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Risk for Peripartum Hysterectomy and Center Hysterectomy and Delivery Volume

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Abstract

Objective—To characterize where women at risk for and undergoing peripartum hysterectomy delivered in terms of obstetric volume and procedural experience.

Methods—We used data from the Perspective database to retrospectively evaluate trends in peripartum hysterectomy and deliveries at high risk for peripartum hysterectomy based on placenta previa and prior cesarean delivered from 2006 through 2014. Hospitals were categorized two separate ways for the analysis: (i) into five roughly equal quintiles based on annualized delivery volume, and (ii) by the mean number of hysterectomies performed annually over the study period.

Results—Four thousand eight hundred eleven hysterectomies occurred among 5,388,486 deliveries in 500 hospitals over the study period. The peripartum hysterectomy rate increased from 81.4 per 100,000 deliveries in 2006 to 98.4 in 2014. The prevalence rate of placenta previa in the setting of previous cesarean also increased over the study period. Between 2006-2008 and 2012-2014, the peripartum hysterectomy decreased in the lowest delivery volume quintile and increased in the highest delivery volume quintile (minus 14.9 per 100,000 deliveries, 95% CI –25.6 to –4.2) and (plus 35.4 per 100,000 deliveries, 95% CI 20.3 –50.5), respectively. Similarly, hospitals performing high rates of hysterectomies saw the largest increase over the study period.

Conclusion—With peripartum hysterectomy rates increasing in the population, hospitals with high delivery volumes and high rates of hysterectomies saw the largest increases in peripartum hysterectomy rates. These trends support that improved referral practices and uptake of evidence-based recommendations may be occurring.

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INTRODUCTION

While peripartum hysterectomy may represent a life-saving intervention for patients with conditions such as placenta accrete-percreta and hemorrhage from uterine atony refractory to other treatment,(1, 2) the procedure commonly results in morbidity(3) with risk of death ranging from 1 to 6%.(4-6) The benefit from delivery at experienced centers for the highest risk patients – such as those with accrete-percreta – is supported by both expert opinion and evidence that experienced surgeons and anesthesiologists, blood-product availability, and planning by consultative services, among other factors, may make delivery safer.(1,7) Research evidence supports that maternal outcomes may be improved at centers that perform peripartum hysterectomy more frequently(8) and use a multidisciplinary approach in planning and delivery.(9)

While population-based risk factors and ultrasound findings suggestive of abnormal placentation may identify patients at increased risk for peripartum hysterectomy, it is unclear to what degree patients requiring this procedure are delivering at high-volume centers or at those that perform peripartum hysterectomy more frequently. Uterine atony and other complications leading to peripartum hysterectomy may occur among low as well as high risk patients.(10) In the setting of peripartum hysterectomy rates increasing,(10) it is possible that this procedure is occurring more diffusely across centers with varying experience and volume as opposed to becoming more concentrated at the most experienced centers.

Given that trends in where patients requiring peripartum hysterectomy deliver may be an important factor in adverse maternal outcomes, the purposes of this study were: (i) to characterize where women at high risk for peripartum hysterectomy deliver, and (ii) to estimate the proportion of women undergoing peripartum hysterectomy who deliver at high-volume or experienced centers.

MATERIALS AND METHODS

The Perspective (Premier Inc) database was used for the analysis.(11) Perspective is a voluntary, fee-supported database that includes hospitalization data from more than 500 United States acute care hospitals. This database includes patient demographics, diagnosis and procedure codes, and hospital and provider characteristics. Data undergo a quality control including 95 separate quality assurance and data validation before being used for research.(12) For each hospital included, 100% of discharge data is present. Perspective has been used in numerous outcomes studies.(13, 14) Approximately 15% of all hospitalizations within the United States (almost 5.5 million hospital discharges) were captured in Perspective in 2006.(13) All data were de-identified and we received an exemption from the Columbia University institutional review board specifically to perform analyses with the Perspective data set.

