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The impact of hospital obstetric volume on maternal outcomes in term, non-low-birthweight pregnancies

Jonathan M. Snowden, PhD¹, Yvonne W. Cheng, MD, PhD², Cathy L. Emeis, CNM, PhD³, and Aaron B. Caughey, MD, PhD¹

¹Department of Obstetrics & Gynecology, Oregon Health & Science University, Portland, OR

²Department of Obstetrics, Gynecology, California Pacific Medical Center, San Francisco, CA

³School of Nursing, Oregon Health & Science University, Portland, OR

Abstract

Objective—The impact of hospital obstetric volume specifically on maternal outcomes remains under-studied. We examined the impact of hospital obstetric volume on maternal outcomes in low-risk women delivering non-low-birthweight infants at term.

Study Design—We conducted a retrospective cohort study of term, singleton, non-low-birthweight live births between 2007 – 2008 in California. Deliveries were categorized by hospital obstetric volume categories, separately for non-rural hospitals (Category 1: 50 – 1,199 deliveries per year; Category 2: 1,200 – 2,399; Category 3: 2,400 – 3,599, and Category 4: 3,600) and rural hospitals (Category R1: 50 – 599 births per year; Category R2: 600 – 1,699; Category R3: 1,700). Maternal outcomes were compared using the chi-square test and multivariable logistic regression.

Results—There were 736,643 births in 267 hospitals that met study criteria. After adjusting for confounders, there were higher rates of postpartum hemorrhage in the lowest-volume rural hospitals (Category R1 aOR 3.06; 95% CI 1.51 – 6.23). Rates of chorioamnionitis, endometritis, severe perineal lacerations, and wound infection did not differ between volume categories. Longer lengths of stay were observed after maternal complications (e.g., chorioamnionitis) in the lowest-volume hospitals (16.9% prolonged length of stay in Category 1 hospitals versus 10.5% in Category 4 hospitals; aOR, 1.91; 95% CI, 1.01 – 3.61).

Conclusion—After confounder adjustment, few maternal outcomes differed by hospital obstetric volume. However, elevated odds of postpartum hemorrhage in low-volume rural hospitals raises the possibility that maternal outcomes may differ by hospital volume and

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Corresponding author: Jonathan M. Snowden, PhD, Department of Obstetrics & Gynecology, Oregon Health & Science University, 3181 SW Sam Jackson Park Rd, Mail Code L466, Portland, OR 97239, Phone: (503) 494-0904, Fax: (503) 494-4473, Cell: (650) 704-9967, snowden@ohsu.edu.

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All authors declare that we have no perceived or real competing interests.

geography. Further research is needed on maternal outcomes in hospitals of different obstetric volumes.

Keywords

delivery complications; health care systems; health facility size; maternal infection rates; obstetrics

Introduction

A wide range of factors likely affect obstetric outcomes for low-risk women delivering in hospitals.^{1,2} For example, hospital-level factors including ownership, obstetric provider and nursing staffing, and delivery volume are increasingly known to affect perinatal outcomes.^{3–7} Hospital obstetric volume is one hospital factor that has received research attention in recent years, with some studies demonstrating increased rates of adverse perinatal outcomes at the extremes of annual delivery volume.^{8–13} Several of these studies were conducted outside of the United States, some focused on one or two outcomes (some exclusively neonatal), and some did not stratify by maternal risk profile.

The impact of hospital volume on neonatal outcomes has been well studied in very low-birthweight infants,^{14–17} leading to evidence-based recommendations for neonatal regionalization and designated levels of neonatal intensive care.¹⁸ Perinatal regionalization gained widespread attention with the 1976 publication of the landmark March of Dimes report *Toward Improving the Outcome of Pregnancy*,¹⁹ and can be defined as “a systematized cohesive regional network in which the complexity of patient needs determines where and by whom care should be provided.”²⁰ In contrast with neonatal outcomes, maternal outcomes have not yet been studied in the same level of detail, particularly in the larger population of pregnant women delivering non-low-birthweight infants at term.²¹ This evidence gap is especially pressing given the increasing prevalence of severe maternal complications (e.g., postpartum hemorrhage) and maternal mortality in the developed world.^{22, 23} Further, the birth setting and obstetric care that specifically optimize maternal outcomes may not be identical to those that optimize outcomes for their neonates.²⁴ Because a policy of regionalization must take into account both maternal and fetal/neonatal outcomes, it is crucial to advance our understanding of maternal outcomes across different hospital settings and characteristics including obstetric volumes. It was our aim to help fill this gap regarding hospital volume for a variety of maternal outcomes in low-risk women.

