OBSTETRICS

The association between hospital obstetrical volume and maternal postpartum complications

Kathy L. Kyser, MD, MSCI; Xin Lu, MS; Donna A. Santillan, PhD; Mark K. Santillan, MD; Stephen K. Hunter, MD, PhD; Alison G. Cahill, MD, MSCI; Peter Cram, MD, MBA

OBJECTIVE: The purpose of this study was to examine the relationship between delivery volume and maternal complications.

STUDY DESIGN: We used administrative data to identify women who had been admitted for childbirth in 2006. Hospitals were stratified into deciles that were based on delivery volume. We compared composite complication rates across deciles.

RESULTS: We evaluated 1,683,754 childbirths in 1045 hospitals. Decile 1 and 2 hospitals had significantly higher rates of composite complications than decile 10 (11.8% and 10.1% vs 8.5%, respectively; $P < .0001$). Decile 9 and 10 hospitals had modestly higher composite complications as compared with decile 6 (8.8% and 8.5% vs 7.6%, respectively; $P < .0001$). Sixty percent of decile 1 and 2 hospitals were located within 25 miles of the nearest greater volume hospital.

CONCLUSION: Women who deliver at very low-volume hospitals have higher complication rates, as do women who deliver at exceedingly high-volume hospitals. Most women who deliver in extremely low-volume hospitals have a higher volume hospital located within 25 miles.

Key words: complication, obstetrical volume, patient safety

Cite this article as: Kyser KL, Lu X, Santillan DA, et al. The association between hospital obstetrical volume and maternal postpartum complications. Am J Obstet Gynecol 2012;207:42.e1-17.

More than 4 million women give birth annually in the United States,[1] which makes childbirth the single most common reason for hospitalization among young women. Childbirth in the United States generally is safe with a major complication rate (eg, hemorrhage or infection) of <10%.[2-4] At the same time, there is growing appreciation that the variation in hospital outcomes that have been observed in many medical and surgical diagnoses may also exist for childbirth.

★ EDITORS' CHOICE ★

More than 2 decades of research has documented a relationship between higher hospital volume and improved clinical outcomes for medical and surgical diagnoses,[5-14] but data in the area of maternal childbirth outcomes are sorely lacking. The paucity of empiric studies of the volume-outcome relationship for maternal complications is striking, given the clinical volume and economic impact of childbirth in the United States. In addition, methodologic limitations of the few published studies that have related to a volume-outcome relationship for the maternal outcomes of childbirth make interpretation of the conflicting findings difficult.[15-19]

Our objective was to examine rigorously the relationship between hospital volume and maternal childbirth outcomes. Specifically, we set out to examine the association between hospital childbirth volume and important maternal complications (eg, hemorrhage, infection, death) and whether the volume-outcome relationship might differ for vaginal and cesarean deliveries.

From the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology (Drs Kyser, D. A. Santillan, M. K. Santillan, and Hunter), and the Division of General Medicine, Department of Internal Medicine (Ms Lu and Dr Cram), University of Iowa Hospital and Clinics, and CADRE, Iowa City Veterans Administration Medical Center (Ms Lu and Dr Cram), Iowa City, IA, and the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Washington University School of Medicine, St. Louis, MO (Dr Cahill).

Received Jan. 3, 2012; revised March 23, 2012; accepted May 10, 2012.

Supported in part by the Robert Wood Johnson Physician Faculty Scholars Program (A.G.C.); by NIH grant number R01GM090148 (D.A.S. and S.K.H.); by the University of Iowa Institute for Clinical and Translational Science KL2 Scholar program (NIH grant number KL2RR024980-2) and by the Reproductive Scientist Development Program (NIH grant number K12 HD000849 ; M.K.S.); by a K23 career development award (RR01997201) from the National Center for Research Resources, NIH (grant number R01 HL085347-01A1, NHLBI, NIH), the Robert Wood Johnson Physician Faculty Scholars Program; and the Department of Veterans Affairs (P.C.).

P.C. has received consulting fees from Vanguard Health, an operator of for-profit hospitals, for assistance on a quality improvement project and from Consumers Union.

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, the US Government (K.L.K), or the Department of Veterans Affairs (P.C.).

The authors report no conflict of interest.

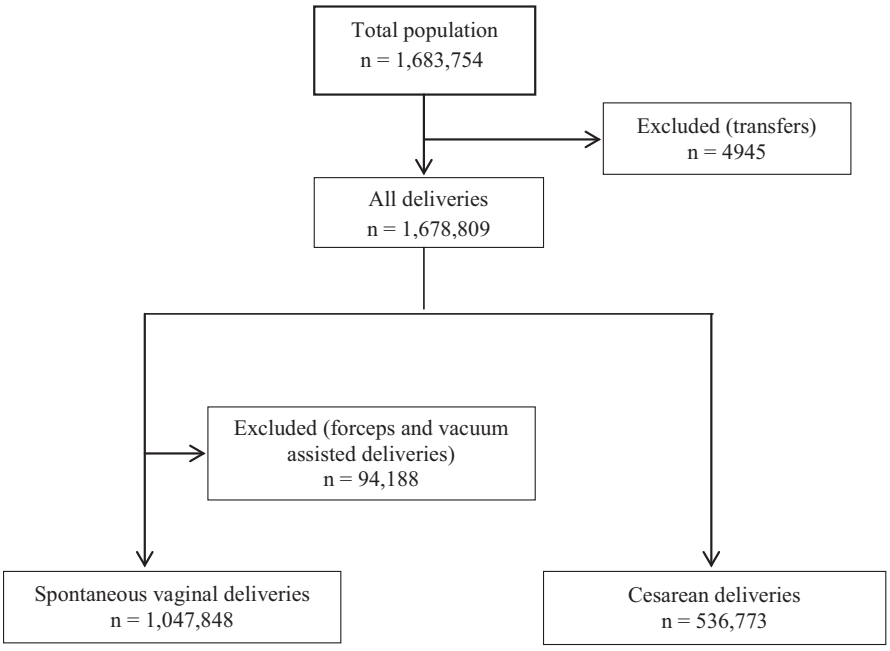
Reprints: Kathy Kyser, MD, Department of Obstetrics and Gynecology, University of Iowa Hospital and Clinics, 200 Hawkins Dr., Iowa City, IA 52242. kathy-kyser@uiowa.edu.

0002-9378/free • Published by Mosby, Inc. • http://dx.doi.org/10.1016/j.ajog.2012.05.010

For Editors' Commentary, see Contents

See related editorial, page 1

FIGURE 1
Patients included in this study



Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

Materials and Methods

We used a 100% sample of State Inpatient Data (SID) for year 2006 from 11 states (Arizona, California, Florida, Iowa, Massachusetts, Maryland, North Carolina, New York, New Jersey, Washington, and Wisconsin) to identify all patients who were hospitalized with childbirth (*International Classification of Diseases*, 9th Clinical Modification [ICD-9-CM] code 650 or 640x to 676.9x [n = 1,683,754]). Maternal childbirth admissions were stratified into cesarean deliveries (ICD-9 procedure code 74) or normal spontaneous vaginal deliveries (ICD-9 diagnosis codes 640.x to 676.9x and the absence of a code for cesarean delivery).

We excluded patients who delivered after transfer from another acute care hospital because transfer patients are more complex than patients who are admitted through other routes and because administrative data do not adequately capture this excess complexity that leads to potentially biased results.[20] All other cases of childbirth (spontaneous vaginal deliveries, cesarean deliveries, forceps, and vacuum) were included in the analysis of "all deliveries" (Figure 1). Our analysis of spontaneous vaginal deliveries excluded instrument deliveries with forceps or vacuums because the use of such devices suggests a more complicated delivery and may introduce unwanted heterogeneity. Application of these criteria left us with a cohort of what we would describe as routine childbirth admissions without obvious evidence of complicating factors.

The SID databases that were used in this study were developed by the Agency for Healthcare Research and Quality as part of the health care utilization project in partnership with individual states (http://hcupnet.ahrq.gov/). We deliberately acquired SID data from the 11 states that were included in this study because they represented all regions of the United States, because they included a disproportionate percentage of the US population, and because they covered a mix of urban and rural regions. SID data include many elements that are included on the Uniform Billing claim form (UB-92) hospital discharge abstract and have been used extensively in previous health services research, including previous obstetrics studies.[21-23] Key data elements include patient demographics, admitting hospital, primary and secondary diagnoses and procedures (as captured by ICD-9-CM codes), the diagnosis related group, admission source (eg, emergency department, transfer from another hospital), admission and discharge dates, patient's primary insurance (categorized as Medicare, private insurance, Medicaid, self-pay, other), type of insurance (fee-for-service or health maintenance organization), and disposition at the time of hospital discharge (eg, transfer to another acute care hospital, deceased).

We calculated 3 separate measures of childbirth volume for each hospital by summing the total number of deliveries that were performed during 2006: (1) total childbirth volume, (2) spontaneous vaginal delivery volume, and (3) cesarean delivery volume. Hospitals were then stratified into deciles of volume for each of the 3 delivery categories; thus, a hospital could be in the highest (tenth) decile of volume for total childbirth but the eighth decile for vaginal deliveries.

