

## Supplemental Digital Content

### Adverse events and factors associated with potentially avoidable use of general anesthesia in cesarean deliveries.

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This supplementary material has been provided by the authors to give readers additional information about their work.

**Table 1: ICD-9-CM definitions of clinical indications for general anesthesia.**

	<b>ICD-9-CM codes</b>
<b>1. Obstetrical indications</b>	
Abnormality in fetal heart rate or rhythm	763.81, 763.82, 659.7
Fetal distress	656.3
Abruptio placenta	641.2, 762.1
Uterine rupture	665.0, 665.1
Umbilical cord prolapse	663.0
Severe postpartum hemorrhage: hemorrhage associated with at least one of the 3 following elements: - Blood transfusion - Hysterectomy - Disseminated intravascular coagulation	666 99.0 (procedure) 68.3-68.9 (procedure) 286.6, 286.9, 666.3
Amniotic fluid embolism	673.1
Placenta praevia	641.0, 641.1
Placenta accreta	667.0
<b>2. Maternal indications</b>	
Comorbidity index for obstetric patients $\geq 3$	Algorithm
Charlson comorbidity index $\geq 2$	Algorithm
<b>3. Contraindications to neuraxial techniques</b>	
Coagulation factor deficit and Von Willebrand disease	286.0, 286.1, 286.2, 286.3, 286.4
Thrombocytopenia	287.1, 287.3, 287.4, 287.5
Sepsis and septic shock	995.1, 995.92, 785.52
Maternal pyrexia or generalized infection during labor	659.2, 659.3
Chorioamnionitis	658.4

Table 2: ICD-9-CM definitions of adverse events

	<b>Codes</b>
<b>1. Cardiac arrest</b>	427.41, 427.5, 37.91 (procedure), 99.60 (procedure), 99.63 (procedure)
<b>2. Anesthesia-related complications</b>	
<i>2.1. Systemic adverse events</i>	
- Pulmonary complication	668.0
- Cardiac complication	668.1
- Central nervous system complication	668.2
- Malignant hyperthermia	995.86
- Hypothermia due to anesthesia	995.89
- Endotracheal tube wrongly placed during anesthetic procedure	E876.3
- Shock due to anesthesia	995.4
<i>2.2. Adverse events related to neuraxial anesthesia</i>	
- Headache following lumbar puncture	349.0
- Abscess of spinal cord: epidural, extradural, subdural	324.1
- Spinal blood patch	03.95 (procedure)
- Poisoning and adverse effects by spinal anesthetics	968.7, E938.7
<i>2.3. Adverse events related to anesthetic drugs</i>	
- Poisoning and adverse effects by halothane	968.1, E938.1
- Poisoning and adverse effects by other gaseous anesthetics	968.2, E938.2
- Poisoning and adverse effects by intravenous anesthetics	968.3, E938.3
- Poisoning and adverse effects by other and unspecified general anesthetics	968.4, E938.4, E855.1
- Poisoning and adverse effects by local anesthetics	968.5, 968.9, E855.2, E938.5, E938.6, E938.9
- Other and unspecified adverse effect of drug, medicinal and biological substance (due) to correct medicinal substance properly administered: unspecified adverse effect of anesthesia	995.22
<b>3. Surgical site infection</b>	674.3, 998.5, 998.51, 998.59
<b>4. Venous thromboembolic events</b>	
<i>4.1. Deep venous thrombosis</i>	671.3, 671.4, 453.4
<i>4.2. Pulmonary embolism</i>	415.1, 673.2

**Table 3: ICD-9-CM definitions of conditions to qualify anesthesia-related complications as severe.**

Anesthesia-related complications (Table 2) were defined severe if associated with death, cardiac arrest, at least 1 of the severe organ dysfunction, or hospital stay greater than the 99<sup>th</sup> percentile (7 days). Organ dysfunction variable reflects concurrent coding in individual cases, and it is not possible to establish a causal relationship between anesthesia-related complications and organ dysfunctions.