To address this gap, we analyzed the association between annual hospital obstetric volume and various maternal complications of hospitalization. We conducted a retrospective cohort study of births in the state of California between 2007 and 2008, analyzing linked vital statistics data and hospital discharge data. We categorized hospitals by annual delivery volume and analyzed rates of maternal outcomes across categories to provide evidence on the impact of hospital obstetric volume specifically on maternal outcomes. We restricted our sample to the population of women delivering a non-low-birthweight infant at term without certain preexisting medical conditions, to inform the dialogue on optimal birth setting for

low-risk women. We hypothesized that obstetric complications would be more frequent in the highest and lowest-volume hospitals.

Materials and Methods

This was a retrospective cohort study of California deliveries in 2007 – 2008, using linked vital statistics/patient discharge data. The California Patient Discharge Data, Vital Statistics Birth Certificate Data, and Vital Statistics Death Certificate data are linked and maintained by the Office of Statewide health Planning and Development (OSHPD), Healthcare Information Resource Center, under the California Health and Human Services Agency (CHHS).²⁵ The dataset contains patient discharge data (diagnosis and procedure codes) for antepartum admissions in the 9 months prior to delivery, and maternal and infant admissions in the year after delivery, as well as data from the US Standard Certificate of Live Birth. Maternal and infant records were linked using the record linkage number, a unique, encrypted alphanumeric code specific to each mother/baby pair. Reporting of births in California is almost 100% comprehensive, with CHHS personnel coding the data according to uniform specifications, performing rigorous quality checks, and reviewing the birth cohort file before it is released. We obtained human subjects approval from the Committee on Human Research at the University of California, San Francisco, the California OSHPD Committee for the Protection of Human Subjects, and the Institutional Review Board at Oregon Health & Science University. The linked dataset did not contain potential patient privacy/identification information, so informed consent was exempted.

Considerations of hospital volume and obstetric regionalization depend on hospital geography.²⁶ Rural labor & delivery units face a unique set of issues in assuring patient safety, and regionalization/high obstetric volume may not be feasible for such hospitals.^{27, 28} Rural hospitals account for a substantial proportion of hospitals in our study (27%) but only a small fraction of births (8%). This reflects the marked difference in distribution of delivery volume for rural versus non-rural hospitals: volumes are lower in rural hospitals (often by a factor of 3 – 5), with key demographic and health-related differences between populations of women served.^{29,30} To reflect these distinct distributions, and to assess for effect modification by rurality, we conducted a geography-stratified analysis with a separate definition of “low rural volume.” Maternity hospital rurality was defined based on OSHPD rural hospital designations, presence of a California Association of Rural Health Clinics member clinic, and/or rural zip code according to the Rural-Urban Commuting Area-2 codes.¹¹

Annual hospital obstetric volume was categorized using previously published volume categories.¹¹ For non-rural maternity hospitals, the categories were: 50 – 1,199 deliveries per year (Category 1), 1,200 – 2,399 deliveries (Category 2), 2,400 – 3,599 deliveries (Category 3), and 3,600 or more deliveries per year (Category 4). Rural hospitals were divided using separate, previously published volume categories: 50 – 599 births per year (Category R1), 600 – 1,699 births (Category R2), and 1,700 or more births per year (Category R3). Further, we compared outcomes between rural and non-rural hospitals with the lowest obstetric volume (< 1,000 annual delivery), to help tease out the effect of low absolute volume versus geography.

