Effect of Academic Affiliation and Obstetric Volume on Clinical Outcome and Cost of Childbirth

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Objective: To determine whether the academic affiliation and obstetric volume of the delivering hospital has an impact on clinical and economic outcomes.

Methods: We performed a cross-sectional analysis of data for all births in the State of Maryland during 1996. Acute hospital discharge data were obtained from the publicly available Maryland Health Services Cost Review Commission database. Institutions were classified as community hospitals, community teaching hospitals, and academic medical centers. Principal outcome variables included cesarean birth and complication rates, total hospital charges, and length of stay.

Results: A total of 63,143 cases were identified for analysis. The cesarean delivery rate was lower among academic medical centers, compared with community teaching hospitals and community hospitals (18.4% compared with 24.3% and 21.2%, respectively). After adjustment for patient case-mix, the adjusted odds ratio (OR) for cesarean birth was 0.66 at academic medical centers and 1.23 at community teaching hospitals compared with community hospitals ($P < .01$). Rates of episiotomy and serious complications were lower at academic medical centers compared with community hospitals. Adjusted total hospital charges were lower and length of stay was shorter for community hospitals compared with academic medical centers ($2937 compared with $3564 and 2.2 days compared with 2.5 days, respectively).

Conclusion: Hospital academic affiliation was an important predictor of clinical outcomes. Better clinical outcomes were found primarily among patients at academic medical centers, although these institutions demonstrated moderately higher resource utilization, compared with community hospitals. (Obstet Gynecol 2001;97:567–76.

The impact of academic affiliation on health care resource utilization and clinical outcomes has been examined for a variety of medical diagnoses and procedures.[1–7] These studies have generally found that academic institutions, specifically academic medical centers, are associated with improved in-hospital mortality rates.[1–3] Findings with respect to resource utilization have been mixed.[4,5]

Recent studies also examined the relationship between clinical outcomes and hospital case volume for a spectrum of complex medical and surgical procedures. These procedures included coronary angioplasty, coronary artery bypass graft, pancreatic and hepatic resections, pancreatico-duodenectomy, and other complex gastrointestinal and vascular operations.[8–22] With few exceptions, these procedures are relatively infrequent, affect a small proportion of the population, and represent a small proportion of total health expenditures.

By contrast, childbirth is a ubiquitous event that, in the United States, usually occurs in a hospital setting. The average woman will have 3.3 pregnancies resulting in 2.1 live births.[23] In 1995, there were more than 3.9 million hospital births, representing 12% of all hospitalizations.[24] Inpatient medical and surgical procedures associated with childbirth constitute more than 15% of all procedures performed in American hospitals.[24] Despite the obvious importance of such episodes of care, determinants of clinical and economic outcomes at the time of childbirth have yet to be fully elucidated.

Earlier studies have examined certain aspects of maternal outcomes at childbirth. Oleske et al[25] demon-

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strated that among the Medicaid population in California there was no difference in cesarean delivery rates between women in fee for service compared with capitated plans. Placek et al[26] noted higher cesarean delivery rates among privately owned hospitals compared with nonprofit community hospitals. Lieberman et al[27] noted that differences in case-mix accounted for differential cesarean rates between community- and hospital-based practitioners. Although initially high (24.4%), the rates for the hospital-based practitioners dropped to 20.1% after adjustment for differences in patient populations.

Teaching hospitals have been noted to have generally lower cesarean rates compared with other community institutions. A study of cesarean delivery in Ontario, for example, revealed that teaching hospitals had a lower unadjusted cesarean rate compared with community hospitals in the same province.[28] Similarly, Oleske et al[29] found that for births in the state of Illinois, the teaching status of a hospital had a protective effect on the likelihood of cesarean birth, regardless of maternal age and type of insurance coverage.

In our study, we examined the effect of academic affiliation and hospital volume on clinical and economic outcomes of hospital services at parturition. Given the inverse relationship between hospital volume and outcomes found in other studies, we sought to separate the effect of hospital volume from academic affiliation and other patient- and institution-related factors that might affect childbirth. Our hypothesis was that clinical measures of obstetric care would be positively related to academic affiliation, whereas resource utilization measures, as reflected by hospital charges and length of stay, would be lower at community institutions.

Materials and Methods

To assess the impact of hospital academic affiliation and obstetric volume on clinical markers of quality and resource utilization at the time of parturition, we designed a cross-sectional study to examine all births occurring in the State of Maryland during 1996. Data were obtained from the publicly available Maryland Health Services Cost Review Commission database, which includes inpatient hospital discharge information for all 52 nonfederal acute-care hospitals in the state. Discharge abstracts include information on patient demographics, length of stay, and hospital charges, and allow for the coding of up to 15 diagnoses and 15 procedures using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes.