	<b>Diagnosis codes</b>	<b>Procedure codes</b>
<b>1. Death</b>	Provided by the SID	--
<b>2. Cardiac arrest</b>	427.5, 427.41	99.60, 99.63, 37.91
<b>3. Severe organ dysfunction</b>		
- Coma	780.01, 997.01, 348.1, 780.03	--
- Convulsions and status epilepticus	780.3, 345.3	--
- Heart failure and cardiogenic shock	415.0, 428.1, 428.21, 428.23, 428.31, 428.33, 428.41, 428.43, 669.4, 997.1, 785.51	--
- Myocardial infarction and ischemia	410, 411.1, 411.81, 411.89	--
- Respiratory failure	518.4, 518.5, 518.81, 518.82, 518.84, 799.1	--
- Kidney failure	669.3, 584.	--
- Hepatic failure	570, 572.2	--
- Disseminated intravascular coagulation	286.6, 286.9, 666.3	--

*Abbreviation:* SID: State Inpatient Databases

**Table 4: ICD-9-CM definitions of preexisting and pregnancy-associated maternal conditions**

<b>Preexisting conditions</b>	<b>Diagnosis codes</b>
Mental retardation	317-319
Depression	300.4, 309.0, 309.1, 311
Schizophrenia	295
Bipolar disorders	296
Drugs use	292.1, 292.9, 304, 305.2-305.9, 648.3
Smoking	305.1, V15.82
Preexisting hypertension	401-405, 642.0, 642.1, 642.2
Pulmonary hypertension	416.0, 416.8, 416.9
Heart valve disease	394-397, 424
Cardiac arrhythmias	426
Cardiac conduction disorders	427
Obesity	278.0, 649.1, V85.3, V85.4
Systemic lupus erythematosus	710.0
Human immunodeficiency virus infection	042, V08
Asthma	493
Chronic kidney disease	581-583, 585, 587, 588, 646.2
Chronic hepatitis including viral hepatitis	571.4, 070.3, 070.52, 070.53, 070.54, 070.59
<b>Pregnancy-associated conditions</b>	<b>Diagnosis Codes</b>
Isolated gestational hypertension	642.3
Preeclampsia and eclampsia	642.7, 642.4, 642.5, 642.6
Previous cesarean delivery	654.2
Uterine scar	654.9
Pregnancy from assisted reproductive technology	V23.85
Multiple gestation	V27.2-V27.7, 651
Abnormal presentation	652
Fetal macrosomia	653.5, 656.6, 766.0, 766.1

**Table 5: Imputation of missing values**

<b>Variables with missing values</b>	<b>Number of missing values</b>
Race and ethnicity	12,362
Elective admission	1094
Urban hospital	1894
Teaching hospital	1894
Neonatal level-of-care designation	91,819
Neuraxial use during labor and vaginal deliveries	10
In-hospital death	2
<b>Predictor matrix used to estimate missing values</b>	
<b>1) Exposure</b>	
General anesthesia	
<b>2) Adverse events</b>	
Anesthesia-related complications	
Surgical site infections	
Venous thromboembolic events	
<b>3) Miscellaneous</b>	
Hospital identifier	
Year of delivery	
Length of hospital stay	
<b>4) Patient characteristics</b>	
Age	
Insurance	
Admission during weekend	
Mental retardation	
Depression	
Schizophrenia	
Bipolar disorders	
Drug use	
Smoking	
Preexisting hypertension	
Heart valve disease	
Cardiac arrhythmias	
Cardiac conduction disorders	
Obesity	
Lupus	
HIV infection	
Asthma	
Chronic kidney disease	
Chronic hepatitis	
Gestational hypertension	
Preeclampsia and eclampsia	
Previous cesarean delivery	
Uterine scar	
Pregnancy resulting from ART	
Multiple gestation	
Abnormal presentation	
Fetal macrosomia	
<b>5) Hospital characteristics</b>	
Volume of delivery	
Percent admission during weekend	
Percent comorbidity index in deliveries $\geq 2$	
Coding intensity	

**Table 6: Variables included in the propensity score**

<b>1. General characteristics</b>
Hospital identifier
Year of admission
Age
Race and ethnicity
Insurance
<b>2. Admission</b>
Elective admission
Admission during weekend
<b>3. Preexisting conditions</b>
Mental retardation
Depression
Schizophrenia
Bipolar disorders
Drug use
Smoking
Preexisting hypertension
Heart valve disease
Cardiac arrhythmias
Cardiac conduction disorders
Obesity
Lupus
HIV infection
Asthma
Chronic kidney disease
Chronic hepatitis
<b>4. Pregnancy-associated conditions</b>
Gestational hypertension
Preeclampsia and eclampsia
Previous cesarean delivery
Uterine scar
Pregnancy resulting from ART
Multiple gestation
Abnormal presentation
Fetal macrosomia
<b>5. Hospital characteristics</b>
Urban hospital
Teaching hospital
Neonatal level of care
Neuraxial use during vaginal deliveries
Volume of delivery
Percent admission during weekend $\geq 20\%$
Percent comorbidity index in deliveries $\geq 2$
Coding intensity