We identified 6 key adverse outcomes of childbirth that have been evaluated in previous studies using administrative data that included hemorrhage, severe perineal lacerations (3rd- or 4th-degree lacerations), operative complications, infection, thrombotic complications, and death.[2,3,24] Outcomes of interest for vaginal deliveries included all of the outcomes described, with the exception of operative complications that are not relevant to vaginal delivery. Outcomes of interest for cesarean deliveries included all outcomes, except for severe perineal lacerations that are not relevant to cesarean deliveries. From an analytic standpoint, our primary outcome was a composite measure that represented the occurrence of ≥1 adverse outcomes in a given patient. We identified comorbid illnesses using the method developed by Elixhauser et al[25] and supplemented this by high-risk obstetrical conditions that have been identified previously.[26]

Statistical analysis

We used bivariate methods that included the *t*-test and Cochran-Mantel-Haenszel statistics to compare the demographic characteristics (eg, age, race) of patients across hospital volume deciles. We used similar methods to compare insurance

coverage and the incidence of comorbid illnesses across deciles of hospital volume. All analyses were conducted separately for spontaneous vaginal deliveries, cesarean section deliveries, and all deliveries in aggregate. We used similar methods to compare the unadjusted incidence of in-hospital maternal complications across hospital volume deciles.

Finally, we used a series of logistic regression models to evaluate the association between rates of childbirth complications and hospital obstetrics volume after adjustment for differences in patient demographics and comorbidity. We used the patient as the unit of analysis; volume was measured at the hospital level. The standard errors, 95% confidence intervals, and associated significance levels for adjusted odds ratios based on logistic regression accounted for clustering with the use of hospital random-effect models. For purposes of these analyses, the outcome (dependent variable) was an indicator variable that represented the occurrence of the composite outcome. The dependent variables of interest were a series of indicator variables that represented the decile of hospital volume, with hospitals in the highest volume decile serving as the reference category. The models included 19 covariates that included patient age, race, payor, and a number of important comorbid illness. Separate analyses were performed for (1) all childbirths in aggregate, (2) spontaneous vaginal deliveries only, and (3) cesarean deliveries only. We applied 3 separate models to each patient cohort: (1) unadjusted, (2) adjustment for patient demographics alone, and (3) adjustment for patient demographics plus comorbidities.

Because we hypothesized that more complex cases would be referred selectively to higher volume hospitals, we conducted a number of sensitivity analyses. Specifically, we stratified both vaginal deliveries and cesarean deliveries into high-risk and low-risk cohorts. *High-risk patients* were defined as those with any of the following conditions that typically are considered a cause for concern among obstetricians: advanced age, asthma, cerebral hemorrhage, hypertensive disorders, diabetes mellitus, obesity, chorioamnionitis, congenital heart disease, liver anomalies, renal anomalies, thyroid disease, mental disorder, multiple gestation, preterm gestation, pulmonary embolism, and uterine rupture. The low-risk cohort included patients without any of these conditions. We also replicated our analyses to examine alternative methods for categorizing hospital volume (eg, quintiles, quartiles) and defining high- and low-volume hospitals.

All statistical analyses were performed with SAS software (version 9.2; SAS Institute Inc., Cary, NC). The study was approved by the Institutional Review Board of the University of Iowa.

RESULTS

We identified a total of 1,683,754 childbirths. After excluding transfer cases (n = 4945), our final cohort of spontaneous vaginal deliveries, forceps deliveries, vacuum extractions, and cesarean deliveries included 1,678,809 admissions to 1045 hospitals. After the exclusion of forceps and vacuum-assisted deliveries (n = 94,188), there were a total of 1,047,848 spontaneous vaginal deliveries in 1011 hospitals (34 hospitals delivered only by cesarean section) and 536,773 cesarean deliveries in 1030 hospitals (15 hospitals delivered only by vaginal route). For hospitals that performed both vaginal and cesarean deliveries, the cesarean delivery rate ranged from 13.0–96.7% across 1030 hospitals (mean, 31.3%; median, 30.3%). The mean hospital childbirth volume was 1606.5 (interquartile range, 442.0–2299.0); the mean vaginal delivery volume was 1036.4 (interquartile range, 308.0–1472.0), and the mean cesarean delivery volume was 521.1 (interquartile range, 135–754).

The characteristics of patients with spontaneous vaginal delivery that were stratified by hospital volume deciles are displayed in Table 1. Women who delivered in lower volume hospitals tended to younger, were more likely to be white, and were more likely to be categorized as self-pay when compared with women who delivered at higher volume hospitals. Women who underwent vaginal delivery in lower volume hospitals tended to have fewer comorbid conditions such as advanced maternal age, hypertension, and diabetes mellitus (Table 1). Conversely, women who had vaginal deliveries in high-volume hospitals were more likely to be older and Hispanic or black and to have more comorbid illness. Results were similar for cesarean deliveries (Table 2), with low-volume hospitals treating a higher proportion of uninsured younger white women, although high-volume hospitals treated more women with advanced age and comorbid illness.

In analyses of unadjusted outcomes (Table 3; Figure 2), we found higher rates of the composite adverse outcome and most of the individual adverse outcomes in the lowest volume hospitals (deciles 1 and 2), when compared with all other hospitals within all deliveries, vaginal deliveries, or cesarean deliveries. For example, with at all deliveries in aggregate, the incidence of the composite outcome in decile 1 was 11.8% and in decile 2 was 10.1%; the incidence ranged from 7.6-8.8% for the other 8 deciles in aggregate ($P < .0001$). Looking at spontaneous vaginal deliveries and cesarean deliveries in isolation, we saw similar results with higher unadjusted rates of both the composite and most individual adverse outcomes in decile 1 and 2 hospitals. We also observed a modest increase in unadjusted complication rates in the highest volume hospitals (deciles 8-10) when compared with intermediate volume hospitals (deciles 5-7). This effect was particularly apparent in cesarean deliveries (Table 3). To ensure the robustness of our findings, we repeated our analyses examining the relationship between volume and outcome while stratifying hospitals on the basis of total delivery volume rather than vaginal or cesarean delivery volume; thus, in these analyses, we explored the relationship between vaginal delivery outcomes and volume after stratifying hospitals by their total delivery volume and did analogous analyses for cesarean deliveries. We found that the volume-outcome relationship was similar, irrespective of the measure of volume that was used. We also calculated the proportion of cesarean deliveries according to hospital decile to cesarean delivery volume (Table 3) and found no difference in the proportion of deliv-

TABLE 1
Patient characteristics by annual spontaneous vaginal deliveries

Vaginal deliveries	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
General characteristics										
Hospitals, n	105	104	104	105	104	105	105	104	105	104
Range of delivery volume, n	1–99	100–307	308–551	552–788	789–1133	1134–1567	1568–2048	2049–2675	2676–3724	3725–12,845
Specific characteristics										
Patients, n	1930	13,299	28,507	48,108	63,105	88,305	117,133	150,944	210,723	328,794
Delivery volume, n[a]	44.3 ± 33.2	165.6 ± 39.4	309.8 ± 48.6	464.3 ± 43.0	643.0 ± 54.2	868.6 ± 81.8	1139.8 ± 78.9	1489.0 ± 130.7	2010.8 ± 186.1	3231.4 ± 919.9
High-risk volume, n[a]	9.1 ± 6.6	33.7 ± 16.1	67.1 ± 29.5	107.7 ± 40.2	155.0 ± 57.7	217.6 ± 77.1	306.4 ± 120.7	400.2 ± 144.1	541.0 ± 194.2	941.0 ± 402.0
Low-risk volume, n[a]	38.7 ± 27.6	131.9 ± 33.7	242.7 ± 43.3	356.6 ± 49.3	488.0 ± 68.6	651.1 ± 88.6	833.4 ± 135.2	1088.8 ± 153.8	1469.8 ± 227.3	2290.3 ± 683.7
Age, y[a]	26.0 ± 5.6	25.9 ± 5.7	26.0 ± 5.9	26.4 ± 6.0	26.8 ± 6.1	27.2 ± 6.1	27.4 ± 6.2	27.2 ± 6.1	27.3 ± 6.1	27.9 ± 6.2
Race, n (%)										
White	1445 (74.9)	8807 (66.2)	15,707 (55.1)	25,333 (56.2)	28,628 (45.4)	41,419 (46.9)	44,652 (38.1)	60,716 (40.2)	77,926 (37.0)	119,403 (36.3)
Hispanic	63 (3.3)	728 (5.5)	3473 (12.2)	5627 (12.5)	14,030 (22.2)	19,767 (22.4)	33,203 (28.4)	41,500 (27.5)	64,437 (30.6)	96,110 (29.2)
Black	59 (3.1)	372 (2.8)	1237 (4.3)	2165 (4.8)	5085 (8.1)	10,031 (11.4)	14,143 (12.1)	21,137 (14.0)	18,876 (9.0)	36,585 (11.1)
Other	363 (18.8)	3392 (25.5)	8090 (28.4)	11,983 (26.6)	15,362 (24.3)	17,088 (19.4)	25,135 (21.5)	27,591 (18.3)	49,484 (23.5)	76,696 (23.3)
Payor, n (%)										
Medicaid	858 (44.5)	6694 (50.3)	14,324 (50.3)	21,108 (46.7)	28,514 (45.2)	36,643 (41.5)	54,524 (46.6)	66,010 (43.7)	93,202 (44.2)	142,979 (43.5)
Private	862 (44.7)	5,734 (43.1)	11,682 (41.0)	21,482 (47.6)	28,885 (45.8)	45,110 (51.1)	54,512 (46.5)	73,341 (48.6)	105,493 (50.1)	170,092 (51.7)
Medicare	8 (0.4)	36 (0.3)	200 (0.7)	174 (0.4)	255 (0.4)	340 (0.4)	338 (0.3)	549 (0.4)	770 (0.4)	643 (0.2)
Self-pay	164 (8.5)	531 (4.0)	1077 (3.8)	1377 (3.1)	3682 (5.8)	3740 (4.2)	5575 (4.8)	7995 (5.3)	6772 (3.2)	9650 (2.9)
Comorbidities, n										
Advanced maternal age, n (%)	166 (8.6)	1177 (8.9)	2710 (9.5)	4905 (10.9)	7781 (12.3)	11,935 (13.5)	16,502 (14.1)	20,323 (13.5)	28,322 (13.4)	52,611 (16.0)
Hypertension disorder, n (%)	33 (1.7)	277 (1.3)	661 (2.3)	885 (2.0)	1363 (2.2)	1867 (2.1)	2712 (2.3)	3455 (2.3)	4797 (2.3)	9210 (2.8)
Diabetes mellitus, n (%)	22 (1.1)	222 (1.7)	500 (1.8)	891 (2.0)	1436 (2.3)	2016 (2.3)	3114 (2.7)	4043 (2.7)	5814 (2.8)	10,126 (3.1)
Obesity, n (%)	10 (0.5)	94 (0.7)	194 (0.7)	358 (0.8)	476 (0.8)	788 (0.9)	1287 (1.1)	1565 (1.0)	3068 (1.5)	2758 (0.8)
Multiple gestation, n (%)	2 (0.1)	11 (0.1)	21 (0.01)	59 (0.1)	72 (0.1)	161 (0.2)	222 (0.2)	306 (0.2)	494 (0.2)	1032 (0.3)
Preterm gestation, n (%)	18 (0.9)	185 (1.4)	452 (1.6)	727 (1.6)	1209 (1.9)	1801 (2.0)	2674 (2.3)	3879 (2.6)	5783 (2.7)	10,699 (3.3)

[a] Data are given as mean ± SD.