Hospitals were categorized two separate ways for the analysis: (i) into five roughly equal quintiles based on annualized delivery volume, and (ii) by the mean number of peripartum hysterectomies performed annually over the study period (<1, 1 to <2, 2 to <3, 3 to <4, 4 to <5, and ≥5). We classified hospitals performing a mean of ≥4 peripartum hysterectomies per

year over the study period as high volume for the procedure. Data from 2006 through 2014 was used for this study. Besides hospital delivery and peripartum hysterectomy volume, other hospital characteristics included location (urban versus rural), teaching status (teaching versus nonteaching), hospital bed size, and region (Eastern, Midwest, South, or West).

We analysed the data to evaluate temporal trends in where hysterectomies were performed. First, we evaluated rates of peripartum hysterectomy over the study period by delivery volume quintile. Second, we evaluated the proportion of peripartum hysterectomies over the study period occurring at hospitals with different annualized peripartum numbers (<1, 1 to <2, 2 to <3, 3 to <4, 4 to <5, 5 cases per year). We restricted these analyses to hospitals that contributed a minimum of 1 full year of data. The cohort of deliveries in hospitals that contributed 1 year of data is referred to subsequently as Cohort 1. Because not all hospitals contributed data throughout the study period and the sample frame changes year to year, we performed sensitivity analyses restricted to centers that contributed data throughout the entire 2006 to 2014 study period to address for possibility of confounding due to the changing sampling frame. The subset of Cohort 1 hospitals that contributed data throughout the entire study period is subsequently referred to as Cohort 2.

In addition to evaluating peripartum hysterectomy rates, we evaluated trends in where patients at high risk for peripartum hysterectomy delivered. We analysed trends in where patients with placenta previa and prior caesarean delivered in terms of both hospital delivery volume quintile and annualized hospital peripartum hysterectomy rate category. We similarly restricted these analyses to hospitals contributing at least 1 year of data, and performed sensitivity analysis including only centers contributing data throughout the 2006 to 2014 study period. We used Cochran-Mantel-Haenszel test to assess whether differences in rates of binary outcomes differed significantly.

Patient inclusion criteria included women age 15-54 who underwent a delivery. Delivery hospitalizations were identified based on whether *International Classification of Diseases*, ninth revision, (ICD-9) billing codes v27.x and/or 650 were present. These codes have been shown to identify >95% of all delivery hospitalizations.(15) For the purposes of this study we identified a group of patients at high-risk for peripartum hysterectomy: those with both placenta previa (641.0x, 641.1x) and prior cesarean (654.2x). While other risk factors are associated with increased risk for peripartum, patients with previa and prior cesarean can be readily identified prior to delivery based on ultrasound findings and clinical history, and, if concerning features are found, referred to a larger center for delivery. To evaluate trends in the incidence of less predictable cases, we also determined rates of peripartum hysterectomy associated with uterine atony. Peripartum hysterectomy cases were identified by ICD-9 codes 68.3x, 68.4x, and 68.9 in the setting of a delivery hospitalization. Patient demographic characteristics included: maternal age, race (white, black, other), marital status, year of discharge, and payer status.

Finally, to determine factors associated with undergoing peripartum hysterectomy at a hospital with high peripartum hysterectomy volume versus low or moderate volume for Cohort 1 (mean of 4 hysterectomies per year versus <4 hysterectomies per year) we developed log-linear Poisson regression models. These models included all the clinical and

demographic characteristics. Given that hospital teaching status and bed size were likely to be closely related to the outcome of peripartum hysterectomy volume, these variables were not included in the adjusted analysis. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC.).