The study population was selected based on the presence of one of six diagnostic-related group (DRG) codes for childbirth (DRGs 370–375), which include both complicated and uncomplicated vaginal and cesarean deliveries. Exclusion criteria included encounters with fewer than $200 in total hospital charges, because these were assumed to be coding errors given the nature of these DRGs; and births at a hospital with fewer than five deliveries during the entire year, because these hospitals lacked established labor and delivery services and the births likely represented emergent events.

Hospitals were classified into one of three categories according to their degree of academic affiliation. *Community hospitals* were defined as hospitals without a residency program in obstetrics. *Community teaching hospitals* were defined as hospitals with a residency program in obstetrics and with or without an affiliation to a school of medicine. *Academic medical centers* were defined as hospitals with a residency program in obstetrics, and a sole, primary affiliation to a school of medicine. All academic medical centers were staffed primarily by tenure-track faculty with full-time academic appointments, had 24-hour in-house attending faculty coverage, and most births at those centers were attended by residents and/or medical students with faculty supervision.

Categories for hospital volume were determined based on the distribution of the annual volume of obstetric deliveries in the study. Very-high-volume institutions had more than 4000 deliveries per year. High-volume institutions had between 2001 and 4000 deliveries per year, medium-volume hospitals had between 1001 and 2000 deliveries per year, and low-volume hospitals had 1000 or fewer deliveries each year.

Both academic affiliation and hospital volume were treated as dummy variables in the analysis. Community hospitals were chosen as the comparison group for academic affiliation because they comprise the largest proportion of both hospitals and births. Very-high-volume hospitals were chosen as the comparison group for hospital volume. Assuming a positive volume–outcomes association, the highest-volume institutions would be expected to have the most efficient and best economic and clinical outcomes.

Because the availability of neonatal resources would be expected to affect patient referral patterns, dummy variables were created to account for differences in the availability of supportive neonatal technology and the associated human resources required by such technology. These variables were based on information obtained from the Maryland Hospital Association regarding the neonatal capabilities of all hospitals in the state. Institutions were classified as having Level I, Level II, and Level III-or-higher nursery capacity.

In addition, the following patient demographic and clinical variables were examined for potential inclusion in the regression models: age, race, substance abuse (ICD-9 diagnosis codes 303.0–303.93, 304.5–304.93, 305.0–305.93, excluding 305.1 [tobacco use], and 648.3) payment source, admission source, marital status, place of residence, DRG category, previous cesarean delivery (ICD-9 diagnosis codes 654.2–654.23), a complications index, total number of obstetric procedures, and total number of diagnoses indicated in the discharge abstract.

To create the complications index, ICD-9 diagnosis codes were identified indicating serious complications related to anesthesia, cardiac problems of surgery, infections, pulmonary emboli, obstetric surgery, postpartum hemorrhage, renal failure, respiratory problems, surgical or other wounds, and other complications of childbirth (codes provided upon request). Dummy variables were created for each category of complications and an index score assigned for each patient by summing across the categories. We did not attempt to weigh the severity of the complications. A dichotomous variable indicating no complications or one or more complications was created from the index score, because the proportion of mothers having more than one serious complication accounted for only 0.3% of the study population.

The Romano adaptation of the Charlson comorbidity index was explored as a measure of variation in patient comorbidities.[30,31] Ultimately the index was not used because it was not found to be discriminatory in this predominantly healthy population. As an alternative means of accounting for the presence of comorbidities in an otherwise healthy patient population, we created an index by calculating the total number of diagnoses associated with each patient. This variable was treated as continuous.

Clinical outcomes analyzed included cesarean birth, vaginal birth after cesarean, episiotomy, laceration associated with vaginal delivery, total lacerations, and the complications index. These clinical markers were selected because of their relevance to the primary research question, their reliability in coding, and their availability in the Maryland Health Services Cost Review Commission database. In-hospital mortality was rare in this population (nine deaths or less than 0.0001% of the entire study population), and it was therefore not an outcome that could be evaluated.

For each institution, the economic outcomes studied were average in-hospital length of stay and average total hospital charges. Length of stay was calculated by subtracting the patient admission date from the discharge date. If these two dates were the same, the patient was assigned a 1-day length of stay. Total hospital charge information is included in the discharge abstract and comes from hospital billing records. Hospital charges are regulated in the State of Maryland, and are considered to be a reasonable approximation of actual costs.