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

TABLE 2
Patient characteristics by annual cesarean deliveries

Cesarean deliveries	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
General characteristics										
Hospitals, n	105	104	104	105	104	105	105	104	105	104
Range of delivery volume, n	1–99	100–307	308–551	552–788	789–1133	1134–1567	1568–2048	2049–2675	2676–3724	3725–12,845
Specific characteristics										
Patients, n	922	6006	14,175	20,779	30,229	45,435	60,659	79,007	102,481	177,080
Volume, n[a]	13.2 ± 11.8	64.1 ± 17.3	135.5 ± 21.8	208.1 ± 19.9	291.1 ± 33.9	422.1 ± 45.3	575.2 ± 45.6	749.5 ± 51.0	999.8 ± 98.5	1752.6 ± 561.4
High-risk volume, n[a]	5.1 ± 4.3	23.1 ± 12.0	52.9 ± 16.0	83.5 ± 24.0	119.0 ± 33.4	187.3 ± 53.0	253.6 ± 67.5	355.1 ± 88.4	466.8 ± 109.0	891.2 ± 332.6
Low-risk volume, n[a]	10.4 ± 8.8	41.0 ± 12.3	82.6 ± 19.4	124.6 ± 24.0	172.1 ± 31.6	234.7 ± 56.5	321.6 ± 61.4	394.4 ± 85.9	533.0 ± 119.2	861.5 ± 308.8
Age, y[a]	26.7 ± 5.7	27.2 ± 6.0	27.4 ± 6.2	27.9 ± 6.2	28.5 ± 6.3	29.0 ± 6.3	29.3 ± 6.4	29.1 ± 6.3	29.3 ± 6.3	29.9 ± 6.3
Race, n (%)										
White	653 (70.8)	3842 (64.0%)	7552 (53.3)	11,888 (57.2)	13,687 (45.3)	21,857 (48.1)	24,980 (41.2)	32,986 (41.8)	40,745 (39.8)	67,392 (38.1)
Hispanic	59 (6.4)	418 (7.0)	1938 (13.7)	2635 (12.7)	6940 (23.0)	10,554 (23.2)	16,155 (26.6)	21,102 (26.7)	29,559 (28.8)	49,018 (27.7)
Black	43 (4.7)	227 (3.8)	775 (5.5)	1093 (5.3)	2748 (9.1)	5606 (12.3)	8000 (13.2)	11,851 (15.0)	9687 (9.5)	22,147 (12.5)
Other	167 (18.1)	1519 (25.3)	3910 (27.6)	5163 (24.9)	6854 (22.7)	7418 (16.3)	11,524 (19.0)	13,068 (16.5)	22,490 (22.0)	38,523 (21.8)
Payor, n (%)										
Medicaid	366 (39.7)	2893 (48.2)	6850 (48.3)	9119 (43.9)	12,589 (41.7)	16,771 (36.9)	25,559 (42.1)	31,104 (39.4)	40,108 (39.1)	65,216 (36.8)
Private	449 (48.7)	2733 (45.5)	6237 (44.0)	10,535 (50.7)	15,225 (50.4)	25,838 (56.9)	31,530 (52.0)	42,733 (54.1)	56,965 (55.6)	104,763 (59.2)
Medicare	7 (0.8)	37 (0.6)	138 (0.1)	112 (0.5)	204 (0.7)	208 (0.5)	269 (0.4)	378 (0.5)	455 (0.4)	552 (0.3)
Self-pay	82 (8.9)	225 (3.8)	444 (3.1)	524 (2.5)	1443 (4.8)	1559 (3.4)	2135 (3.5)	3198 (4.1)	2855 (2.8)	3831 (2.2)
Comorbidities, n (%)										
Advanced maternal age	93 (10.1)	798 (13.3)	2124 (15.0)	3546 (17.1)	5832 (19.3)	9862 (21.7)	13,878 (22.9)	17,408 (22.0)	23,115 (22.6)	45,659 (25.8)
Hypertension disorder	49 (5.3)	380 (6.3)	995 (7.0)	1386 (6.7)	2123 (7.0)	3019 (6.6)	4288 (7.1)	5922 (7.5)	7731 (7.5)	15,330 (8.7)
Diabetes mellitus	55 (6.0)	327 (5.4)	886 (6.3)	1424 (6.9)	2240 (7.4)	3165 (7.0)	4564 (7.5)	6204 (7.9)	8633 (8.4)	15,335 (8.7)
Obesity	17 (1.8)	165 (2.8)	331 (2.3)	548 (2.6)	739 (2.4)	1137 (2.5)	1581 (2.6)	2275 (2.9)	3655 (3.6)	4810 (2.7)
Multiple gestations	5 (0.5)	34 (0.6)	112 (0.8)	179 (0.9)	273 (0.9)	515 (1.1)	774 (1.3)	1158 (1.5)	1915 (1.9)	3720 (2.1)
Preterm gestation	24 (2.6)	224 (3.7)	537 (3.8)	928 (4.5)	1622 (5.4)	2570 (5.7)	3851 (6.4)	5528 (7.0)	8389 (8.2)	16,279 (9.2)

[a] Data are given as mean ± SD.

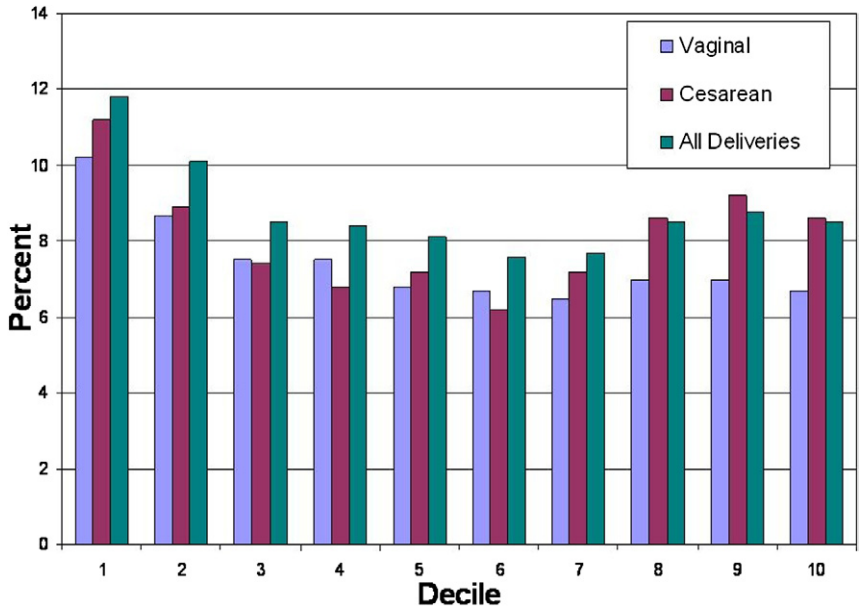
Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

TABLE 3
Total population: unadjusted percent complications by hospital decile and route of delivery