RESULTS

Of 5,550,239 delivery hospitalizations in women that met inclusion criteria, 5,388,486 (97%) occurred in 500 hospitals that contributed at least one full year of data (Cohort 1). 3,009,828 (54%) deliveries occurred in 183 hospitals that contributed obstetric data throughout the study period (1/2006-12/2014) (Cohort 2). Within these two cohorts, 4,811 and 2,832 hysterectomies occurred respectively). In Cohort 1, the peripartum hysterectomy rate increased from 81.4 per 100,000 deliveries in 2006 to 98.4 in 2014 (**Figure 1A**). The rate of repeat caesarean delivery in the setting of placenta previa also increased over the study period (**Figure 1B**). **Appendix 1** demonstrates year-by-year peripartum hysterectomy volume of the 40 hospitals in Cohort 2 that performed the most procedures. The 10 hospitals that performed the most hysterectomies accounted for 23.1% (653/2832) of hysterectomies (n=653) and 12.1% of delivery volume of the 183 hospitals included in Cohort 2. Fourteen hospitals performed on average of 5 or more hysterectomies per year. **Table 1** demonstrates the range of obstetric volume by year by time period for the different hospital categories.

Table 2 demonstrates demographic data for Cohort 1. Peripartum hysterectomy was more common amongst women ≥ 35 years of age compared to younger women, black compared white women, and at hospitals with bed size >600 compared to smaller hospitals. Deliveries at hospitals in the highest delivery volume quintile were more likely to result in peripartum hysterectomy. Deliveries occurring in the setting of previa and prior cesarean were more likely to be performed in teaching hospitals, urban hospitals, hospitals with bed size >600 , hospitals in the highest delivery volume quintile, and hospitals with the highest peripartum hysterectomy rate. All comparisons were statistically significant ($p < 0.001$)

Table 3 compares rates of (i) peripartum hysterectomy and (ii) previa with prior cesarean between 2006-8 and 2012-14. Comparing these two time periods, the rate of previa with prior cesarean increased across all five annualized delivery volume quintiles and peripartum hysterectomy increased overall by a rate of 31.1 cases per 100,000 deliveries. Similarly, previa and prior cesarean increased across all peripartum hysterectomy-rate hospital categories. In comparison, the peripartum hysterectomy decreased in the lowest delivery volume quintile and increased in the highest delivery volume quintile (minus 14.9 per 100,000 deliveries, 95% CI -25.6 to - 4.2) and (plus 35.4 per 100,000 deliveries, 95% CI 20.3 to 50.5), respectively. Peripartum hysterectomy rates at hospitals performing <1 peripartum hysterectomy annually were essentially unchanged over the study period (0.1 per 100,000 deliveries, 95% CI -8.5 – 8.7) while the largest increase came at hospitals performing ≥ 5 cases per year (52.3, 95% CI 32.2-72.4). **Table 4** demonstrates peripartum hysterectomy in the setting of atony for the different hospital categories. Peripartum hysterectomy for atony did not seem to increase appreciably for hospitals in the lowest delivery volume quintile or for hospitals performing <1 delivery per year.

Table 5 demonstrates results from the univariable and multivariable analyses evaluating factors associated with delivering at a high-peripartum-hysterectomy-rate hospital (mean of 4 cases per year) versus a lower-peripartum-hysterectomy-rate hospital (<4 cases per year). Overall, 1,819 hysterectomies (37.8%) occurred in hospitals with high peripartum hysterectomy rates while 2,992 hysterectomies (62.2%) occurred at centers with lower rates. Factors associated with undergoing hysterectomy in a high-peripartum-hysterectomy-rate hospital included urban versus rural location (40.4% versus 4.6%, $p<0.001$), delivery in 2014 compared to 2006 (44.4% versus 34.1%, $p<0.001$), and Northeastern versus Midwest, South, or West region (54.4% versus, 21.7%, 41.4% and 22.8% respectively, $p<0.001$).

Factors in the multivariable analysis associated with increased probability of undergoing peripartum hysterectomy at a high-rate hospital included: urban as opposed to rural location (risk ratio (RR) 8.05, 95% confidence interval (CI) 4.91-13.19), black race with white race as a referent (RR 1.19, 95% CI 1.05-1.36), multiple gestation (RR 1.23, 95% CI 1.03-1.48), and delivery in 2014 with 2006 as a referent (RR 1.28, 95% CI 1.05-1.57). In comparison to the Northeast, peripartum hysterectomy occurring in the Midwest, South, and West was less likely to occur at high peripartum hysterectomy rate hospitals (RR 0.43 95% CI 0.36-0.51, RR 0.86 95% CI 0.77-0.96, RR 0.46 95% CI 0.39-0.55, respectively). Sensitivity analyses for the univariate comparisons, temporal trends, and multivariable model were performed with the subset of patients in Cohort 2. These results were similar to the primary analyses (results not shown).