We assessed the distribution of patient characteristics by academic affiliation and among hospital volume groups using the χ^2 statistic for dummy variables and analysis of variance for continuous variables. Bivariate analyses were used to assess the association between the independent variables and our main outcomes. From these analyses, we determined which variables to include in the regression models.

Multiple logistic regression was used to assess differences in the likelihood of clinical outcomes by academic affiliation and hospital volume. Multiple linear regression was used to assess differences in average length of stay and total charges by academic affiliation and among hospital volume groups.

Both academic affiliation and hospital volume group were included together in all the models, to assess the influence of each independent of the other. The logistic regression models for primary cesarean birth, episiotomy, laceration associated with vaginal delivery, and total lacerations were adjusted for age, race, neonatal intensive care unit (NICU) level, substance abuse, payment source, source of admission, marital status, place of residence, and number of diagnoses. The model for cesarean birth was adjusted for all of the above variables, as well as previous cesarean delivery. The model for the complications index was adjusted for age, race, NICU level, substance abuse, payment source, marital status, cesarean delivery, place of residence, and number of diagnoses.

The linear regression models for length of stay and total charges were adjusted for age, race, NICU level, substance abuse, payment source, source of admission, marital status, DRG, place of residence, complications index, number of procedures, and number of diagnoses. Because the distribution of total hospital charges was highly skewed, a natural log transformation was performed to achieve a more normal distribution and minimize the effect of outliers.

In all models, the unit of analysis was the individual patient. *P* values in the models were based on two-tailed tests of significance. Probability values greater than or equal to .01 were reported as nonsignificant. In the case of total charges, reported *P* values and inferences about statistical significance from the multiple regression models were based on the log-transformed data. Adjusted log total charge values were calculated from the regression models, and were transformed back to their original scales for ease of reporting and interpretation. Data management and analysis were performed using Paradox 4.5 (Borland International, Scotts

Table 1. Summary Information of Hospital Groupings

Hospital grouping	Number of hospitals	Volume (births/y)	Total births	Average cases/y	%
Academic affiliation					
Community	28	NA	46,637	1666	73.9
Community teaching	5	NA	12,134	2427	19.2
Academic medical centers	3	NA	4372	1457	6.9
Hospital volume					
Very high	3	>4000	16,785	5595	26.6
High	7	2001–4000	19,318	2760	30.6
Medium	10	1001–2000	16,953	1695	26.8
Low	16	≤1000	10,087	630	16.0
Total	36	NA	63,143	1754	100.0

NA = not applicable.

Valley, CA) and Stata 5.0 (Stata Corp., College Station, TX), respectively.

Results

A total of 63,196 records were identified from the Maryland Health Services Cost Review Commission database using the six DRG codes associated with childbirth. Forty-three of those records had fewer than $200 in total hospital charges and ten encounters occurred at hospitals with fewer than five deliveries during the study year. Following these exclusions, 63,143 records were available for analysis.

The vast majority of births occurred at community hospitals (73.9%). Community teaching hospitals and academic medical centers accounted for a significantly smaller proportion of births, 19.2% and 6.9%, respectively. There was less variability in the proportion of births occurring in each of the four volume groups. The very-high-volume hospitals accounted for 26.6% of births, whereas the low-volume hospitals represented 16.0% of births (Table 1).

The characteristics of study patients are summarized by the academic affiliation of the delivering institution in Table 2. Women who received care at academic medical centers tended to be younger and never married compared with women at the community hospitals. They were also more likely to be black, have government insurance (primarily Medicaid), and reside in inner-city Baltimore. Community hospital patients were older, more likely to be married, and white. Patients at community hospitals were more than twice as likely to have commercial insurance coverage, and were less likely to reside in the inner city. In general, community teaching hospitals tended to mirror the patient characteristics of community hospitals, except they drew a higher percentage of patients from the inner city.

Table 3 summarizes the clinical findings by the academic affiliation of the hospitals. The observed cesarean birth rate, including both primary and repeat cesareans, was 21.2% at community hospitals, compared with 24.3% at community teaching hospitals and 18.4% at academic medical centers. Following adjustment for the effect of volume and case-mix differences, the odds of cesarean birth were significantly lower for academic medical centers (odds ratio [OR] 0.66, 99% confidence interval [CI] 0.55, 0.76), but were higher for community teaching hospitals (OR 1.23, CI 1.12, 1.34), compared with community hospitals.