Variable	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10	*P* value
All deliveries											
N	3011	20,678	45,446	69,869	99,654	141,844	188,227	243,475	331,801	534,804	
Hemorrhage, n (%)	241 (8.0)	1383 (6.7)	2527 (5.6)	3644 (5.2)	4849 (4.9)	6378 (4.5)	8878 (4.7)	12,342 (5.1)	17,539 (5.%)	26,210 (4.9)	< .0001
Infection, n (%)	26 (0.9)	102 (0.5)	212 (0.5)	252 (0.4)	455 (0.5)	693 (0.5)	1178 (0.6)	2061 (0.9)	2450 (0.7)	4709 (0.9)	< .0001
Laceration, n (%)	84 (2.8)	528 (2.6)	927 (2.0)	1508 (2.2)	2152 (2.2)	2859 (2.0)	3404 (1.8)	5005 (2.1)	7161 (2.2)	10,910 (2.0%)	< .0001
Thrombotic, n (%)	26 (0.9)	252 (1.2)	542 (1.2)	874 (1.3)	1168 (1.2)	1674 (1.2)	2270 (1.2)	2,23 (1.2)	4366 (1.3)	7116 (1.3)	< .0001
Operative, n (%)	9 (0.3)	58 (0.3)	121 (0.3)	227 (0.3)	339 (0.3)	426 (0.3)	576 (0.3)	921 (0.4)	1,350 (0.4)	2413 (0.5)	< .0001
Mortality, n (%)	1 (0.03)	2 (0.01)	2 (0.00)	5 (0.01)	4 (0.00)	13 (0.01)	17 (0.01)	20 (0.01)	27 (0.01)	56 (0.01)	.5449
Composite, n (%)	354 (11.8)	2082 (10.1)	3880 (8.5)	5884 (8.4)	8021 (8.1)	10,788 (7.6)	14,531 (7.7)	20,651 (8.5)	29,151 (8.8)	45,288 (8.5)	< .0001
Vaginal deliveries											
N	1898	13,301	28,511	45,112	63,108	88,309	117,137	150,948	210,727	328,797	
Hemorrhage, n (%)	136 (7.2)	806 (6.1)	1,458 (5.1)	2,232 (5.0)	2,740 (4.3)	3,732 (4.2)	4,972 (4.2)	6,571 (4.4)	9,254 (4.4)	13,540 (4.1)	< .0001
Infection, n (%)	13 (0.7)	32 (0.2)	89 (0.3)	121 (0.3)	181 (0.3)	286 (0.3)	472 (0.4)	697 (0.5)	950 (0.5)	1707 (0.5)	< .0001
Laceration, n (%)	50 (2.6)	354 (2.7)	596 (2.1)	1025 (2.3)	1379 (2.2)	1922 (2.2)	2202 (1.9)	3378 (2.2)	4707 (2.2)	7016 (2.1)	< .0001
Thrombotic, n (%)	6 (0.3)	41 (0.3)	93 (0.3)	168 (0.4)	228 (0.4)	312 (0.4)	378 (0.3)	470 (0.3)	692 (0.3)	1063 (0.3)	.5073
Mortality, n (%)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (0.00)	6 (0.01)	7 (0.00)	3 (0.00)	21 (0.01)	.0868
Composite, n (%)	194 (10.2)	1,150 (8.7)	2,123 (7.5)	3,379 (7.5)	4,283 (6.8)	5,935 (6.7)	7,617 (6.5)	10,551 (7.0)	14,771 (7.0)	22,126 (6.7)	< .0001
Cesarean deliveries											
N	922	6006	14,175	20,779	30,229	45,435	60,659	79,007	102,481	177,080	
Hemorrhage, n (%)	86 (9.3)	438 (7.3)	841 (5.9)	1103 (5.3)	1665 (5.5)	2115 (4.7)	3264 (5.4)	4958 (6.3)	7140 (7.0)	10,819 (6.1)	< .0001
Infection, n (%)	12 (1.3)	55 (0.9)	102 (0.7)	111 (0.5)	246 (0.8)	351 (0.8)	633 (1.0)	1231 (1.6)	1360 (1.3)	2779 (1.6)	< .0001
Operative, n (%)	9 (1.0)	58 (1.0)	121 (0.9)	227 (1.1)	339 (1.1)	426 (0.9)	576 (1.0)	921 (1.2)	1350 (1.3)	2413 (1.4%)	< .0001
Thrombotic, n (%)	11 (1.2)	70 (1.2)	182 (1.3)	249 (1.2)	363 (1.2)	493 (1.1)	803 (1.3)	1152 (1.5)	1578 (1.5)	2881 (1.6)	< .0001
Mortality, (n)	1 (0.11)	2 (0.03)	2 (0.01)	3 (0.01)	4 (0.01)	9 (0.02)	11 (0.02)	13 (0.02)	22 (0.02)	34 (0.02)	.7240
Composite, n (%)	103 (11.2)	535 (8.9)	1043 (7.4)	1412 (6.8)	2166 (7.2)	2809 (6.2)	4342 (7.2)	6810 (8.6)	9378 (9.2)	15,304 (8.6)	< .0001

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

FIGURE 2
Unadjusted composite morbidity and mortality rates by hospital decile, stratified by route of delivery



Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

eries that were cesarean sections across volume deciles.

In analyses that adjusted for patient demographics and comorbidities (Table 4), we again found higher risk of adverse outcomes in lowest volume hospitals (decile 1 and 2). Specifically, odds of experiencing the composite outcome were between 43% and 60% higher for decile 1 hospitals (with decile 10 serving as the reference category) even after adjustment for patient demographics and comorbidity ($P < .05$). Alternatively, the odds of adverse outcomes appeared modestly lower for intermediate volume hospitals (decile 5 and 6), with the effect particularly notable for cesarean deliveries.

To ensure the robustness of our findings, we conducted additional supplemental analyses. First, we repeated our unadjusted and adjusted analyses examining outcomes across deciles of hospital volume after stratifying patients into high- and low-risk subgroups. Unadjusted analyses produced similar results to our main analyses, with higher complication rates in the lowest volume hospitals for both the high- and low-risk patient strata, irrespective of delivery route (Appendix; Supplementary Tables 1-3). Adjusted results in the high- and low-risk subgroups were also similar to the main analyses, with higher odds of experiencing the composite outcomes in the lowest volume hospitals (Appendix; Supplementary Tables 4-6). Additional results were significant for high-risk patients who had higher odds of adverse outcomes compared with low-risk subgroups in the lowest volume hospitals ($P < .05$). Interestingly, in our supplementary analyses high-volume hospitals again appeared to have marginally higher rates of adverse outcomes in both the high- and low-risk strata. We also conducted additional analyses using alternative methods for the stratification of hospitals according to volume (eg, quartiles, quintiles), and the results were again similar.

COMMENT

In an analysis of >1.6 million maternal hospitalizations for childbirth, we identified a number of important findings. First, we found markedly higher rates of maternal complications for deliveries in low-volume hospitals. Second, we found modestly higher rates of complications for deliveries at exceedingly high-volume hospital, which is a finding that, if not related to unmeasured difference in comorbidity, would give one pause. Third, we found marked variation in cesarean delivery rates across hospitals.

The finding of higher rates of adverse outcomes at low-volume hospitals has been well-documented in medical and surgical literature[5-14] but has not been well-studied in obstetrics. Previous studies that evaluated the volume-outcome relationship in obstetrics have been limited to studies from single state populations, to data that are now >1 decade old, and to conflicting results about the volume-outcome relationship.[15-19] In addition, many previous obstetrics volume-outcome studies focused exclusively on neonatal outcomes without investigating maternal complications.[27-33] Our study provides important new evidence of higher maternal complication rates at very low-volume hospitals.

The finding of higher obstetrics complication rates in low-volume hospitals is not necessarily unexpected. The mean overall childbirth volume for decile 1 hospitals was 31.6 per year and for decile 2 hospitals 204.8 per year. Moreover, the mean cesarean section volumes for decile 1 and 2 hospitals were 13.2 and 64.1, respectively. With such low volumes, it seems logical that complication rates would be high, especially given the importance of both experience and teamwork in the health care setting. Several hospitals in our study had only 1 or 2 admissions for childbirth during 2006, which suggests that such deliveries represented emergent cases that were treated at hospitals without an experienced physician or obstetrics team.

Alternatively, it is interesting to think about how the health care system might be changed in a way that might reduce the need for mothers to give birth at extremely low-volume hospitals. In supplementary analyses, we explored the role of distance in women giving birth at decile 1 and 2 hospitals. Notably, we found 60% of decile 1 and 2 hospitals were located within 25 miles of a higher obstetrics volume hospital (decile ≥4; mean distance, 25.9 miles). Practically speaking, our results would suggest that a certain percentage of deliveries at very

TABLE 4
Unadjusted and adjusted odds of composite adverse outcome by volume decile

	Lowest volume								
	Decile 1		Decile 2		Decile 3		Decile 4		Decile 5
Adverse outcomes	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)
All deliveries									
Unadjusted	1.37 (1.07–1.75)	.0112	1.17 (0.98–1.39)	.0901	0.92 (0.78–1.10)	.3712	0.96 (0.81–1.14)	.6641	0.87 (0.73–1.03)
Adjusted for demographics[a]	1.38 (1.08–1.76)	.0100	1.17 (0.98–1.40)	.0861	0.92 (0.77–1.10)	.3333	0.96 (0.81–1.14)	.6481	0.87 (0.73–1.02)
Adjusted for demographics and selected comorbidities[b]	1.43 (1.13–1.82)	.0035	121 (1.02–1.44)	.0328	0.95 (0.80–1.12)	.5304	0.99 (0.83–1.17)	.8652	0.89 (0.75–1.05)
Vaginal deliveries									
Unadjusted	1.51 (1.16–1.96)	.0024	1.28 (1.08–1.53)	.0055	1.05 (0.88–1.24)	.6006	1.10 (0.93–1.30)	.2825	0.94 (0.79–1.11)
Adjusted for demographics[a]	1.57 (1.13–1.92)	< .0001	1.32 (1.10–1.57)	< .0001	1.05 (0.89–1.24)	.0002	1.11 (0.94–1.32)	< .0001	0.92 (0.78–1.09)
Adjusted for demographics and selected comorbidities	1.60 (1.38–1.86)	< .0001	1.33 (1.25–1.42)	< .0001	1.12 (1.07–1.17)	< .0001	1.13 (1.08–1.17)	< .0001	1.02 (0.99–1.06)
Cesarean deliveries									
Unadjusted	1.37 (0.96–1.95)	.0828	1.01 (0.79–1.29)	.9507	0.79 (0.62–1.00)	.0469	0.76 (0.60–0.95)	.0175	0.73 (0.58–0.91)
Adjusted for demographics[a]	1.38 (0.97–1.97)	.0760	1.02 (0.80–1.31)	.8841	0.79 (0.62–1.00)	.0462	0.76 (0.61–0.96)	.0224	0.73 (0.58–0.91)
Adjusted for demographics and selected comorbidities[b]	1.45 (1.01–2.04)	.0436	1.06 (0.83–1.36)	.6286	0.82 (0.65–1.03)	.0871	0.79 (0.63–0.99)	.0402	0.75 (0.60–0.94)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012. *(continued)*

low-volume hospitals reasonably might be transitioned to higher volume hospitals with little inconvenience to patients or their families. It is also important to consider our findings in the context of existing guidelines that are related to childbirth. The American Congress of Obstetrics and Gynecology readily recommends that women who are likely to deliver preterm be transferred to tertiary centers,[34] yet there is no equivalent guideline for establishing minimum hospital delivery volume and tiered maternal referrals based on patient safety.