**Table 7: Sensitivity analyses using various cutoff values for the Charlson comorbidity index and the comorbidity index for obstetric patients (all other inclusion criteria unchanged)**

	Initial analysis			Sensitivity analysis 1			Sensitivity analysis 2		
<b>Inclusion criteria</b>									
Charlson comorbidity index	≤ 1			≤ 1			0		
Comorbidity index for obstetric patients	≤ 2			≤ 1			0		
<b>Study sample</b>									
Number of cesarean deliveries	466,014			369,422			162,132		
Number (%) of general anesthetics	26,431 (5.67%)			20,545 (5.56%)			9857 (6.08%)		
	Events	aOR <sup>a</sup> (95% CI)	P-value <sup>b</sup>	Events	aOR <sup>a</sup> (95% CI)	P-value <sup>b</sup>	Events	aOR <sup>a</sup> (95% CI)	P-value <sup>b</sup>
<b>Death or cardiac arrest</b>	31	2.44 (0.67-8.93)	0.18	22	1.34 (0.26-6.81)	0.76	11	2.83 (0.52-15.47)	0.23
<b>Anesthesia-related complications</b>	2757	1.62 (1.37-1.92)	< 0.001	2146	1.68 (1.39-2.02)	< 0.001	903	2.05 (1.59-2.64)	< 0.001
<b>Severe complications<sup>c</sup></b>	136	2.86 (1.58-5.19)	< 0.001	94	3.79 (2.00-7.20)	< 0.001	51	4.86 (2.21-10.66)	< 0.001
<b>Surgical site infections</b>	3154	1.74 (1.47-2.06)	< 0.001	2291	1.78 (1.47-2.16)	< 0.001	932	2.09 (1.60-2.74)	< 0.001
<b>Venous thromboembolic events</b>	342	1.92 (1.23-2.97)	0.004	264	2.39 (1.50-3.79)	< 0.001	137	1.56 (0.77-3.22)	0.23

**Table 7 (continued)**

*Abbreviations:* CI: confidence interval; aOR: adjusted odds ratio.

<sup>a</sup> Adjustment using propensity score weighting

<sup>b</sup> The P-value for statistical significance is 0.01.

<sup>b</sup> Complications associated with death, cardiac arrest, severe organ dysfunction, or hospital stay  $\geq$  99<sup>th</sup> percentile (7 days)

**Table 8: Temporal trends in the utilization of general anesthesia for cesarean delivery without a recorded clinical indication.** The P-value is from Cochran-Armitage test. The percent change is calculated as the difference between the rate in 2013-2014 and the rate in 2003-2004 divided by the rate in 2003-2004.

### 8.1. Overall trends

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
Number of general anesthetics	4374	4316	5392	4861	4201	3287	--	--
Number of cesarean deliveries	78,132	85,166	82,850	79,078	72,527	68,261	--	--
Proportion of general anesthetics	5.6	5.1	6.5	6.1	5.8	4.8	-14% (95% CI, -18 to -10)	< 0.001

### 8.2. Trends according to race and ethnicity

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>Non-White women including Hispanics</b>								
Number of general anesthetics	1738	2036	2852	2657	2559	2070	--	--
Number of cesarean deliveries	31,990	36,637	38,097	37,567	35,478	34,259	--	--
Proportion of general anesthetics	5.4	5.6	7.5	7.1	7.2	6.0	+11% (95% CI, 4 to 18)	< 0.001
<b>White women</b>								
Number of general anesthetics	2511	2215	2485	2183	1634	1217	--	--
Number of cesarean deliveries	41,201	44,602	42,904	40,383	36,535	33,999	--	--
Proportion of general anesthetics	6.1	5.0	5.8	5.4	4.5	3.6	-41% (95% CI, -45 to -37)	< 0.001

### 8.3. Trends according to Medicaid/Medicare status

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>Medicaid/Medicare beneficiaries</b>								
Number of general anesthetics	1437	1652	2274	2074	1750	1317	--	--
Number of cesarean deliveries	24,316	30,080	28,671	29,631	30,614	28,723	--	--
Proportion of general anesthetics	5.9	5.5	7.9	7.0	5.7	4.6	-22% (95% CI, -28 to -17)	< 0.001
<b>Non-Medicaid/Medicare beneficiaries</b>								
Number of general anesthetics	2937	2664	3118	2787	2451	1970	--	--
Number of cesarean deliveries	53,816	55,086	54,179	49,447	41,913	39,538	--	--
Proportion of general anesthetics	5.5	4.8	5.8	5.6	5.8	5.0	-9% (95% CI, -14 to -4)	< 0.001

