup>c</sup>	151	7.13	162	7.31	81	6.62	26	9.06
Birth trauma	39	1.84	98	4.42	65	5.31	27	9.41
Severe maternal morbidity	14	0.66	34	1.53	7	0.57	5	1.74
Severe postpartum haemorrhage <sup>d</sup>	7	0.33	29	1.31	<5	<0.41	<5	<1.74
Shock	<5	<0.24	0	0.00	0	0.00	0	0.00
Sepsis	<5	<0.24	<5	<0.23	<5	<0.41	<5	<1.74
Obstetric embolism	0	0.00	0	0.00	<5	<0.41	0	0.00
Cardiac complication <sup>e</sup>	<5	<0.24	<5	<0.23	0	0.00	0	0.00
Acute renal failure	<5	<0.24	0	0.00	0	0.00	0	0.00
Postpartum haemorrhage <sup>f</sup>	107	5.05	438	19.8	151	12.4	51	17.8
Obstetric trauma <sup>g</sup>	101	4.77	535	24.2	121	9.89	74	25.8
Severe perineal laceration (3 <sup>rd</sup> /4 <sup>th</sup> degree)	0	0.00	439	19.8	104	8.50	63	22.0

OVD, operative vaginal delivery.

a Only stillbirths that occurred after the onset of labour were included.

b Severe birth trauma included intracranial laceration and haemorrhage, skull fracture, severe injury to CNS, severe injury to PNS, long bone injury, subaponeurotic haemorrhage, injury to liver, and injury to spleen.

c Respiratory distress included RDS (hyaline membrane disease, idiopathic respiratory distress syndrome) and transient tachypnoea of the newborn and other neonatal respiratory distress.

d Severe postpartum haemorrhage includes postpartum haemorrhage requiring transfusion.

e Cardiac complications included cardiac arrest, cardiac failure, myocardial infarction and pulmonary embolism.

f Postpartum haemorrhage (PPH) included atonic PPH, 3rd stage PPH, delayed PPH, and PPH due to coagulation defects.

g Obstetric trauma included 3rd/4th degree perineal laceration, cervical laceration, uterine rupture during labour, high vaginal laceration, other obstetric injury to pelvic organs, and obstetric damage to pelvic joints and ligaments.

Table S3. Rate ratios expressing the association between operative vaginal delivery (OVD) vs caesarean delivery and severe perinatal and maternal morbidity/mortality among women with dystocia and fetal distress with adjustment using multivariable logistic regression, British Columbia, 2004–2014

Outcome	Caesarean delivery	Attempted midcavity forceps	Attempted midcavity vacuum	Attempted sequential midcavity OVD
	ARR (95% CI)	ARR (95% CI)	ARR (95% CI)	ARR (95% CI)
<b>Dystocia cohort</b>				
Severe perinatal morbidity/mortality <sup>a</sup>	Reference	2.32 (1.24-4.36)	2.94 (1.43-6.05)	4.80 (1.92-12.0)
Severe maternal morbidity <sup>b</sup>	Reference	1.79 (0.89-3.60)	2.01 (0.89-4.54)	1.59 (0.35-7.16)
<b>Fetal distress cohort</b>				
Severe perinatal morbidity/mortality <sup>a</sup>	Reference	1.56 (1.00-2.45)	1.43 (0.85-2.42)	1.15 (0.47-2.81)
Severe maternal morbidity <sup>b</sup>	Reference	2.04 (1.01-4.14)	0.80 (0.30-2.17)	2.62 (0.89-7.74)

ARR, adjusted rate ratio; CI, confidence interval.

Results adjusted for maternal age, parity, pre-pregnancy weight, previous caesarean delivery, position of the fetal head at delivery, birth weight, income quintile, and year of delivery.

a Severe perinatal morbidity/mortality included neonatal convulsions, assisted ventilation by endotracheal tube, 5-minute Apgar score of <4, severe birth trauma (see below for definition), stillbirth that occurred after the onset of labour, and neonatal death.

b Severe maternal morbidity included severe postpartum haemorrhage, shock, sepsis, obstetric embolism, cardiac complication, and acute renal failure.

Table S4. Rate ratios expressing the association between operative vaginal delivery (OVD) vs caesarean delivery and severe perinatal and maternal morbidity/mortality among women with dystocia and fetal distress with adjustment using regression with propensity score weights and doubly robust estimators, British Columbia, 2004–2014

Outcome	Caesarean delivery	Attempted midcavity forceps	Attempted midcavity vacuum	Attempted sequential midcavity OVD
	ARR (95% CI)	ARR (95% CI)	ARR (95% CI)	ARR (95% CI)
<b>Dystocia cohort</b>				
Severe perinatal morbidity/mortality <sup>a</sup>	Reference	2.26 (1.54-3.32)	2.36 (1.60-3.47)	5.07 (3.54-7.25)
Severe maternal morbidity <sup>b</sup>	Reference	1.72 (1.13-2.61)	2.44 (1.65-3.62)	1.68 (1.08-2.60)
<b>Fetal distress cohort</b>				
Severe perinatal morbidity/mortality <sup>a</sup>	Reference	1.20 (0.94-1.53)	1.36 (1.06-1.74)	1.02 (0.77-1.36)
Severe maternal morbidity <sup>b</sup>	Reference	2.41 (1.58-3.68)	0.79 (0.46-1.36)	3.26 (2.11-5.02)

ARR, adjusted rate ratio; CI, confidence interval.