The primary cesarean rates were calculated by identifying all subjects who had a cesarean delivery, but no indication of a previous cesarean birth as evidenced by the presence of an ICD-9 code for a prior uterine scar. This primary cesarean analysis included only the subset of 55,429 women who did not have a previous cesarean birth indicated, and then looked at the likelihood of a cesarean among that population. Primary cesarean rates were 15.7% for community hospitals, 17.5% for community teaching hospitals, and 14.3% for academic medical centers. After adjustment, women at academic medical centers were less likely to have a primary cesarean birth compared with women delivering at community hospitals (OR 0.64, CI 0.52, 0.75), although women at community teaching hospitals were significantly more likely to have one compared with women at community hospitals (OR 1.17, CI 1.05, 1.29).

Episiotomies were performed with less frequency at academic medical centers (8.9%), compared with community teaching hospitals (23.7%) and community hospitals (27.1%). After adjusting for case-mix and volume differences, the likelihood of an episiotomy at community teaching hospitals and academic medical centers was significantly lower compared with community hospitals (OR 0.88, CI 0.81, 0.95, and OR 0.46, CI 0.38, 0.54, respectively).

The observed laceration rate was 29.5% at community hospitals compared with 32.0% and 30.3% at commu-

Table 2. Summary of Patient Characteristics by Academic Affiliation

Characteristics	Academic affiliation			
	Community	Community teaching	AMC	P*
Mean age (y)	28.1	28.2	25.2	<.01
(SD)	(6.0)	(6.0)	(6.6)	
Race				
White	66.1	65.7	32.7	<.01
Black	27.2	30.9	62.7	
Other	6.7	3.3	4.6	
NICU level				
Level I	14.2	0.0	0.0	<.01
Level II	30.7	4.2	0.0	
Level III and higher	55.1	95.9	100.0	
Substance abuse				
Yes	1.5	2.9	11.2	<.01
Payment source				
Commercial	69.4	72.8	31.9	<.01
Government (Medicare/Medicaid)	26.5	25.1	59.5	
Other	4.2	2.1	8.6	
Admission source				
Home	98.6	99.6	93.4	<.01
Transfer	0.8	0.4	6.6	
Marital status				
Currently married	66.4	65.7	27.3	<.01
Never married	30.2	30.9	67.5	
Previously married	3.1	3.3	2.8	
Place of residence				
Baltimore inner city	3.8	13.2	43.8	<.01
Central Maryland	30.9	83.5	50.3	
District of Columbia suburbs	36.9	0.5	1.9	
Other Maryland	24.0	0.6	3.5	
Out of state	4.7	2.0	0.9	
DRG category				
Cesarean del with CC (DRG 370)	9.7	13.3	13.3	<.01
Cesarean del without CC (DRG 371)	11.5	11.0	5.1	
Vaginal del with CC (DRG 372)	14.4	10.9	17.8	
Vaginal del without CC (DRG 373)	61.2	62.4	57.2	
Vaginal del with other procedures (DRGs 374 and 375)	3.2	2.5	6.7	
Previous cesarean delivery				
Yes	12.4	12.7	9.5	<.01
Serious complications index				
None	93.4	93.8	88.9	<.01
1 or more	6.6	6.2	11.1	
Mean total number of obstetric procedures (SD)	2.0 (0.94)	1.6 (0.76)	1.9 (0.99)	<.01
Mean total number of diagnoses (SD)	3.9 (2.01)	4.0 (1.92)	4.9 (2.49)	<.01

AMC = academic medical center; SD = standard deviation; NICU = neonatal intensive care unit; DRG = diagnostic related group; CC = complications and/or comorbidities; del = delivery.

Values presented as percentages unless otherwise noted. Column totals may not add to 100% due to rounding.

* χ^2 for categorical variables, analysis of variance for continuous variables, for the comparison between hospital groups.

nity teaching hospitals and academic medical centers, respectively. Following adjustment, patients at both community teaching hospitals and academic medical centers were more likely to have lacerations than were patients at community hospitals (OR 1.08, CI 1.00, 1.16, and OR 1.22, CI 1.07, 1.37, respectively).

Further analysis was conducted to clarify the relationship between episiotomy rates and rates of vaginal laceration. A combined dichotomous measure, any type of laceration, was created to indicate that a patient experienced either an episiotomy or laceration associated with vaginal delivery. The observed "any type of