### 8.4. Trends according to hospital location

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>Rural hospitals</b>								
Number of general anesthetics	349	271	237	191	189	142	--	--
Number of cesarean deliveries	4222	4838	4792	4544	4392	4044	--	--
Proportion of general anesthetics	8.3	5.6	4.9	4.2	4.3	3.5	-58% (95% CI, -66 to -49)	< 0.001
<b>Urban hospitals</b>								
Number of general anesthetics	4021	4045	5141	4659	4006	3141	--	--
Number of cesarean deliveries	73,268	80,328	77,667	74,237	67,895	63,893	--	--
Proportion of general anesthetics	5.5	5.0	6.6	6.3	5.9	4.9	-10% (95% CI, -14 to -6)	< 0.001

### 8.5. Trends according to hospital teaching status

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>Teaching hospitals</b>								
Number of general anesthetics	4265	4231	5369	4795	4070	3192	--	--
Number of cesarean deliveries	75,762	83,675	68,203	77,171	68,870	64,237	--	--
Proportion of general anesthetics	5.6	5.1	6.5	6.2	5.9	5.0	-12% (95% CI, -16 to -8)	< 0.001
<b>Non-teaching hospitals</b>								
Number of general anesthetics	105	85	-- <sup>a</sup>	55	125	91	--	--
Number of cesarean deliveries	1728	1491	-- <sup>a</sup>	1610	3417	3700	--	--
Proportion of general anesthetics	6.1	5.7	2.1%	3.4	3.7	2.5	-60% (95% CI, -71 to -48)	< 0.001

<sup>a</sup> Because of HCUP data use agreement restrictions on small cell size, the number of observed cases and exact proportions are not presented.

### 8.6. Trends according to hospital annual volume of deliveries

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>≤ 500 annual deliveries</b>								
Number of general anesthetics	536	331	280	205	174	138	--	--
Number of cesarean deliveries	5384	4639	4946	4455	3659	3363	--	--
Proportion of general anesthetics	10.0	7.1	5.7	4.6	4.8	4.1	-59% (95% CI, -66 to -51)	< 0.001
<b>501-2499 annual deliveries</b>								
Number of general anesthetics	1319	1194	1014	899	747	748	--	--
Number of cesarean deliveries	35,858	39,733	40,985	39,817	37,625	30,768	--	--
Proportion of general anesthetics	3.7	3.0	2.5	2.3	2.0	2.4	-34% (95% CI, -40 to -28)	< 0.001
<b>≥ 2500 annual deliveries</b>								
Number of general anesthetics	2519	2791	4098	3757	3280	2401	--	--
Number of cesarean deliveries	36,890	40,794	36,919	34,806	31,243	34,130	--	--
Proportion of general anesthetics	6.8	6.8	11.1	10.8	10.5	7.0	3% (95% CI, -3 to 9)	--

**Table 9:** Temporal trends in the utilization of anesthesia care during labor and vaginal deliveries in the State Inpatient Databases for New York 2003-2014 (N = 1,701,075). Discharges with missing hospital identifier and missing information for the type of anesthesia were excluded. The P-value is from Cochran-Armitage test. The percent change is calculated as the difference between the rate in 2013-2014 and the rate in 2003-2004 divided by the rate in 2003-2004. Similar results were observed when limiting the analysis to neuraxial analgesic techniques.

### 9.1. Overall trends

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
Number of vaginal deliveries who received anesthesia care	139,834	141,652	139,845	138,669	139,756	139,201	--	--
Number of vaginal deliveries	340,525	324,760	282,439	254,958	248,557	249,836	--	--
Proportion	41.1	43.6	49.5	54.4	56.2	55.7	35.7% (95%CI, 34.9 to 36.4)	< 0.001

### 9.2. Trends according to race and ethnicity

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>Non-White women including Hispanics</b>								
Number of vaginal deliveries who received anesthesia care	48,735	52,616	59,941	61,435	65,021	67,609	--	--
Number of vaginal deliveries	154,915	152,720	143,856	129,636	128,235	130,554	--	--
Proportion	31.5	34.5	41.7	47.4	50.7	51.8	64.6% (95%CI, 63.1 to 66.1)	< 0.001
<b>White women</b>								
Number of vaginal deliveries who received anesthesia care	78,624	79,878	77,215	75,960	73,681	71,588	--	--
Number of vaginal deliveries	162,374	155,227	132,363	121,758	117,932	119,274	--	--
Proportion	48.4	51.5	58.3	62.4	62.5	60.0	23.9% (95%CI, 23.1 to 24.8)	< 0.001