To define a population of relatively low-risk deliveries, we restricted analyses to women carrying a singleton, vertex-presenting fetus at term. We excluded low birthweight infants (birthweight <2,500 grams) and fetuses with chromosomal or anatomical anomalies (defined by the birth certificate and International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9] codes 740 – 759.9). Women with preexisting diabetes and chronic hypertension (as defined by ICD-9 codes) were also excluded, as were women with a prior cesarean. All exclusions were conducted after calculating hospital obstetric volume.

We compared rates of outcomes across hospital volume categories separately for rural and non-rural hospitals. The following maternal quality outcomes were analyzed as outcomes: chorioamnionitis, endometritis, postpartum hemorrhage (overall and stratified by spontaneous vaginal delivery, operative vaginal delivery, and cesarean delivery), transfusion of blood products, severe perineal lacerations (3rd and 4th degree) in spontaneous vaginal deliveries, wound infection in cesarean deliveries, and the cesarean delivery rate in the nulliparous, term, singleton, vertex population. The final outcome was prolonged length of stay (LOS, as indicated in the discharge data), which was defined as maternal LOS > 3 days for vaginal deliveries and LOS > 5 days for cesarean deliveries. The ICD-9 codes listed in Table 1 were used to define chorioamnionitis, endometritis, postpartum hemorrhage, blood transfusion, severe perineal lacerations, and wound infection. Mode of delivery and parity were derived from birth certificate data. Maternal mortality was not recorded in the database.

Unadjusted comparisons between volume categories were calculated using the chi-square test. We used multivariable logistic regression models to assess the association between obstetric volume category and outcomes, controlling for confounding. We adjusted for the following potential confounders: advanced maternal age (≥ 35 years versus <35), maternal education (≥ 12 years versus <12), maternal race/ethnicity, maternal public insurance status, prenatal care initiation (first trimester versus later), teaching hospital, and where appropriate, parity (nulliparous versus multiparous). Covariates were selected for inclusion in the model based on *a priori* subject matter knowledge. Models adjusted for hospital-level clustering of outcomes using the clustered Huber/White variance estimator,³¹ and calculated robust standard errors.

Finally, we were interested in whether the management of maternal complications differed between hospital volume categories. Therefore, we calculated the rate of prolonged length of stay after maternal complications (chorioamnionitis, endometritis, and postpartum hemorrhage). We compared the rates of prolonged length of stay following maternal complications across volume categories in non-rural hospitals (cell sizes were too small in rural hospitals). We estimated adjusted associations using multivariable logistic regression, as described above. In all analyses, statistical significance was indicated by a P-value of <0.05 and/or 95% confidence intervals (CI).

Power calculations revealed substantial power to detect modest differences (OR=1.3) in even the rarest outcome (blood transfusion) between volume categories in non-rural hospitals (power=98%). For outcomes stratified by mode of delivery, power was in some cases lower (e.g., 77% power to detect an OR of 1.5 for wound infection after cesarean

delivery), although still substantial for some outcomes (e.g., >99% for postpartum hemorrhage in cesarean deliveries). Power was lower but still substantial in the rural analyses (e.g., 82% percent power to detect an OR of 1.5 for transfusion). For rural analysis stratified by mode of delivery, we were under-powered for some outcomes (e.g., 24% power to detect OR=1.5 for wound infection) but not for others (e.g., 83% power to detect OR=1.5 for postpartum hemorrhage after cesarean delivery). Power was sufficient for prolonged LOS after maternal complications in non-rural hospitals (e.g., 82% power to detect OR=1.3 for postpartum hemorrhage), but insufficient in rural hospitals (e.g., 12% power). We therefore restricted the length of stay analyses to non-rural hospitals.