DISCUSSION

This analysis of a large sample of delivery hospitalizations demonstrated several clinically important findings related to care for women undergoing peripartum hysterectomy. First, as other studies have demonstrated, risk for peripartum cesarean is rising. Bateman et al. demonstrated increasing peripartum hysterectomy rates between 1994 and 2007 in the Nationwide Inpatient Sample.⁽¹⁰⁾ In this analysis from 2006 through 2014, also using a large administrative database, the rate of peripartum hysterectomy increased as did the prevalence of women with placenta previa and prior cesarean. In both of these analyses, relatively large increases in peripartum hysterectomy rates occurred relative to the study duration. While the increasing prevalence of at-risk deliveries cannot be established as causal for peripartum hysterectomy trends in this analysis, it may represent an important factor. Second, in the setting of increased risk, peripartum hysterectomy rates rose differentially; hospitals in the highest volume quintile and that performed peripartum hysterectomy most frequently saw the largest increases in peripartum hysterectomy rates. Hospitals in the lowest volume quintile and those that performed <1 peripartum hysterectomy per year on average saw peripartum hysterectomy rates decrease or stay stable over the study period. These trends may represent increasing regionalization of maternal care, improvements in screening and referral, and uptake of evidence based recommendations.

While peripartum hysterectomy became more concentrated at high volume and experienced centers over the study period, results from the adjusted analysis suggest limitations to this trend in specific settings. Specifically, patients undergoing peripartum hysterectomy at rural

hospitals and in the Midwest and West were much less likely to deliver at centers with high peripartum hysterectomy volumes. While clinical practice factors may play a role, it is likely that referrals may be restricted by geography. Additionally, historically higher rates of cesarean may result in certain geographic areas being more experienced in peripartum hysterectomy. In our evaluation of peripartum hysterectomy cases on a year-by-year basis of the 183 hospitals that contributed data throughout the study period (**Appendix 1**) only a small handful of hospitals were performing the procedure 4 times per year on a perennial basis. Residing in a part of the country with more residential concentration in close proximity to urban centers, such as the Northeast, may represent a significant factor in undergoing peripartum hysterectomy at a referral center. For at-risk patients delivering at centers with limited referral capabilities, strategies to optimize care such as telemedicine consultation and planning, simulations, and hemorrhage protocols may be critically important.

Strengths of this study include a relatively long study period (9 years) up through 2014, a variety of clinical care setting including rural and urban, low to high volume centers, broad geographical distribution, a large population, and a large number of peripartum hysterectomy cases. In interpreting our data, there are important limitations to consider. First, with this dataset we only evaluated volume and were not able to evaluate specific clinical practices that may best define referral centers with expertise in peripartum hysterectomy. The American College of Obstetricians and Gynecologists recommends that for placenta accreta, “It is important that the delivery be performed in an operating room by an experienced obstetric team that includes an obstetric surgeon, with other surgical specialists, such as urologists, general surgeons, and gynecologic oncologists, available if necessary.”(16) These recommendations are similar to those from the Society for Maternal Fetal Medicine(17) and other expert consensus efforts.(7) Deliveries in a multidisciplinary setting are associated with improved outcomes.(7, 18) While peripartum hysterectomy and delivery volume may be a reasonable surrogate for availability of resources and institutional experience, there may be large differences in care quality and resultant outcomes among centers with similar volume. We are not able to assess surgical technique, the availability of consultants, and multidisciplinary planning strategies.