Results adjusted for maternal age, parity, pre-pregnancy weight, previous caesarean delivery, position of the fetal head at delivery, birth weight, income quintile, and year of delivery.

a Severe perinatal morbidity/mortality included neonatal convulsions, assisted ventilation by endotracheal tube, 5-minute Apgar score of <4, severe birth trauma (see below for definition), stillbirth that occurred after the onset of labour, and neonatal death.

b Severe maternal morbidity included severe postpartum haemorrhage, shock, sepsis, obstetric embolism, cardiac complication, and acute renal failure.

Table S5. Adjusted rate ratios (ARR) and 95% confidence intervals (CI) for severe perinatal and maternal composite morbidity and mortality following deliveries by attempted midcavity operative vaginal delivery compared with caesarean delivery, stratified by position of fetal head at delivery, British Columbia, 2004–2014

Outcome	Attempted midcavity instrument(s)	Anterior			Posterior/Transverse			P-value for interaction		
		Outcome rate in caesarean delivery (%)	ARR	95% CI	Outcome rate in caesarean delivery (%)	ARR	95% CI			
<b>Dystocia</b>										
Severe perinatal morbidity/mortality	Forceps		1.65	0.78	3.52		3.14	1.03	10.44	0.18
	Vacuum	1.46	1.94	0.79	4.79	0.73	5.40	1.57	18.61	0.14
	Sequential		4.08	1.34	12.43		5.86	0.81	42.39	0.63
Severe maternal morbidity	Forceps		2.11	0.72	6.18		1.84	0.52	6.52	0.79
	Vacuum	0.65	2.28	0.66	7.88	1.09	2.51	0.69	9.13	0.86
	Sequential		1.34	0.15	12.24		2.40	0.30	19.34	0.78
Severe perineal lacerations (3 <sup>rd</sup> /4 <sup>th</sup> deg) <sup>a</sup>	Forceps		21.6	19.4	24.0		36.7	30.1	43.8	-
	Vacuum	0.00	11.5	8.77	15.0	0.00	4.88	2.25	10.2	-
	Sequential		23.9	17.0	32.5		22.7	12.8	37.0	-
<b>Fetal distress</b>										
Severe perinatal morbidity/mortality	Forceps		1.27	0.69	2.34		1.29	0.46	3.65	0.87
	Vacuum	2.46	<b>0.97</b>	<b>0.48</b>	<b>1.96</b>	1.61	<b>3.00</b>	<b>1.28</b>	<b>7.01</b>	<b>0.03</b>
	Sequential		0.75	0.24	2.36		2.09	0.47	9.27	0.15
Severe maternal morbidity	Forceps		3.73	1.05	13.18		1.40	0.39	5.06	0.21
	Vacuum	0.45	1.34	0.31	5.70	0.99	0.72	0.09	5.69	0.52
	Sequential		3.54	0.71	17.76		2.88	0.38	21.76	0.69
Severe perineal lacerations (3 <sup>rd</sup> /4 <sup>th</sup> deg) <sup>a</sup>	Forceps		20.5	18.5	22.6		24.6	19.8	30.2	-
	Vacuum	0.00	8.85	7.08	11.0	0.00	9.79	5.92	15.8	-
	Sequential		18.8	13.7	25.2		35.6	23.2	50.2	-

Adjusted for parity, pre-pregnancy weight, and infant birth weight.

Bold text denotes statistically significant differences between ARR in deliveries to infants with a fetal head in occiput anterior vs occiput posterior/transverse position at delivery.

<sup>a</sup> Rate (%) and 95% CI provided for severe perineal lacerations as relative estimates were not estimable due to small numbers in the reference group.

Table S6. Adjusted rate ratios (ARR) and 95% confidence intervals (CI) for perinatal and maternal outcomes following deliveries with dystocia by attempted midcavity operative vaginal delivery compared with caesarean delivery, stratified by prolonged second stage of labour, British Columbia, 2004–2014