Results

There were a total of 267 maternity hospitals in California meeting study criteria, with a total of 736,643 deliveries. 211 hospitals with 678,622 deliveries were located in non-rural locations, and 56 hospitals were located in rural locations, with 58,021 deliveries (Table 2). The larger hospitals in Categories 3 and 4 cared for more Black and Asian-American women compared to the smallest hospitals (Categories 1 and 2), which cared for a larger share of white women (Categories 1 and 2, 30% white; Categories 3 and 4, 25% white). In rural hospitals, the higher-volume hospitals (Category R3) cared for predominantly Hispanic women with lower educational attainment (73% Hispanic, 22% education $\leq$ 12 years), compared to the lowest-volume rural hospitals in Category R1 whose patient populations were majority white (55% white, 38% education $\leq$ 12 years).

In unadjusted analyses, hospital obstetric volume was associated with multiple outcomes. Rates of chorioamnionitis, endometritis, postpartum hemorrhage, and severe lacerations differed significantly for non-rural hospitals (Table 3, $P < 0.001$). The magnitude of these differences was small (frequently $< 1\%$), and generally favored lower-volume hospitals when a pattern was apparent (e.g., in chorioamnionitis and postpartum hemorrhage after cesarean delivery).

Significant differences were also observed in unadjusted analysis across rural hospital volume categories (Table 4). Postpartum hemorrhage decreased with increasing obstetric volume. The overall hemorrhage rates decreased from 4.5% in Category R1 hospitals to 1.7% in Category R3 hospitals; for operative vaginal deliveries the decrease was 6.2% to 2.6% (both $P < 0.001$).

After adjusting for confounders, there were few significant differences between volume categories in non-rural hospitals (Table 5). The odds of blood transfusion were significantly higher in Category 2 hospitals (odds ratio [OR] compared to Category 4, 1.30; 95% confidence interval [CI], 1.03 – 1.66). For all other outcomes, 95% CIs included one, and effect sizes were generally small (mostly 0.8 – 1.4). In rural hospitals, odds of postpartum hemorrhage remained elevated in low-volume hospitals after adjusting for confounders in the regression models (Table 6). The overall odds of postpartum hemorrhage was three-fold higher in the lowest-volume hospitals compared to the highest-volume (Category R1 OR, 3.06; 95% CI, 1.52 – 6.62). Adjusted odds of postpartum hemorrhage were two-fold higher in medium-volume rural hospitals compared with highest-volume (Category R2 OR 1.95;

95% CI, 1.00 – 3.81). These increased risks of postpartum hemorrhage were also observed in models stratified by mode of delivery. There were no other differences for the other outcomes between rural volume categories.

We compared outcomes across rural versus non-rural hospitals with low obstetric volume (< 1,000 annual deliveries, Table 7). In adjusted analyses, rural hospital geography was a risk factor for postpartum hemorrhage overall (OR, 1.96; 95% CI, 1.22 – 3.17) and stratified by mode of delivery. Adjusted odds of blood transfusion were also elevated in rural low-volume hospitals, compared to non-rural low-volume hospitals (OR, 1.76; 95% CI, 1.18 – 2.61). NTSV cesarean delivery was less common in rural hospitals with low volume (OR, 0.73; 95% CI, 0.59 – 0.92).

When considering the rate of prolonged length of stay after maternal complication in non-rural hospitals, rates were generally increased in the lowest- volume hospitals (Category 1). The rate of prolonged LOS after chorioamnionitis was 16.9% in Category 1 hospitals, as compared to 10.5% in Category 4 hospitals ($P<0.001$, Table 8). For prolonged LOS after endometritis, the difference was 30.8% in Category 1 hospitals versus 22.8% in Category 4 hospitals ($P<0.001$). There was no difference in the case of postpartum hemorrhage. These differences persisted after multivariable adjustment in the lowest-volume hospitals (chorioamnionitis OR, 1.91; 95% CI, 1.01 – 3.61; endometritis OR, 1.50; 95% CI, 1.00 – 2.23).