A second limitation of this manuscript is that we were not able to evaluate clinical management practices that may have affected the peripartum hysterectomy rate. Active management of the third stage, timely use of uterotonics, fluid resuscitation, appropriate use of blood products, and surgical procedures short of hysterectomy may all reduce peripartum hysterectomy risk and may have been a factor in procedure rates apart from referral.(19) In particular, centers with timely access to interventional radiology procedures and more frequent use of balloon tamponade may have performed the procedure less often. A third limitation is that this study is not able to evaluate outpatient care; identification and referral of high risk patients may have occurred differentially across volume centers and could have been a significant factor that we were not able to account for. Fourth, while this data set contains a large number of hospitalizations from diverse clinical settings it is not necessarily representative of the United States as a whole.

In summary, the findings from this study demonstrate increasing peripartum hysterectomy at centers with high delivery volumes and procedural rates. With risk for peripartum hysterectomy increasing in the population, that experienced and high-volume centers saw the largest increases in peripartum hysterectomy rates supports improved referral practices and uptake of evidence based recommendations. Because of geographical limitations, improvements in referral and clinical management strategies may result in improved care for women in urban centers and certain regions of the country differentially.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

A. The rate of delivery hospitalizations complicated by peripartum hysterectomy over the study period for hospitals with >1 year of data. The whiskers demonstrate 95% confidence intervals. $P < .05$. **B.** The rate of delivery hospitalizations complicated by placenta previa with prior cesarean delivery over the study period for hospitals with >1 year of data. The whiskers demonstrate 95% confidence intervals. $P < .05$.

Table 1

Annual range of deliveries per year by time period

	2006-8, n	2012-4, n
<u>By delivery volume quintile</u>		
1 st quintile (4-1320 deliveries)	106,814-108,240	120,035-140,932
2 nd quintile (1301-2187 deliveries)	96,767-98,844	123,244-145,342
3 rd quintile (2200-2931 deliveries)	109,065-116,151	103,511-135,486
4 th quintile (2943-4000 deliveries)	103,676-111,881	113,948-137,334
5 th quintile (4041-9363 deliveries)	106,549-117,045	141,214-152,356
<u>By annual hysterectomy rate</u>		
0 to < 1 per year	131,642-140,758	150,942-183,898
1 to < 2 per year	111,837-112,028	139,273-160,945
2 to < 3 per year	95,652-100,292	97,151-116,932
3 to < 4 per year	72,953-75,096	64,009-80,734
4 to < 5 per year	40,972-41,623	38,484-47,519
5 per year	74,853-77,326	110,280-123,235

Table 2

Demographic characteristics for patients delivering in hospitals contributing 1 year of data