Second, it is interesting that we consistently found modestly higher rates of complications for deliveries at exceedingly high-volume hospitals. There are several potential explanations for our findings. It is possible, and indeed highly likely, that the higher rates of adverse outcomes in the highest volume hospitals represent the higher risk of the population that our highest volume hospitals serve. Patients who are referred to high-volume hospitals for childbirth have a greater likelihood of having medical conditions with an increased severity of illness that is poorly represented in claims data.[20] The finding that the higher rates of adverse outcomes persisted after adjustment for patient demographics and comorbidities may merely reflect unmeasured differences in comorbidity that are not captured well in administrative data. Alternatively, it is possible that extremely high-volume hospitals truly do have higher complication rates for childbirth. Specifically, if our highest volume hospitals were too busy, staffed by trainees without adequate supervision, and under extreme financial pressure, higher complication rates might well be expected. Further study is needed to examine this issue in greater detail.

Third, we found marked variation in mean hospital cesarean delivery rates across hospitals (13.0-96.7%). These results are consistent with several previous studies that found highly variable rates of cesarean deliveries with significant regional variation.[35-37] The reasons for these differences remain unknown and far exceeded the expected variation that can be explained by differences in patient risk factors alone. These findings suggest that there is insufficient outcomes-based evidence to guide effective clinical decision-making. Future research is needed to further explain the unknown variation in rates of cesarean deliveries, especially given our finding of higher rates of maternal complications after cesarean delivery compared with vaginal delivery.

There are a number of limitations to our study. First, our study relied on administrative data and thus may have been subject to bias if diagnoses or procedures were systematically miscoded more often by 1 group of hospitals. We have, however, no reason to believe that this happened; previous studies have shown that there is reliable coding of obstetrics diagnoses and procedures.[38] Second, our analysis was limited to 11 states, and results must be generalized to other states with care. Third, the structure of the SID data precluded us from tracking maternal complications that may have occurred after discharge; likewise, we lacked the ability to link mothers to their newborn infants and to track complications jointly in both. Fourth, similar to all studies that use large administrative databases, our investigation is restricted to the variables that are considered necessary for claims data. Consequently, certain clinical information is not available for analysis.

In conclusion, our study suggests elevated complication rates for women who are hospitalized for childbirth at extremely low-volume hospitals and mod-

TABLE 4
Unadjusted and adjusted odds of composite adverse outcome by volume decile *(continued)*

Lowest volume									Highest volume
P value	Decile 6 OR (95% CI)	*P* value	Decile 7 OR (95% CI)	*P* value	Decile 8 OR (95% CI)	*P* value	Decile 9 OR (95% CI)	*P* value	Decile 10
									Reference
.1046	0.81 (0.68–0.96)	.0142	0.86 (0.73–1.02)	.0814	0.96 (0.81–1.14)	.6643	0.97 (0.82–1.15)	.7279	
.0956	0.81 (0.69–0.96)	.0155	0.86 (0.73–1.02)	.0819	0.96 (0.81–1.14)	.6622	0.97 (0.82–1.14)	.6867	
.1640	0.83 (0.70–0.98)	.0277	0.87 (0.74–1.03)	.1112	0.98 (0.83–1.15)	.7674	0.97 (0.82–1.15)	.7322	
									Reference
.4364	0.90 (0.76–1.06)	.1940	0.92 (0.78–1.08)	.2907	1.00 (0.85–1.17)	.9625	0.98 (0.83–1.16)	.8179	
.9741	0.91 (0.77–1.08)	.7261	0.92 (0.78–1.08)	.0066	0.99 (0.84–1.17)	.0014	0.99 (0.84–1.16)	.0004	
.2401	1.01 (0.98–1.04)	.3933	0.97 (0.95–1.00)	.0581	1.05 (1.02–1.07)	.0002	1.04 (1.02–1.06)	.0002	
									Reference
.0063	0.65 (0.52–0.82)	.0002	0.77 (0.62–0.97)	.0252	0.94 (0.75–1.18)	.5991	0.94 (0.75–1.18)	.5986	
.0062	0.65 (0.52–0.82)	.0002	0.77 (0.61–0.96)	.0216	0.93 (0.75–1.17)	.5482	0.94 (0.75–1.18)	.6020	
.0129	0.67 (0.53–0.84)	.0004	0.78 (0.62–0.97)	.0278	0.95 (0.76–1.18)	.6250	0.95 (0.76–1.18)	.6313	

CI, confidence interval; *OR*, odds ratio.

[a] Adjusted for race, age, and payor; [b] Adjusted for race, age, payor, advanced age, herpes, asthma, cerebral hemorrhage, chorioamnionitis, diabetes mellitus, hypertensive disorders, congenital heart disease, liver anomalies, renal anomalies, thyroid disease, mental disorder, multiple gestation, preterm gestation, obesity, pulmonary embolism, and uterine rupture.

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

estly higher rates of complications for deliveries at exceedingly high-volume hospitals. Further study is needed to elucidate whether the higher rates of complications at higher volume hospitals merely reflect unmeasured severity of illness or are a result of more intangible factors. Because a significant proportion of low-volume hospitals are located in close proximity to higher volume facilities, physicians and patients should consider carefully the need for delivery at low-volume hospitals when viable alternatives exist. ■

REFERENCES

1. Martin JA, Kung HC, Mathews TJ, et al. Annual summary of vital statistics: 2006. Pediatrics 2008;121:788-801.

2. Duff P. Maternal and perinatal infection. In: Gabbe S, Niebyl JR, Simpson JL, eds. Obstetrics: normal and problem pregnancies. New York: Churchill Livingstone; 2002:1239-42.

3. American College of Obstetricians and Gynecologists. ACOG practice bulletin: clinical management guidelines for obstetrician-gynecologists, no. 76: postpartum hemorrhage. Obstet Gynecol 2006;108:1039-47.

4. Heron M, Hoyert DL, Murphy SL, Xu J, Kochanek KD, Tejada-Vera B. Deaths: final data for 2006. Natl Vital Stat Rep 2009;57:1-134.

5. Hannan EL, O'Donnell JF, Kilburn H Jr, Bernard HR, Yazici A. Investigation of the relationship between volume and mortality for surgical procedures performed in New York State hospitals. JAMA 1989;262:503-10.

6. Showstack JA, Rosenfeld KE, Garnick DW, Luft HS, Schaffarzick RW, Fowles J. Association of volume with outcome of coronary artery bypass graft surgery: scheduled vs nonscheduled operations. JAMA 1987;257:785-9.

7. Phillips KA, Luft HS, Ritchie JL. The association of hospital volumes of percutaneous transluminal coronary angioplasty with adverse outcomes, length of stay, and charges in California. Med Care 1995;33:502-14.

8. Hannan EL, Racz M, Ryan TJ, et al. Coronary angioplasty volume-outcome relationships for hospitals and cardiologists. JAMA 1997;277:892-8.

9. Thiemann DR, Coresh J, Oetgen WJ, Powe NR. The association between hospital volume and survival after acute myocardial infarction in elderly patients. N Engl J Med 1999;340:1640-8.

10. Steiner CA, Bass EB, Talamini MA, Pitt HA, Steinberg EP. Surgical rates and operative mortality for open and laparoscopic cholecystectomy in Maryland. N Engl J Med 1994;330:403-8.

11. Birkmeyer JD, Siewers AE, Finlayson EV, et al. Hospital volume and surgical mortality in the United States. N Engl J Med 2002;346:1128-37.

12. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. N Engl J Med 2003;349:2117-27.

13. Finks JF, Osborne NH, Birkmeyer JD. Trends in hospital volume and operative mortality for high-risk surgery. N Engl J Med 2011;364:2128-37.

14. Ross JS, Normand SL, Wang Y, et al. Hospital volume and 30-day mortality for three common medical conditions. N Engl J Med 2010;362:1110-8.

15. Grobman WA, Feinglass J, Murthy S. Are the Agency for Healthcare Research and Quality obstetric trauma indicators valid measures of hospital safety? Am J Obstet Gynecol 2006;195:868-74.

16. Heaphy PE, Bernard SL. Maternal complications of normal deliveries: variation among rural hospitals. J Rural Health 2000;16:139-47.

17. Chang JJ, Stamilio DM, Macones GA. Effect of hospital volume on maternal outcomes in women with prior cesarean delivery undergoing trial of labor. Am J Epidemiol 2008;167:711-8.

18. Garcia FA, Miller HB, Huggins GR, Gordon TA. Effect of academic affiliation and obstetric volume on clinical outcome and cost of childbirth. Obstet Gynecol 2001;97:567-76.

19. Janakiraman V, Lazar J, Joynt KE, Jha AK. Hospital volume, provider volume, and complications after childbirth in U.S. hospitals. Obstet Gynecol 2011;118:521-7.

20. Rosenberg AL, Hofer TP, Strachan C, Watts CM, Hayward RA. Accepting critically ill transfer patients: adverse effect on a referral center's outcome and benchmark measures. Ann Intern Med 2003;138:882-90.