Comment

In this large retrospective cohort of term, non-low-birthweight California deliveries, we observed some differences in maternal quality outcomes by hospital volume category. The lowest-volume and medium-volume rural hospitals exhibited higher rates of postpartum hemorrhage compared to higher-volume rural hospitals, a difference that persisted after confounder adjustment. While most outcomes did not differ in non-rural hospitals, rates of prolonged LOS after chorioamnionitis and endometritis did differ by volume category. Specifically, the lowest-volume hospitals exhibited higher rates of prolonged LOS, suggesting that management of these maternal complications is different in low-volume hospitals. Perhaps these findings reflect different levels of provider coverage, resource availability, and preparedness for unexpected events.^{28,32} Future research should further analyze the impact of hospital-level factors on management of maternal complications, and examine the factors that may explain these differences. These findings add to the small body of literature on maternal complications and hospital-level factors. One prior study using the National Inpatient Sample found no consistent association between hospital obstetric volume and maternal complications.⁹ In contrast, one study found increased rates of adverse maternal outcomes in very low-volume hospitals, and in the highest-volume hospitals for cesarean deliveries;¹⁰ another study found increased rates of obstetric infection in teaching hospitals and hospitals with higher numbers of beds.⁷ Several design and analysis differences could explain these differences: different study populations/states, modeling approaches, and outcome definitions. The lack of agreement between studies highlights the importance of additional research on maternal complications associated with hospital volume and regionalization.

Our study is not without limitations. We analyzed administrative data, which are not collected for research purposes and are recorded with variable reliability and accuracy.^{33,34} Nevertheless, for topics such as this where randomization is not feasible and large samples are required, administrative data may be the best option. Although California is a large and racially diverse state, these findings may not be generalizable to other regions with different hospital policies, obstetric practice, and populations. We analyzed the most recent data we have available, however safety and quality initiatives have been instituted since 2008. Our definition of low-risk excluded low-birthweight and preterm deliveries and women with preexisting medical conditions. There are varying definitions of “low-risk” and seemingly low-risk pregnancies may become high-risk in the prenatal period or intrapartum. The definition of low-risk is an open question in obstetric/perinatal research, and the definitions should continue to be refined as research in this area progresses.¹ Our system of categorizing hospitals relied on arbitrary obstetric volume cutoffs. Cutoffs were chosen to maintain adequate numbers of births and unique hospitals in each category, and using another categorization systems may alter results. Lastly, our database lacks information on the staffing factors, physical space and equipment, and availability of ancillary resources (e.g., blood products) that might explain differences between obstetric volumes and geography.

This study adds to the growing literature on hospital obstetric volume and maternal outcomes in low-risk deliveries. We found that most obstetric complications did not differ between hospitals of varying volumes after adjustment for maternal characteristics. However, it is noteworthy that rates of postpartum hemorrhage were elevated in low-volume rural hospitals, especially given that this outcome is a leading cause of preventable maternal mortality.³⁵ There is still insufficient evidence to determine if there are meaningful differences in maternal outcomes by hospital-level factors. Future research should analyze this study question across a variety of populations and hospital settings. Where differences in maternal outcomes exist, it will be important to consider clinical approaches, hospital policies, and potentially systemic strategies (e.g., regionalization) to remediate disparities and ensure a universally high quality of maternity care. By furthering our understanding of maternal outcomes and maternal preferences of varying birth settings, we can enable clinicians, hospital administrators, and mothers to make fully informed decisions.

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Table 1

ICD-9 codes for maternal complications

Outcome	ICD-9 codes
Chorioamnionitis	658.4, 658.40, 658.41, 658.43, 762.7
Endometritis	670, 670.00, 670.02, 670.04, 670.1, 670.10, 670.12, 670.14, 672, 672.00, 672.02, 672.04
Postpartum hemorrhage	285.1, 666, 666.0, 666.00, 666.02, 666.04, 666.1, 666.10, 666.12, 666.14, 666.2, 666.20, 666.22, 666.24, 666.3, 666.30, 666.32, 666.34
Transfusion of blood products	99.00, 99.01, 99.02, 99.03, 99.04, 99.05, 99.06, 99.07, 99.08, 99.09
Severe perineal lacerations (3 rd or 4 th degree)	664.2, 664.20, 664.21, 664.24, 664.3, 664.30, 664.31, 664.34, 664.60, 664.61, 664.64
Wound infection	674.3, 674.30, 674.32, 674.34