		All patients, n (%)		Placenta previa and prior CS, n(%)		Hysterectomy, n (%)	
All patients		5,388,486		7,337		4,811	
Age, years	15-17	138,399	(2.6)	7	(0.1)	7	(0.1)
	18-24	1,597,268	(29.6)	683	(9.3)	476	(9.9)
	25-34	2,858,324	(53.0)	3,982	(54.3)	2,428	(50.5)
	>=35	794,495	(14.7)	2,665	(36.3)	1,900	(39.5)
Marital	Married	2,643,963	(49.1)	4,294	(58.6)	2,725	(56.6)
	Single	2,096,635	(38.9)	2,133	(29.0)	1,556	(32.3)
	Other/Unknown	647,888	(12.0)	910	(12.4)	530	(11.0)
Race	White	2,882,317	(53.5)	3,723	(50.7)	2,348	(48.8)
	Black	752,314	(14.0)	1,011	(13.8)	873	(18.1)
	Other	1,752,531	(32.5)	2,603	(35.5)	1,590	(33.0)
	Unknown	1,324	(0.0)	0	(0)	0	(0)
Payer	Medicare	40,447	(0.8)	69	(0.9)	61	(1.3)
	Medicaid	2,291,243	(42.5)	2,890	(39.4)	1,957	(40.7)
	Commercial	2,743,966	(50.9)	3,980	(54.2)	2,521	(52.4)
	Uninsured	133,675	(2.5)	176	(2.4)	114	(2.4)
	Unknown	179,155	(3.3)	222	(3.0)	158	(3.3)
Multiple gestation	No	5,286,330	(98.1)	7,150	(97.4)	4,532	(94.2)
	Yes	102,156	(1.9)	187	(2.6)	279	(5.8)
Preexisting diabetes	No	5,338,405	(99.1)	7,204	(98.2)	4,711	(97.9)
	Yes	50,081	(0.9)	133	(1.8)	100	(2.1)
Preexisting hypertension	No	5,270,551	(97.8)	7,068	(96.3)	4,527	(94.1)
	Yes	117,935	(2.2)	269	(3.7)	284	(5.9)
Rurality	Urban	4,873,551	(90.4)	6,879	(93.8)	4,460	(92.7)
	Rural	514,935	(9.6)	458	(6.2)	351	(7.3)
Year	2006	533,367	(9.9)	637	(8.7)	434	(9.0)
	2007	551,637	(10.2)	681	(9.2)	437	(9.1)
	2008	541,665	(10.1)	695	(9.5)	451	(9.4)
	2009	562,883	(10.4)	753	(10.2)	507	(10.5)
	2010	574,333	(10.7)	711	(9.7)	492	(10.2)
	2011	637,628	(11.8)	917	(12.5)	589	(12.2)
	2012	700,308	(13.0)	1,020	(13.9)	681	(14.2)
	2013	673,571	(12.5)	979	(13.3)	617	(12.8)
	2014	613,094	(11.4)	944	(12.9)	603	(12.5)
Teaching	No	3,228,816	(59.9)	3,770	(51.4)	2,349	(48.8)
	Yes	2,159,670	(40.1)	3,567	(48.7)	2,462	(51.2)
Bed Size	<400	2,991,016	(55.5)	3,544	(48.3)	2,230	(46.4)
	400-600	1,400,089	(26.0)	2,104	(28.7)	1,254	(26.1)
	>600	997,381	(18.5)	1,689	(23.0)	1,327	(27.6)

		All patients, n (%)		Placenta previa and prior CS, n(%)		Hysterectomy, n (%)	
All patients		5,388,486		7,337		4,811	
Region	Northeastern	864,715	(16.0)	1,444	(19.7)	910	(18.9)
	Midwest	936,410	(17.4)	1,200	(16.4)	706	(14.7)
	South	2,455,369	(45.6)	3,131	(42.7)	2,374	(49.3)
	West	1,131,992	(21.0)	1,562	(21.3)	821	(17.1)
Mean hysterectomy volume year	<1	1,382,706	(25.7)	1294	(17.6)	549	(11.4)
	1 to <2	1,206,510	(22.4)	1427	(19.4)	855	(17.8)
	2 to <3	951,293	(17.7)	1293	(17.6)	875	(18.2)
	3 to <4	664,450	(12.3)	1043	(14.2)	713	(14.9)
	4 to <5	380,780	(7.1)	685	(9.3)	465	(9.6)
	5	802,747	(14.9)	1595	(21.7)	1354	(28.1)
Delivery volume quintile	1 st	1,078,132	(20.0)	986	(13.4)	680	(14.1)
	2 nd	1,073,018	(19.9)	1274	(17.4)	839 (17.4)	(17.4)
	3 rd	1,081,127	(20.1)	1490	(20.3)	1054 (21.9)	(21.9)
	4 th	1,066,234	(19.8)	1636	(22.3)	1036 (21.5)	(21.5)
	5 th	1,089,975	(20.2)	1951	(3.8)	1202 (25.0)	(25.0)

All comparisons p <0.001

Table 3

Outcomes per 100,000 deliveries by hospital hysterectomy and overall delivery rates