Outcome	Attempted midcavity instrument(s)	No prolonged second stage of labour (n=1,787)			Prolonged second stage of labour (n=3,270)				
		Outcome rate in caesarean delivery (%)	ARR	95% CI	Outcome rate in caesarean delivery (%)	ARR	95% CI		
Perinatal morbidity/mortality	Forceps		2.70	1.23	5.92		2.36	0.98	5.69
	Vacuum	1.24	2.92	1.15	7.41	0.56	3.60	1.27	10.23
	Sequential		2.66	0.57	12.49		7.77	2.40	25.21
Birth trauma	Forceps		6.71	3.08	14.61		2.86	1.65	4.96
	Vacuum	0.93	12.48	5.62	27.74	1.32	5.56	3.05	10.12
	Sequential		21.76	8.58	55.14		7.29	3.33	15.96
Respiratory distress	Forceps		<b>2.88</b>	<b>1.56</b>	<b>5.32</b>		<b>1.06</b>	<b>0.67</b>	<b>1.66</b>
	Vacuum	1.96	1.74	0.74	4.09	2.85	1.99	1.19	3.34
	Sequential		3.09	1.00	9.58		1.43	0.55	3.72
Maternal morbidity	Forceps		1.70	0.56	5.18		1.56	0.72	3.39
	Vacuum	0.72	1.74	0.43	7.01	0.83	2.16	0.83	5.64
	Sequential		2.20	0.25	19.45		1.35	0.17	10.73
Postpartum haemorrhage	Forceps		5.61	3.72	8.45		5.80	4.41	7.64
	Vacuum	4.03	3.88	2.35	6.39	5.01	3.39	2.36	4.87
	Sequential		5.68	2.84	11.36		4.18	2.47	7.06
Obstetric trauma	Forceps		<b>14.36</b>	<b>9.28</b>	<b>22.23</b>		<b>7.68</b>	<b>5.78</b>	<b>10.20</b>
	Vacuum	2.90	3.51	1.97	6.27	4.45	3.36	2.30	4.91
	Sequential		<b>14.35</b>	<b>7.47</b>	<b>27.57</b>		<b>5.50</b>	<b>3.29</b>	<b>9.18</b>
Severe perineal lacerations (3 <sup>rd</sup> /4 <sup>th</sup> deg)*	Forceps		24.64	21.02	28.66		22.34	20.14	24.70
	Vacuum	0.00	7.75	5.07	11.67	0.00	11.81	9.09	15.19
	Sequential		24.00	15.75	34.78		19.35	13.37	27.19

Adjusted for maternal age, parity, pre-pregnancy weight, infant birth weight, income quintile and year of birth. Bold text denotes statistically significant differences between ARR with and without prolonged second stage of labour.

\*Rate (%) and 95% CI provided for severe perineal lacerations as relative estimates were not estimable due to low rate in the reference group.



Table S7. Adjusted rate ratios (ARR) and 95% confidence intervals (CI) for perinatal and maternal outcomes following deliveries with fetal distress by attempted midcavity operative vaginal delivery compared with caesarean delivery, stratified by prolonged second stage of labour, British Columbia, 2004–2014

Outcome	Attempted midcavity instrument(s)	No prolonged second stage of labour (n=3,891)			Prolonged second stage of labour (n=1,953)				
		Outcome rate in caesarean delivery (%)	ARR	95% CI	Outcome rate in caesarean delivery (%)	ARR	95% CI		
Perinatal morbidity/mortality	Forceps		1.47	0.86	2.52		1.48	0.78	2.81
	Vacuum	1.78	1.24	0.67	2.31	2.03	2.58	1.17	5.69
	Sequential		0.82	0.24	2.78		2.07	0.58	7.44
Birth trauma	Forceps		2.58	1.56	4.25		2.86	1.58	5.17
	Vacuum	1.78	3.66	2.18	6.13	1.92	2.42	1.09	5.37
	Sequential		5.32	2.71	10.43		8.17	3.55	18.77
Respiratory distress	Forceps		1.09	0.80	1.47		1.08	0.74	1.56
	Vacuum	6.89	<b>0.78</b>	<b>0.53</b>	<b>1.13</b>	7.46	<b>1.86</b>	<b>1.19</b>	<b>2.93</b>
	Sequential		1.22	0.69	2.14		1.73	0.84	3.55
Maternal morbidity	Forceps		<b>5.58</b>	<b>1.94</b>	<b>16.06</b>		<b>0.86</b>	<b>0.32</b>	<b>2.29</b>
	Vacuum	0.32	1.95	0.54	7.04	1.13	0.35	0.04	2.75
	Sequential		5.92	1.45	24.11		1.05	0.13	8.60
Postpartum haemorrhage	Forceps		5.91	4.30	8.12		4.11	2.97	5.68
	Vacuum	3.97	<b>3.89</b>	<b>2.74</b>	<b>5.53</b>	6.55	<b>1.87</b>	<b>1.16</b>	<b>3.02</b>
	Sequential		4.52	2.79	7.32		4.84	2.69	8.70
Obstetric trauma	Forceps		7.92	5.78	10.86		5.36	3.86	7.45
	Vacuum	3.89	2.89	2.00	4.17	5.99	2.25	1.39	3.62
	Sequential		9.66	6.29	14.83		5.44	3.00	9.87
Severe perineal lacerations (3 <sup>rd</sup> /4 <sup>th</sup> deg)*	Forceps		19.81	17.86	21.92		19.84	17.12	22.87
	Vacuum	0.00	8.25	6.68	10.15	0.00	9.49	6.46	13.73
	Sequential		22.60	17.44	28.75		20.25	12.87	30.40

Adjusted for maternal age, parity, pre-pregnancy weight, infant birth weight, income quintile and year of birth.

Bold text denotes statistically significant differences between ARR with and without prolonged second stage of labour.

\*Rate (%) and 95% CI provided for severe perineal lacerations as relative estimates were not estimable due to low rate in the reference group.