Table 2

Maternal characteristics by hospital obstetric volume categories (percent)

	Non-rural					Rural			
	Overall	Hospital volume category				Overall	Hospital volume category		
		1 50–1,199	2 1,200– 2,399	3 2,400– 3,599	4 3,600		R1 50–599	R2 600–1,699	R3 1,700
	Overall	N=48,450 n=49	N=164,372 n=69	N=183,573 n=48	N=282,227 n=45	N=58,021 births n=56 hospitals	N=17,742 n=35	N=17,699 n=14	N=22,580 n=7
Nulliparous	46.8	44.4	47.3	45.6	47.6	43.0	45.4	43.0	41.1
Advanced maternal age	15.1	14.9	15.6	13.4	16.0	8.5	9.1	9.0	7.7
Public insurance	49.2	56.1	45.5	50.4	49.4	69.2	64.1	70.4	71.7
Education 12 years	47.2	43.3	48.2	44.4	49.0	30.2	38.1	32.7	22.1
Prenatal care initiated in 1 st trimester	83.6	80.2	82.0	83.2	85.5	70.5	73.7	68.2	69.7
Race/ethnicity									
White	26.3	28.1	30.5	24.0	25.1	33.2	55.0	29.3	19.2
Black	4.9	4.0	4.1	5.3	5.2	2.4	2.4	0.8	3.6
Hispanic	54.0	55.6	53.1	56.6	52.5	58.7	34.2	65.2	72.9
Asian-American	12.9	10.2	10.2	12.1	15.3	2.7	3.1	2.0	3.0
Other	2.1	2.1	2.1	1.9	2.0	2.9	5.3	2.7	1.3

Table 3
Rates of maternal outcomes across non-rural hospital volume categories (percent)

	Non-rural Hospital volume category				P-value
	1 50–1,199	2 1,200–2,399	3 2,400–3,599	4 3,600	
Chorioamnionitis	1.8	2.0	2.5	2.2	<0.001
Endometritis	0.5	0.5	0.8	0.7	<0.001
Postpartum hemorrhage					
Overall	2.9	2.7	2.9	2.8	<0.001
Spontaneous vaginal delivery	2.9	2.6	2.7	2.7	<0.087
Operative vaginal delivery	3.7	3.3	3.7	3.8	0.160
Cesarean delivery	2.6	2.8	4.1	3.1	<0.001
Blood transfusion	0.5	0.6	0.6	0.5	<0.001
Severe perineal lacerations (spontaneous vaginal delivery)	2.3	2.4	2.6	2.8	<0.001
Wound infection (cesarean delivery)	0.7	0.6	0.7	0.6	0.268
Prolonged length of stay ^a	2.8	2.7	2.3	2.5	<0.001
NTSV cesarean delivery	28.1	26.8	25.1	27.8	<0.001

^a Prolonged length of stay: < 3 days for vaginal deliveries; ≥ 5 days for cesarean deliveries

Abbreviations: NTSV, nulliparous, term, singleton, vertex

Table 4

Rates of maternal outcomes across rural hospital volume categories (percent)

	Rural Hospital volume category			
	R1 50–5,99	R2 600–1,699	R3 1,700	P-value
Chorioamnionitis	0.7	0.8	0.7	0.561
Endometritis	0.5	0.5	0.4	0.312
Postpartum hemorrhage				
Overall	4.5	3.3	1.7	<0.001
Spontaneous vaginal delivery	4.4	3.3	1.7	<0.001
Operative vaginal delivery	6.2	5.2	2.6	<0.001
Cesarean delivery	4.1	2.6	2.0	<0.001
Blood transfusion	0.7	0.6	0.6	0.442
Severe perineal lacerations (spontaneous vaginal delivery)	2.1	1.6	2.3	<0.001
Wound infection (cesarean delivery)	0.6	0.9	0.6	0.260
Prolonged length of stay ^a	1.8	1.6	1.2	<0.001
NTSV cesarean delivery	24.9	26.4	24.0	0.003