	2006-8	2012-4	Difference in rate 2006-8 to 2012-4	(95% CI)
Cases of placenta previa with prior cesarean delivery per 100,000 delivery hospitalizations				
All centers	122.3	153.4	31.1	(23.4 – 38.8) *
By delivery volume quintile				
1 st quintile (4-1320 deliveries)	80.9	91.7	10.8	(–2.6 – 24.2)
2 nd quintile (1301-2187 deliveries)	93.2	134.8	41.5	(25.4 – 57.6) *
3 rd quintile (2200-2931 deliveries)	140.9	155.6	14.7	(–2.5 – 31.9)
4 th quintile (2943-4000 deliveries)	142.9	192.5	49.5	(29.8 – 69.2) *
5 th quintile (4041-9363 deliveries)	152.9	193.0	40.2	(21.1 – 59.3) *
By annual hysterectomy rate				
0 to < 1 per year	81.4	99.1	17.8	(4.7 – 30.9) *
1 to < 2 per year	104.7	124.5	19.8	(5.0 – 34.6) *
2 to < 3 per year	124.0	154.5	30.5	(12.2 – 48.8) *
3 to < 4 per year	143.4	158.8	15.4	(–6.0 – 36.8)
4 to < 5 per year	150.6	208.2	57.6	(20.4 – 94.8) *
5 per year	168.0	233.3	65.3	(42.9 – 87.7) *
Hysterectomy rate per 100,000 delivery hospitalizations				
All centers	85.3	102.6	17.3	(11.0 – 23.6) *
By delivery volume quintile				
1 st quintile (4-1320 deliveries)	73.1	58.2	–14.9	(–25.6 – –4.2) *
2 nd quintile (1301-2187 deliveries)	67.1	90.2	23	(9.8 – 36.2) *
3 rd quintile (2200-2931 deliveries)	99.0	126.9	27.9	(12.3 – 43.5) *
4 th quintile (2943-4000 deliveries)	102.2	116.8	14.6	(–0.8 – 30.0) *
5 th quintile (4041-9363 deliveries)	85.1	120.5	35.4	(20.3 – 50.5) *
By annual hysterectomy rate				
0 to < 1 per year	42.6	42.7	0.1	(–8.5 – 8.7)
1 to < 2 per year	67.2	72.0	4.8	(–6.5 – 16.1)
2 to < 3 per year	83.5	100.0	16.4	(1.7 – 31.1) *
3 to < 4 per year	100.2	120.2	20	(1.4 – 38.6) *
4 to < 5 per year	128.9	147.0	18.1	(–13.1 – 49.3)
5 per year	137.0	189.3	52.3	(32.2 – 72.4) *

* p < 0.05

Table 4

Peripartum hysterectomies for atony per 100,000 delivery hospitalizations

	2006-8	2012-4	Difference in rate 2006-8 to 2012-4	(95% CI)
All centers	33.1	41.1	8.1	(4.1 – 12.1) *
By delivery volume quintile				
1 st quintile (4-1320 deliveries)	31.0	25.8	-5.2	(-12.3 – 1.9)
2 nd quintile (1301-2187 deliveries)	29.5	46.6	17.1	(7.6 – 26.6) *
3 rd quintile (2200-2931 deliveries)	40.4	53.4	13.0	(2.9 – 23.1) *
4 th quintile (2943-4000 deliveries)	34.5	36.8	2.3	(-6.3 – 10.9)
5 th quintile (4041-9363 deliveries)	30.1	42.5	12.4	(3.4 – 21.4) *
By annual hysterectomy rate				
0 to < 1 per year	23.5	21.8	-1.7	(-7.8 – 4.4)
1 to < 2 per year	23.6	36.7	13.2	(5.1 – 21.3) *
2 to < 3 per year	40.4	42.6	2.2	(-7.4 – 11.8)
3 to < 4 per year	40.5	47.6	7.1	(-4.6 – 18.8)
4 to < 5 per year	51.2	61.2	10.0	(-10.2 – 30.2)
5 per year	37.2	57.6	20.5	(9.4 – 31.6) *

*
p < 0.05

Table 5

Univariate and adjusted models for undergoing peripartum hysterectomy at hospitals with mean volume 4