21. Cram P, Bayman L, Popescu I, Vaughan-Sarrazin MS, Cai X, Rosenthal GE. Uncompensated care provided by for-profit, not-for-profit, and government owned hospitals. BMC Health Serv Res 2010;10:90.
22. James AH, Patel ST, Watson W, Zaidi QR, Mangione A, Goss TF. An assessment of medical resource utilization and hospitalization cost associated with a diagnosis of anemia in women with obstetrical bleeding in the United States. J Womens Health (Larchmt) 2008;17:1279-84.
23. Weber AM, Meyn L. Episiotomy use in the United States, 1979–1997. Obstet Gynecol 2002;100:1177-82.
24. Peleg D, Kennedy CM, Merrill D, Zlatnik FJ. Risk of repetition of a severe perineal laceration. Obstet Gynecol 1999;93:1021-4.
25. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36:8-27.
26. Srinivas SK, Epstein AJ, Nicholson S, Herrin J, Asch DA. Improvements in US maternal obstetrical outcomes from 1992 to 2006. Med Care 2010;48:487-93.
27. Rosenblatt RA, Reinken J, Shoemack P. Is obstetrics safe in small hospitals? Evidence from New Zealand's regionalised perinatal system. Lancet 1985;2:429-32.
28. Viisainen K, Gissler M, Hemminki E. Birth outcomes by level of obstetric care in Finland: a catchment area based analysis. J Epidemiol Community Health 1994;48:400-5.
29. LeFevre M, Sanner L, Anderson S, Tsutakawa R. The relationship between neonatal mortality and hospital level. J Fam Pract 1992;35:259-64.
30. Larson EH, Hart LG, Rosenblatt RA. Is nonmetropolitan residence a risk factor for poor birth outcome in the US? Soc Sci Med 1997;45:171-88.
31. Phibbs CS, Bronstein JM, Buxton E, Phibbs RH. The effects of patient volume and level of care at the hospital of birth on neonatal mortality. JAMA 1996;276:1054-9.
32. Moster D, Lie RT, Markestad T. Neonatal mortality rates in communities with small maternity units compared with those having larger maternity units. BJOG 2001;108:904-9.
33. Heller G, Richardson DK, Schnell R, Misselwitz B, Kunzel W, Schmidt S. Are we regionalized enough? Early-neonatal deaths in low-risk births by the size of delivery units in Hesse, Germany 1990–1999. Int J Epidemiol 2002;31:1061-8.
34. American College of Obstetricians and Gynecologists. ACOG practice bulletin: clinical management guidelines for obstetrcian-gynecologists, no.: 38: perinatal care at the threshold of viability. Obstet Gynecol 2002;100:617-24.
35. Clark SL, Belfort MA, Hankins GD, Meyers JA, Houser FM. Variation in the rates of operative delivery in the United States. Am J Obstet Gynecol 2007;196:526.e1-5.
36. Baicker K, Buckles KS, Chandra A. Geographic variation in the appropriate use of cesarean delivery. Health Aff (Millwood) 2006;25:w355-67.
37. Hanley GE, Janssen PA, Greyson D. Regional variation in the cesarean delivery and assisted vaginal delivery rates. Obstet Gynecol 2010;115:1201-8.
38. Yasmeen S, Romano PS, Schembri ME, Keyzer JM, Gilbert WM. Accuracy of obstetric diagnoses and procedures in hospital discharge data. Am J Obstet Gynecol 2006;194:992-1001.

APPENDIX

SUPPLEMENTARY TABLE 1
Total population: unadjusted percent complications by hospital decile, route of delivery, and high- and low-risk subgroups

Outcome (n/N)	Decile 1 (n = 3011)	Decile 2 (n = 20,678)	Decile 3 (n = 45,446)	Decile 4 (n = 69,869)	Decile 5 (n = 99,654)	Decile 6 (n = 141,844)	Decile 7 (n = 188,227)	Decile 8 (n = 243,475)	Decile 9 (n = 331,801)	Decile 10 (n = 534,804)
Hemorrhage										
High risk	73/661 (11.0%)	422/5029 (8.4%)	846/12,092 (7.0%)	1269/19,374 (6.6%)	1738/28,951 (6.0%)	2378/44,004 (5.4%)	3713/61,138 (6.1%)	5307/81,934 (6.5%)	7903/111,279 (7.1%)	11,947/194,414 (6.2%)
Low risk	168/2350 (7.2%)	961/15,649 (6.1%)	1681/33,354 (5.0%)	2375/50,495 (4.7%)	3111/70,704 (4.4%)	4000/97,840 (4.1%)	5165/127,089 (4.1%)	7035/161,541 (4.4%)	9636/220,522 (4.4%)	14,263/340,390 (4.2%)
Infection										
High risk	11/661 (1.7%)	36/5029 (0.7%)	70/12,092 (0.6%)	81/19,374 (0.4%)	180/28,951 (0.6%)	303/44,004 (0.7%)	558/61,138 (0.9%)	968/81,934 (1.2%)	1174/111,279 (1.1%)	2349/194,414 (1.2%)
Low risk	15/2350 (0.6%)	66/15,649 (0.4%)	142/33,354 (0.4%)	171/50,495 (0.3%)	275/70,703 (0.4%)	390/97,840 (0.4%)	620/12,7089 (0.5%)	1093/161,541 (0.7%)	1276/220,522 (0.6%)	2360/340,390 (0.7%)
Laceration										
High risk	21/661 (3.2%)	129/5029 (2.6%)	192/12,092 (1.6%)	347/19,374 (1.8%)	536/28,951 (1.9%)	790/44,004 (1.8%)	1060/61,138 (1.7%)	1530/81,931 (1.9%)	2082/111,279 (1.9%)	3342/194,414 (1.7%)
Low risk	63/2350 (2.7%)	399/15,649 (2.6%)	735/33,354 (2.2%)	1161/50,495 (2.3%)	1616/70,703 (2.3%)	2069/97,840 (2.1%)	2344/127,089 (1.8%)	3475/161,541 (2.2%)	5079/220,522 (2.3%)	7568/340,390 (2.2%)
Thrombotic										
High risk	5/661 (0.8%)	78/5029 (1.6%)	173/12,092 (1.4%)	306/19,374 (1.6%)	436/28,951 (1.5%)	613/44,004 (1.4%)	1022/61,138 (1.7%)	1275/81,934 (1.6%)	1802/111,279 (1.6%)	3252/194,414 (1.7%)
Low risk	21/2350 (0.9%)	174/15,649 (1.1%)	372/33,354 (1.1%)	568/50,495 (1.1%)	732/70,703 (1.0%)	1061/97,840 (1.1%)	1248/127,089 (1.0%)	1548/161,541 (1.0%)	2564/220,522 (1.2%)	3864/340,390 (1.1%)
Operative										
High risk	2/611 (0.3%)	22/5029 (0.4%)	61/12,092 (0.5%)	115/19,374 (0.6%)	171/28,951 (0.6%)	251/44,004 (0.6%)	352/61,138 (0.6%)	570/81,934 (0.7%)	807/111,279 (0.7%)	1510/194,414 (0.8%)
Low risk	7/2350 (0.3%)	36/15,649 (0.2%)	60/33,354 (0.2%)	112/50,495 (0.2%)	168/70,703 (0.2%)	175/97,840 (0.2%)	224/127,089 (0.2%)	351/161,541 (0.2%)	543/220,522 (0.3%)	903/340,390 (0.3%)
Death										
High risk	1/661 (0.15%)	2/5029 (0.04%)	1/12,092 (0.01%)	4/19,374 (0.02%)	2/28,951 (0.01%)	8/44,004 (0.02%)	13/61,138 (0.02%)	18/81,931 (0.02%)	15/111,279 (0.01%)	38/194,414 (0.02%)
Low risk	0/2350	0/15,649	1/33,354 (0%)	1/50,495 (0%)	2/70,703 (0%)	5/97,840 (0.01%)	4/127,089 (0.01%)	2/161,541 (0%)	12/220,522 (0.01%)	18/340,390 (0.01%)
Composite										
High risk	105/661 (15.9%)	609/5029 (12.1%)	1182/12,092 (9.8%)	1892/19,374 (9.8%)	2690/28,951 (9.3%)	3799/44,004 (8.6%)	5802/61,138 (9.5%)	8381/81,934 (10.2%)	11,940/111,279 (10.7%)	19,251/194,414 (9.9%)
Low risk	249/2350 (10.6%)	1473/15,649 (9.4%)	2698/33,354 (8.1%)	3992/50,495 (7.9%)	5331/70,703 (7.5%)	6989/97,840 (7.1%)	8729/12,7089 (6.9%)	12,270/161,541 (7.6%)	17,211/220,522 (7.8%)	26,037/340,390 (7.7%)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

SUPPLEMENTARY TABLE 2

Spontaneous vaginal deliveries: unadjusted percent complications by hospital decile, route of delivery, and high- and low-risk subgroups