^aProlonged length of stay: >3 days for vaginal deliveries; >5 days for cesarean deliveries

Abbreviations: NTSV, nulliparous, term, singleton, vertex

Table 5Logistic regression results ^a of maternal outcomes in non-rural hospitals

	Non-rural Hospital volume category			
	1 50–1,199	2 1,200–2,399	3 2,400–3,599	4 3,600
Chorioamnionitis	1.13 (0.74, 1.74)	1.13 (0.79, 1.60)	1.36 (0.94, 1.95)	Ref.
Endometritis	1.07 (0.73, 1.55)	0.94 (0.70, 1.26)	1.40 (1.00, 1.96)	Ref.
Postpartum hemorrhage				
Overall	1.29 (0.92, 1.81)	1.14 (0.86, 1.52)	1.22 (0.86, 1.74)	Ref.
Spontaneous vaginal delivery	1.32 (0.95, 1.83)	1.15 (0.88, 1.52)	1.15 (0.83, 1.57)	Ref.
Operative vaginal delivery	1.16 (0.81, 1.67)	0.94 (0.67, 1.32)	1.09 (0.74, 1.61)	Ref.
Cesarean delivery	1.22 (0.76, 1.97)	1.15 (0.75, 1.76)	1.62 (0.92, 2.83)	Ref.
Blood transfusion	1.02 (0.76, 1.36)	1.30 (1.03, 1.66)	1.19 (0.94, 1.51)	Ref.
Severe perineal lacerations (spontaneous vaginal delivery)	1.01 (0.83, 1.23)	0.94 (0.82, 1.09)	1.04 (0.87, 1.24)	Ref.
Wound infection (cesarean delivery)	1.41 (0.87, 2.29)	1.03 (0.75, 1.42)	1.28 (0.88, 1.84)	Ref.
Prolonged length of stay ^b	1.41 (0.94, 2.13)	1.27 (0.97, 1.66)	1.06 (0.79, 1.42)	Ref.
NTSV cesarean delivery	1.02 (0.85, 1.22)	0.93 (0.81, 1.06)	0.88 (0.78, 1.00)	Ref.

^a Results are presented as adjusted odds ratio (95% confidence interval). Models controlled for maternal race/ethnicity, education, age, prenatal care, insurance status, and teaching hospital. Where appropriate, models controlled for parity. Models estimated robust standard errors accounting for hospital-level clustering.

^b Prolonged length of stay: >3 days for vaginal deliveries; >5 days for cesarean deliveries

Abbreviations: NTSV, nulliparous, term, singleton, vertex

Table 6Logistic regression results ^a of maternal outcomes in rural hospitals

	Rural Hospital volume category		
	R1 50–5,99	R2 600–1,699	R3 1,700
Chorioamnionitis	1.18 (0.66, 2.08)	1.13 (0.58, 2.22)	Ref.
Endometritis	1.69 (0.99, 2.87)	1.36 (0.71, 2.58)	Ref.
Postpartum hemorrhage			
Overall	3.06 (1.51, 6.23)	1.95 (1.00, 3.81)	Ref.
Spontaneous vaginal delivery	3.17 (1.52, 6.62)	2.06 (1.00, 4.22)^b	Ref.
Operative vaginal delivery	2.76 (1.17, 6.50)	2.12 (1.07, 4.23)	Ref.
Cesarean delivery	2.65 (1.30, 5.43)	1.40 (0.64, 3.09)	Ref.
Blood transfusion	1.35 (0.91, 2.00)	1.00 (0.57, 1.74)	Ref.
Severe perineal lacerations (spontaneous vaginal delivery)	1.01 (0.68, 1.53)	0.67 (0.44, 1.01)	Ref.
Wound infection (cesarean delivery)	1.41 (0.63, 3.15)	1.57 (0.67, 3.67)	Ref.
Prolonged length of stay ^c	1.20 (0.78, 1.86)	1.22 (0.73, 2.03)	Ref.
NTSV cesarean delivery	1.08 (0.78, 1.51)	1.11 (0.76, 1.64)	Ref.