### 9.3. Trends according to hospital annual volume of deliveries

	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	Percent change	P-value
<b>≤ 500 annual deliveries</b>								
Number of vaginal deliveries who received anesthesia care	6291	5379	5410	4786	4545	4471	--	--
Number of vaginal deliveries	18,220	14,413	13,274	10,137	9344	8639	--	--
Proportion	34.5	37.3	40.8	47.2	48.6	51.8	49.9% (95%CI, 45.6 to 54.2)	< 0.001
<b>501-2499 annual deliveries</b>								
Number of vaginal deliveries who received anesthesia care	49,974	51,371	51,100	52,465	55,964	48,744	--	--
Number of vaginal deliveries	155,976	146,452	129,629	119,722	119,550	105,388	--	--
Proportion	32.0	35.1	39.4	43.8	46.8	46.3	44.3% (95%CI, 42.9 to 45.8)	< 0.001
<b>≥ 2500 annual deliveries</b>								
Number of vaginal deliveries who received anesthesia care	83,569	84,902	83,335	81,418	79,247	85,986	--	--
Number of vaginal deliveries	166,329	163,895	139,536	125,099	119,663	135,809	--	--
Proportion	50.2	51.8	59.7	65.1	66.2	63.3	26.0% (95%CI, 25.2 to 26.8)	< 0.001

**Table 10: Temporal trends in the utilization of general anesthesia for cesarean delivery with and without a recorded clinical indication according to hospital volume of delivery.** The P-value is from Cochran-Armitage test. The percent change is calculated as the difference between the rate in 2013-2014 and the rate in 2003-2004 divided by the rate in 2003-2004.

<b>WITHOUT A RECORDED INDICATION</b>	<b>2003-2004</b>	<b>2005-2006</b>	<b>2007-2008</b>	<b>2009-2010</b>	<b>2011-2012</b>	<b>2013-2014</b>	<b>Percent change</b>	<b>P-value</b>
<b>≤ 500 annual deliveries</b>								
Number of general anesthetics	536	331	280	205	174	138	--	--
Number of cesarean deliveries	5384	4639	4946	4455	3659	3363	--	--
Proportion of general anesthetics	10.0	7.1	5.7	4.6	4.8	4.1	-59% (95% CI, -66 to -51)	< 0.001
<b>501-2499 annual deliveries</b>								
Number of general anesthetics	1319	1194	1014	899	747	748	--	--
Number of cesarean deliveries	35,858	39,733	40,985	39,817	37,625	30,768	--	--
Proportion of general anesthetics	3.7	3.0	2.5	2.3	2.0	2.4	-34% (95% CI, -40 to -28)	< 0.001
<b>≥ 2500 annual deliveries</b>								
Number of general anesthetics	2519	2791	4098	3757	3280	2401	--	--
Number of cesarean deliveries	36,890	40,794	36,919	34,806	31,243	34,130	--	--
Proportion of general anesthetics	6.8	6.8	11.1	10.8	10.5	7.0	3% (95% CI, -3 to 9)	--

<b>WITH A RECORDED INDICATION</b>	<b>2003-2004</b>	<b>2005-2006</b>	<b>2007-2008</b>	<b>2009-2010</b>	<b>2011-2012</b>	<b>2013-2014</b>	<b>Percent change</b>	<b>P-value</b>
<b>≤ 500 annual deliveries</b>								
Number of general anesthetics	439	378	329	324	195	188	--	--
Number of cesarean deliveries	2702	2397	2560	2247	2151	1968	--	--
Proportion of general anesthetics	16.2	15.8	12.9	14.4	9.1	9.6	-41% (95% CI, -51 to -32)	< 0.001
<b>501-2499 annual deliveries</b>								
Number of general anesthetics	2072	1694	1534	1552	1422	1330	--	--
Number of cesarean deliveries	27,952	29,722	29,015	29,215	29,885	27,485	--	--
Proportion of general anesthetics	7.4	5.7	5.3	5.3	4.8	4.8	-35% (95% CI, -39 to -30)	< 0.001
<b>≥ 2500 annual deliveries</b>								
Number of general anesthetics	3052	3186	4585	4434	3827	3530	--	--
Number of cesarean deliveries	33,690	37,870	36,300	33,892	31,613	37,380	--	--
Proportion of general anesthetics	9.1	8.4	12.6	13.1	12.1	9.4	+4% (95% CI, -1 to +9)	--