Outcome (n/N)	Decile 1 (n = 1898)	Decile 2 (n = 13,301)	Decile 3 (n = 28,511)	Decile 4 (n = 45,112)	Decile 5 (n = 63,108)	Decile 6 (n = 88,309)	Decile 7 (n = 117,137)	Decile 8 (n = 150,948)	Decile 9 (n = 210,727)	Decile 10 (n = 328,797)
Hemorrhage										
High risk	34/337 (10.1%)	204/2636 (7.7%)	425/6186 (6.9%)	648/10,210 (6.4%)	838/14,965 (5.6%)	1174/22,346 (5.3%)	1721/30,708 (5.6%)	2292/40,945 (5.6%)	3353/56,768 (5.9%)	4989/95,598 (5.2%)
Low risk	102/1561 (6.5%)	602/10,665 (5.6%)	1033/22,325 (4.6%)	1584/34,902 (4.5%)	1902/48,143 (4.0%)	2558/65,963 (3.9%)	3251/86,429 (3.8%)	4279/110,003 (3.9%)	5901/153,959 (3.8%)	8551/233,199 (3.7%)
Infection										
High risk	4/337 (1.2%)	7/2636 (0.3%)	23/6186 (0.4%)	35/10,210 (0.3%)	58/14,965 (0.3%)	96/22,346 (0.4%)	176/30,708 (0.6%)	244/40,945 (0.6%)	329/56,768 (0.6%)	618/95,598 (0.7%)
Low risk	9/1561 (0.6%)	25/10,665 (0.2%)	66/22,325 (0.3%)	86/34,902 (0.3%)	123/48,143 (0.3%)	190/65,963 (0.3%)	296/86,429 (0.3%)	453/110,003 (0.4%)	621/153,959 (0.4%)	1089/233,199 (0.5%)
Laceration										
High risk	15/337 (4.5%)	90/2636 (3.4%)	128/6186 (2.1%)	238/10,210 (2.3%)	345/14,965 (2.3%)	560/22,346 (2.5%)	702/30,708 (2.3%)	1029/40,945 (2.5%)	1368/56,768 (2.4%)	2135/95,598 (2.2%)
Low risk	35/1561 (2.2%)	264/10,665 (2.5%)	468/22,325 (2.1%)	787/34,902 (2.3%)	1034/48,143 (2.2%)	1362/65,963 (2.1%)	1500/86,429 (1.7%)	2349/110,003 (2.1%)	3339/153,959 (2.2%)	4881/233,199 (2.1%)
Thrombotic										
High risk	1/337 (0.3%)	11/2636 (0.4%)	22/6186 (0.4%)	45/10,210 (0.4%)	67/14,965 (0.5%)	106/22,346 (0.5%)	149/30,708 (0.5%)	165/40,945 (0.4%)	231/56,768 (0.4%)	391/95,598 (0.4%)
Low risk	5/1561 (0.3%)	30/10,665 (0.3%)	71/22,325 (0.3%)	123/34,902 (0.4%)	161/48,143 (0.3%)	206/65,963 (0.3%)	229/86,429 (0.3%)	305/110,003 (0.3%)	461/153,959 (0.3%)	672/233,199 (0.3%)
Death										
High risk	0/337	0/2636	0/6186	0/10,210	0/14,965	2/22,346 (0%)	5/30,708 (0.02%)	6/40,945 (0.01%)	2/56,768 (0%)	9/95,598 (0.01%)
Low risk	0/1561	0/10,665	0/22,325	0/34,902	0/48,143	2/65,963 (0%)	1/86,429 (0%)	1/110,003 (0%)	1/153,959 (0%)	12/233,199 (0.01%)
Composite										
High risk	51/337 (15.1%)	291/2636 (11.0%)	571/6186 (9.2%)	926/10,210 (9.1%)	1238/14,965 (8.3%)	1836/22,346 (8.2%)	2588/30,708 (8.4%)	3530/40,945 (8.6%)	4999/56,768 (8.8%)	7667/95,598 (8.0%)
Low risk	143/1561 (9.2%)	859/10,665 (8.1%)	1552/22,325 (7.0%)	2453/34,902 (7.0%)	3045/48,143 (6.3%)	4099/65,963 (6.2%)	5029/86,429 (5.8%)	7021/110,003 (6.4%)	9772/153,959 (6.4%)	14,459/233,199 (6.2%)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

SUPPLEMENTARY TABLE 3

Cesarean deliveries: unadjusted percent complications by hospital decile, route of delivery, and high- and low-risk subgroups

Outcomes (n/N)	Decile 1 (n = 922)	Decile 2 (n = 6006)	Decile 3 (n = 14,175)	Decile 4 (n = 20,779)	Decile 5 (n = 30,229)	Decile 6 (n = 45,435)	Decile 7 (n = 60,659)	Decile 8 (n = 79,007)	Decile 9 (n = 102,481)	Decile 10 (n = 177,080)
Hemorrhage										
High risk	35/290 (12.1%)	187/2122 (8.8%)	359/5315 (6.8%)	529/8231 (6.4%)	768/12,383 (6.2%)	1035/19,471 (5.3%)	1765/27,408 (6.4%)	2691/36,989 (7.3%)	4130/49,324 (8.4%)	6187/89,463 (6.9%)
Low risk	51/632 (8.1%)	251/3884 (6.5%)	482/8860 (5.4%)	574/12,548 (4.6%)	897/17,846 (5.0%)	1080/25,964 (4.2%)	1499/33,251 (4.5%)	2267/42,018 (5.4%)	3010/53,157 (5.7%)	4632/87,617 (5.3%)
Infection										
High risk	6/290 (2.1%)	26/2122 (1.2%)	40/5315 (0.8%)	41/8231 (0.5%)	115/12,383 (1.0%)	187/19,471 (1.0%)	354/27,408 (1.3%)	674/36,989 (1.8%)	793/49,324 (1.6%)	1649/89,463 (1.8%)
Low risk	6/632 (1.0%)	29/3884 (0.8%)	62/8860 (0.7%)	70/12,548 (0.6%)	131/17,846 (0.7%)	164/25,964 (0.6%)	279/33,251 (0.8%)	557/42,018 (1.3%)	567/53,157 (1.1%)	1130/87,617 (1.3%)
Operative										
High risk	2/290 (0.7%)	22/2122 (1.0%)	61/5315 (1.2%)	115/8231 (1.4%)	171/12,383 (1.4%)	251/19,471 (1.3%)	352/27,408 (1.3%)	570/36,989 (1.5%)	807/49,324 (1.6%)	1510/89,463 (1.7%)
Low risk	7/632 (1.1%)	36/3884 (0.9%)	60/8860 (0.7%)	112/12548 (0.9%)	168/17,846 (0.9%)	175/25,964 (0.7%)	224/33,251 (0.7%)	351/42,018 (0.8%)	543/53,157 (1.0%)	903/87,617 (1.0%)
Thrombotic										
High risk	3/290 (1.0%)	31/2122 (1.5%)	92/5315 (1.7%)	121/8231 (1.5%)	192/12,383 (1.6%)	269/19,471 (1.4%)	493/27,408 (1.8%)	688/36,989 (1.9%)	953/49,324 (1.9%)	1,792/89,463 (2.0%)
Low risk	8/632 (1.3%)	39/3884 (1.0%)	90/8860 (1.0%)	128/12,548 (1.0%)	171/17,846 (1.0%)	224/25,964 (0.9%)	310/33,251 (0.9%)	464/42,018 (1.1%)	625/53,157 (1.2%)	1,089/87,617 (1.2%)
Death										
High risk	1/290 (0.34%)	2/2122 (0.09%)	1/5315 (0.02%)	3/8231 (0.04%)	2/12,383 (0.02%)	6/19,471 (0.03%)	8/27,408 (0.03%)	12/36,989 (0.03%)	11/49,324 (0.02%)	29/89,463 (0.03%)
Low risk	0/632	0/3884	1/8860 (0.01%)	0/12,548	2/17,846 (0.01%)	3/25,964 (0.01%)	3/33,251 (0.01%)	1/42,018 (0%)	11/53,157 (0.02%)	5/87,617 (0.01%)
Composite										
High risk	42/290 (14.5%)	232/2122 (10.9%)	452/5315 (8.5%)	673/8231 (8.2%)	1010/12,383 (8.2%)	1405/19,471 (7.2%)	2379/27,408 (8.7%)	3748/36,989 (10.1%)	5418/49,324 (11.0%)	8921/89,463 (10.0%)
Low risk	61/632 (9.7%)	303/3884 (7.8%)	591/8860 (6.8%)	739/12,548 (5.9%)	1156/17,846 (6.5%)	1404/25,964 (5.4%)	1963/33,251 (5.9%)	3062/42,018 (7.3%)	3960/53,157 (7.5%)	6383/87,617 (7.3%)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

SUPPLEMENTARY TABLE 4

Total population: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups

Total population	Lowest volume Decile 1 OR (95% CI)	*P* value	Decile 2 OR (95% CI)	*P* value	Decile 3 OR (95% CI)	*P* value	Decile 4 OR (95% CI)	*P* value	Decile 5 OR (95% CI)
All deliveries									
High risk	1.76 (1.31–2.37)	.0002	1.28 (1.07–1.54)	.0077	0.93 (0.78–1.10)	.3776	0.97 (0.82–1.14)	.7106	0.88 (0.75–1.03)
Low risk	1.36 (1.05–1.76)	.0201	1.21 (1.01–1.45)	.0364	0.99 (0.83–1.18)	.8736	(0.84–1.20)	.9177	0.90 (0.76–1.07)
Adjusted for demographics[a]									
High risk	1.78 (1.32–2.39)	.0001	1.28 (1.07–1.53)	.0076	0.91 (0.78–1.08)	.2877	0.96 (0.82–1.13)	.6560	0.87 (0.75–1.02)
Low risk	1.34 (1.04–1.74)	.0261	1.20 (1.00–1.44)	.0509	0.97 (0.81–1.15)	.7033	0.99 (0.84–1.18)	.9479	0.89 (0.75–1.06)
Fully adjusted[b]									
High risk	1.87 (1.39–2.51)	< .0001	1.34 (1.12–1.60)	.0014	0.96 (0.82–1.14)	.6586	1.01 (0.86–1.18)	.9345	0.91 (0.78–1.07)
Low risk	1.49 (1.33–1.67)	< .0001	1.23 (1.17–1.29)	< .0001	1.02 (0.98–1.05)	.3222	1.00 (0.97–1.03)	.9459	0.97 (0.94–0.99)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012. *(continued)*