		Hysterectomy cases by annual hospital hysterectomy rate		Multivariable model of delivery at hospitals performing 4 cases/year	
		4 cases, n (%)	<4 cases, n (%)	Risk ratio	95% confidence interval
Total hysterectomies		1,819 (37.8%)	2,992 (62.2%)		
Age *,years	15-17	2 (28.6%)	5 (71.4%)	0.78	NA
	18-24	162 (34.0%)	314 (66.0%)	1.03	(0.92-1.15)
	25-34	870 (35.8)	1,558 (64.2)	Referent	
	>=35	785 (41.3)	1,115 (58.7)	0.92	(0.67-1.25)
Marital *	Married	1,020 (37.4)	1,705 (62.6)	Referent	
	Single	572 (36.8)	984 (63.2)	1.01	(0.90-1.13)
	Other/Unknown	227 (42.8)	303 (57.2)	1.03	(0.88-1.21)
Race **	White	808 (34.4)	1,540 (65.6)	Referent	
	Black	387 (44.3)	486 (55.7)	1.19	(1.05-1.36)
	Other	624 (39.2)	966 (60.8)	1.19	(1.06-1.33)
Payer	Medicare	19 (31.1)	42 (68.9)	0.99	(0.62-1.58)
	Medicaid	735(37.6)	1,222 (62.4)	1.00	(0.89-1.13)
	Commercial	958 (38)	1,563 (62)	Referent	
	Uninsured	42 (36.8)	72 (63.2)	1.00	(0.73-1.37)
	Unknown	65 (41.1)	93 (58.9)	1.01	(0.76-1.33)
Multiple Gestation *	No	1,692 (37.3)	2,840 (62.7)	Referent	
	Yes	127 (45.5)	152 (54.5)	1.23	(1.03-1.48)
Placenta previa with prior cesarean **	No	1320 (34.9)	2457 (65.1)	Referent	
	Yes	499 (48.3)	535 (51.7)	1.35	(1.22-1.50)
Preexisting Diabetes *	No	1,770 (37.6)	2,941 (62.4)	Referent	
	Yes	49 (49)	51 (51)	1.23	(0.93-1.64)
CHTN *	No	1,690 (37.3)	2,837 (62.7)	Referent	
	Yes	129 (45.4)	155 (54.6)	1.13	(0.94-1.36)
Urban/rural **	Urban	1,803 (40.4)	2,657 (59.6)	8.05	(4.91-13.19)
	Rural	16 (4.6)	335 (95.4)	Referent	
Year **	2006	148 (34.1)	286 (65.9)	Referent	
	2007	138 (31.6)	299 (68.4)	0.94	(0.74-1.18)
	2008	168 (37.3)	283 (62.7)	1.09	(0.87-1.35)
	2009	189 (37.3)	318 (62.7)	1.07	(0.86-1.32)
	2010	176 (35.8)	316 (64.2)	1.05	(0.84-1.30)
	2011	196 (33.3)	393 (66.7)	0.98	(0.79-1.22)
	2012	269 (39.5)	412 (60.5)	1.16	(0.95-1.42)
	2013	267 (43.3)	350 (56.7)	1.23	(1.00-1.50)
	2014	268 (44.4)	335 (55.6)	1.28	(1.05-1.57)
Region **	Northeastern	495 (54.4)	415 (45.6)	Referent	
	Midwest	153 (21.7)	553 (78.3)	0.43	(0.36-0.51)

Hysterectomy cases by annual hospital hysterectomy rate			Multivariable model of delivery at hospitals performing 4 cases/year	
	4 cases, n (%)	<4 cases, n (%)	Risk ratio	95% confidence interval
South	984 (41.4)	1,390 (58.6)	0.86	(0.77-0.96)
West	187 (22.8)	634 (77.2)	0.46	(0.39-0.55)

The adjusted model included all of the factors included in above table.

*
P<0.05

**
p<0.01 for univariate comparisons; *CHTN*, chronic hypertension