^a Results are presented as adjusted odds ratio (95% confidence interval). Models controlled for maternal race/ethnicity, education, age, prenatal care, and insurance status. Where appropriate, models controlled for parity. Models estimated robust standard errors accounting for hospital-level clustering.

^b Confidence interval includes the null value because of rounding; P=0.049

^c Prolonged length of stay: >3 days for vaginal deliveries; >5 days for cesarean deliveries

Abbreviations: NTSV, nulliparous, term, singleton, vertex

Table 7

Comparison of maternal outcomes by hospital geography (rural vs. non-rural) in low-volume hospitals ^a

	Unadjusted ^b			Adjusted ^c	
	Rural N=45 hospitals n=28,393 births	Non-rural N=38 hospitals n=32,811 births	P-value	Rural	Non-rural
Chorioamnionitis	0.8	1.3	<0.001	0.77 (0.50, 1.19)	Ref.
Endometritis	0.5	0.4	0.142	1.52 (0.97, 2.38)	Ref.
Postpartum hemorrhage					Ref.
Overall	4.4	2.6	<0.001	1.96 (1.22, 3.17)	Ref.
Spontaneous vaginal delivery	4.3	2.7	<0.001	1.80 (1.13, 2.87)	Ref.
Operative vaginal delivery	6.1	3.1	<0.001	2.39 (1.21, 4.70)	Ref.
Cesarean delivery	4.2	2.2	<0.001	2.51 (1.34, 4.69)	Ref.
Blood transfusion	0.7	0.4	<0.001	1.76 (1.18, 2.61)	Ref.
Severe perineal lacerations (spontaneous vaginal delivery)	2.3	2.4	0.129	1.00 (0.75, 1.31)	Ref.
Wound infection (cesarean delivery)	0.7	0.6	0.532	1.10 (0.56, 2.16)	Ref.
Prolonged length of stay ^d	1.8	1.9	0.188	0.87 (0.62, 1.22)	Ref.
NTSV cesarean delivery	23.4	30.3	<0.001	0.73 (0.59, 0.92)	Ref.

^aHospitals with annual delivery volume 1,000

^bUnadjusted results are percentages

^cAdjusted results are adjusted odds ratio (95% confidence interval). Models controlled for maternal race/ethnicity, education, age, prenatal care, insurance status, and parity. Models estimated robust standard errors accounting for hospital-level clustering.

^dProlonged length of stay: >3 days for vaginal deliveries; >5 days for cesarean deliveries

Abbreviations: NTSV, nulliparous, term, singleton, vertex

Table 8

Prolonged lengths of stay ^a after maternal complications in non-rural hospitals, stratified by volume category (percent)

	Category 1 50 – 1,199	Category 2 1,200 – 2,399	Category 3 2,400 – 3,599	Category 4 3,600	P-value
Unadjusted^b					
Chorioamnionitis	16.9	12.1	10.2	10.5	<0.001
Endometritis	30.8	23.1	19.7	22.8	0.001
Postpartum hemorrhage	10.1	10.2	10.0	9.7	0.230
Adjusted^c					
Chorioamnionitis	1.91 (1.01, 3.61)	1.28 (0.92, 1.80)	1.10 (0.79, 1.51)	Ref.	-
Endometritis	1.50 (1.00, 2.23)^d	1.07 (0.81, 1.42)	0.86 (0.67, 1.11)	Ref.	-
Postpartum hemorrhage	1.30 (0.88, 1.91)	1.23 (0.96, 1.57)	1.13 (0.88, 1.43)	Ref.	-

^a Prolonged length of stay: >3 days for vaginal deliveries; >5 days for cesarean deliveries

^b Unadjusted results are percentages

^c Adjusted results are adjusted odds ratio (95% confidence interval). Models controlled for maternal race/ethnicity, education, age, prenatal care, insurance status, parity, and teaching hospital. Models estimated robust standard errors accounting for hospital-level clustering.

^d Confidence interval includes the null value because of rounding; P=0.048