SUPPLEMENTARY TABLE 5

Spontaneous vaginal deliveries: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups[b]

Spontaneous vaginal deliveries	Lowest volume Decile 1 OR (95% CI)	*P* value	Decile 2 OR (95% CI)	*P* value	Decile 3 OR (95% CI)	*P* value	Decile 4 OR (95% CI)	*P* value	Decile 5 OR (95% CI)
Unadjusted									
High risk	2.08 (1.45–2.97)	< .0001	1.48 (1.22–1.78)	< .0001	1.134 (0.96–1.34)	.1328	1.16 (1.00–1.36)	.0540	1.02 (0.88–1.19)
Low risk	1.50 (1.12–1.99)	.0057	1.30 (1.08–1.57)	.0055	1.08 (0.90–1.29)	.4125	1.12 (0.94–1.33)	.2123	0.95 (0.80–1.13)
Adjusted for demographics[a]									
High risk	2.13 (1.49–3.04)	< .0001	1.48 (1.23–1.78)	< .0001	1.12 (0.96–1.32)	.1590	1.16 (1.00–1.34)	.0537	1.02 (0.89–1.18)
Low risk	1.50 (1.22–1.99)	.0060	1.30 (1.08–1.57)	.0061	1.06 (0.89–1.27)	.4951	1.11 (0.93–1.32)	.2511	0.94 (0.78–1.19)
Fully adjusted									
High risk	2.21 (1.55–3.16)	< .0001	1.52 (1.27–1.83)	< .0001	1.16 (0.99–1.36)	.0642	1.19 (1.02–1.38)	.0246	1.06 (0.91–1.22)
Low risk	1.50 (1.12–1.99)	.0060	1.30 (1.08–1.57)	.0061	1.06 (0.89–1.27)	.4951	1.11 (0.93–1.32)	.2511	0.94 (0.78–1.12)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012. *(continued)*

SUPPLEMENTARY TABLE 4

Total population: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups *(continued)*

Highest volume									
P value	Decile 6 OR (95% CI)	*P* value	Decile 7 OR (95% CI)	*P* value	Decile 8 OR (95% CI)	*P* value	Decile 9 OR (95% CI)	*P* value	Highest volume Decile 10
									Reference
.1043	0.82 (0.70–0.96)	.0119	0.89 (0.76–1.04)	.1447	0.97 (0.83–1.14)	.7157	0.97 (0.83–1.14)	.7327	
.2455	0.84 (0.70–0.99)	.0398	0.87 (0.74–1.04)	.1227	0.97 (0.82–1.16)	.7561	0.98 (0.83–1.17)	.8447	
									Reference
.0944	0.82 (0.71–0.96)	.0140	0.89 (0.77–1.04)	.1484	0.97 (0.83–1.13)	.6757	0.97 (0.83–1.13)	.6622	
.1957	0.83 (0.70–0.99)	.0366	0.87 (0.74–1.04)	.1188	0.97 (0.82–1.15)	.7312	0.97 (0.82–1.16)	.7595	
									Reference
.2476	0.85 (0.73–0.99)	.0411	0.91 (0.79–1.06)	.2450	0.99 (0.85–1.15)	.9269	0.98 (0.84–1.14)	.7797	
.0068	0.91 (0.89–0.93)	< .0001	0.92 (0.91–0.94)	< .0001	1.01 (1.00–1.03)	.0770	1.02 (1.03–1.06)	< .0001	

CI, confidence interval; *OR*, odds ratio.

[a] Adjusted for race, age, and payor; [b] Adjusted for race, age, payor, advanced age, herpes, asthma, cerebral hemorrhage, chorioamnionitis, diabetes mellitus, hypertensive disorders, congenital heart disease, liver anomalies, renal anomalies, thyroid disease, mental disorder, multiple gestation, preterm gestation, obesity, pulmonary embolism, and uterine rupture.

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

SUPPLEMENTARY TABLE 5

Spontaneous vaginal deliveries: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups[b] *(continued)*

Lowest volume									
P value	Decile 6 OR (95% CI)	*P* value	Decile 7 OR (95% CI)	*P* value	Decile 8 OR (95% CI)	*P* value	Decile 9 OR (95% CI)	*P* value	Highest volume Decile 10
									Reference
.7758	0.99 (0.86–1.15)	.9329	1.01 (0.87–1.16)	.9267	1.03 (0.90–1.18)	.6929	1.02 (0.89–1.17)	.7554	
.5352	0.89 (0.75–1.06)	.1825	0.91 (0.77–1.08)	.2721	1.00 (0.84–1.18)	.9510	0.98 (0.83–1.17)	.8553	
									Reference
.7645	1.00 (0.87–1.15)	.9717	1.05 (1.00–1.10)	.8877	1.01 (0.88–1.16)	.7775	1.02 (0.89–1.17)	.8599	
.4807	0.89 (0.75–1.06)	.1776	0.91 (0.76–1.08)	.2574	0.99 (0.83–1.17)	.9034	0.97 (0.82–1.15)	.7467	
									Reference
.4683	1.03 (0.90–1.18)	.6708	1.03 (0.90–1.18)	.6830	1.04 (0.91–1.19)	.5438	1.03 (0.90–1.17)	.7202	
.4807	0.89 (0.75–1.06)	.1776	0.91 (0.76–1.08)	.2574	0.99 (0.83–1.17)	.9034	0.97 (0.82–1.15)	.7467	

CI, confidence interval; *OR*, odds ratio.

[a] Adjusted for race, age, and payor; [b] Adjusted for race, age, payor, advanced age, herpes, asthma, cerebral hemorrhage, chorioamnionitis, diabetes mellitus, hypertensive disorders, congenital heart disease, liver anomalies, renal anomalies, thyroid disease, mental disorder, multiple gestation, preterm gestation, obesity, pulmonary embolism, uterine rupture.

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

SUPPLEMENTARY TABLE 6

Cesarean deliveries: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups

Cesarean deliveries	Lowest volume Decile 1 OR (95% CI)	*P* value	Decile 2 OR (95% CI)	*P* value	Decile 3 OR (95% CI)	*P* value	Decile 4 OR (95% CI)	*P* value	Decile 5 OR (95% CI)
Unadjusted									
High risk	1.70 (1.10–2.61)	.0163	1.22 (0.95–1.58)	.1193	0.84 (0.67–1.05)	.1250	0.81 (0.65–1.01)	.0554	0.77 (0.60–0.92)
Low risk	1.40 (0.93–2.11)	.1068	1.02 (0.78–1.34)	.8727	0.86 (0.67–1.11)	.2504	0.79 (0.61–1.01)	.0575	0.77 (0.60–0.98)
Adjusted for demographics[a]									
High risk	1.70 (1.10–2.61)	.0137	1.22 (0.95–1.57)	.1632	0.83 (0.66–1.04)	.0897	0.81 (0.65–1.00)	.0428	0.75 (0.60–0.92)
Low risk	1.37 (0.90–2.06)	.1388	1.03 (0.78–1.36)	.8280	0.84 (0.65–1.09)	.1928	0.79 (0.61–1.02)	.0648	0.77 (0.60–0.98)
Fully adjusted[b]									
High risk	1.76 (1.15–2.70)	.0099	1.27 (0.99–1.63)	.0608	0.87 (0.69–1.08)	.2086	0.84 (0.68–1.04)	.1132	0.78 (0.63–0.96)
Low risk	1.39 (0.92–2.10)	.1175	1.02 (0.77–1.34)	.8958	0.85 (0.66–1.10)	.2052	0.78 (0.61–1.01)	.0574	0.76 (0.59–0.97)

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.

(continued)

SUPPLEMENTARY TABLE 6

Cesarean deliveries: unadjusted and adjusted odds of composite adverse outcome by volume decile and high- and low-risk subgroups *(continued)*

Lowest volume									
P value	Decile 6 OR (95% CI)	*P* value	Decile 7 OR (95% CI)	*P* value	Decile 8 OR (95% CI)	*P* value	Decile 9 OR (95% CI)	*P* value	Highest volume Decile 10
									Reference
.0073	0.68 (0.55–0.84)	.0003	0.81 (0.66–0.99)	.0423	0.94 (0.77–1.15)	.5336	0.98 (0.80–1.20)	.8180	
.0343	0.67 (0.53–0.86)	.0013	0.80 (0.63–1.01)	.0614	0.98 (0.77–1.25)	.8799	0.93 (0.74–1.18)	.5712	
									Reference
.0043	0.69 (0.56–0.84)	.0004	0.81 (0.66–0.99)	.0313	0.93 (0.76–1.14)	.5057	0.97 (0.80–1.19	.6807	
.0353	0.66 (0.52–0.85)	.0010	0.77 (0.61–0.98)	.0363	0.97 (0.76–1.23)	.7928	0.94 (0.74–1.19)	.6051	
									Reference
.0184	0.70 (0.57–0.86)	.0007	0.82 (0.67–1.00)	.0510	0.95 (0.78–1.15)	.5782	0.98 (0.81–1.19)	.8473	
.0273	0.67 (0.52–0.85)	.0011	0.79 (0.62–1.00)	.0505	0.97 (0.76–1.23)	.7795	0.93 (0.73–1.18)	.5495	

CI, confidence interval; *OR*, odds ratio.

[a] Adjusted for race, age, and payor; [b] Adjusted for race, age, payor, advanced age, herpes, asthma, cerebral hemorrhage, chorioamnionitis, diabetes mellitus, hypertensive disorders, congenital heart disease, liver anomalies, renal anomalies, thyroid disease, mental disorder, multiple gestation, preterm gestation, obesity, pulmonary embolism, and uterine rupture.

Kyser. Obstetrical volume and postpartum complications. Am J Obstet Gynecol 2012.