Table 3. Clinical Outcomes of Interest by Academic Affiliation

Outcomes	Academic affiliation		
	Community	Community teaching	Academic medical center
Cesarean delivery*			
Unadjusted rate (%)	21.2	24.3	18.4
Unadjusted OR (99% CI)	1.00	1.19 (1.12, 1.27)†	0.84 (0.75, 0.93)†
Adjusted OR (99% CI)	1.00	1.23 (1.12, 1.34)†	0.66 (0.55, 0.76)†
Primary cesarean delivery‡			
Unadjusted rate (%)	15.7	17.5	14.3
Unadjusted OR (99% CI)	1.00	1.14 (1.05, 1.23)†	0.90 (0.79, 1.01) NS
Adjusted OR (99% CI)	1.00	1.17 (1.05, 1.29)†	0.64 (0.52, 0.75)†
Episiotomy‡			
Unadjusted rate (%)	27.1	23.7	8.9
Unadjusted OR (99% CI)	1.00	0.84 (0.79, 0.89)†	0.26 (0.22, 0.30)†
Adjusted OR (99% CI)	1.00	0.88 (0.81, 0.95)†	0.46 (0.38, 0.54)†
Laceration associated with vaginal delivery‡			
Unadjusted rate (%)	29.5	32.0	30.3
Unadjusted OR (99% CI)	1.00	1.12 (1.06, 1.19)†	1.04 (0.94, 1.13) NS
Adjusted OR (99% CI)	1.00	1.08 (1.00, 1.16)†	1.22 (1.07, 1.37)†
Any type of laceration‡			
Unadjusted rate (%)	53.1	51.5	37.2
Unadjusted OR (99% CI)	1.00	0.94 (0.89, 0.99)†	0.52 (0.48, 0.57)†
Adjusted OR (99% CI)	1.00	0.95 (0.88, 1.01) NS	0.86 (0.76, 0.96)†
Serious complications index§			
Unadjusted rate (%)	6.6	6.2	11.1
Unadjusted OR (99% CI)	1.00	0.94 (0.84, 1.04) NS	1.77 (1.54, 2.01)†
Adjusted OR (99% CI)	1.00	0.98 (0.84, 1.11) NS	0.77 (0.61, 0.93)†

OR = odds ratio; CI = confidence interval; NICU = neonatal intensive care unit; NS = not significant.

* Logistic regression model adjusts for hospital volume, age, race, NICU level, substance abuse, previous cesarean delivery, payment source, source of admission, marital status, place of residence, and number of diagnoses.

† $P < .01$. Community hospitals are the comparison group.

‡ Logistic regression models adjust for hospital volume, age, race, NICU level, substance abuse, payment source, source of admission, marital status, place of residence, and number of diagnoses.

§ Logistic regression model adjusts for hospital volume, age, race, NICU level, substance abuse, payment source, marital status, cesarean delivery, place of residence, and number of diagnoses.

laceration" rates were 53.1%, 51.5%, and 37.2% at community hospitals, community teaching hospitals, and academic medical centers, respectively. After case-mix adjustment, the likelihood of experiencing any type of laceration, whether intentional (episiotomy) or incidental (laceration), was significantly lower at academic medical centers and similar at community teaching hospitals compared with community hospitals (OR 0.86, CI 0.76, 0.96, and OR 0.95, CI 0.88, 1.01, respectively).

The final clinical outcome examined was severe complications. The unadjusted complication rate was higher at academic medical centers (11.1%) compared with community hospitals (6.6%) and community teaching hospitals (6.2%). After adjustment for hospital volume and patient case-mix, the likelihood of complications was similar at community teaching hospitals compared with community hospitals (OR 0.98, CI 0.84, 1.11), whereas the likelihood of complications at academic medical centers was lower compared with community hospitals (OR 0.77, CI 0.61, 0.93).

Findings of clinical outcomes by hospital volume group were not as striking (Table 4). Although the adjusted trends were largely in the predicted directions, differences by volume group were generally not significant for cesarean birth, primary cesarean delivery, and episiotomy.

The adjusted likelihood of laceration associated with vaginal delivery was significantly lower among the high-volume, medium-volume, and low-volume groups compared with the very-high-volume group (OR 0.89, CI 0.83, 0.96; OR 0.85, CI 0.77, 0.92; and OR 0.74, CI 0.66, 0.82, respectively). The findings were similar for any type of laceration (OR 0.86, CI 0.80, 0.92; OR 0.84, CI 0.76, 0.91; and OR 0.90, CI 0.81, 0.99, among the high-volume, medium-volume, and low-volume groups compared with the very-high-volume group, respectively).

The adjusted likelihood of complications was higher among the high-volume and medium-volume groups compared with the very-high-volume group (OR 1.24, CI 1.07, 1.41; OR 1.75, CI 1.43, 2.07, respectively). The low-volume group also had an elevated, although not statistically significant, likelihood of complications compared with the very-high-volume group (OR 1.21,

Table 4. Clinical Outcomes of Interest by Hospital Volume Group

Outcomes	Hospital volume group			
	Very high	High	Medium	Low
Cesarean delivery*				
Unadjusted rate (%)	23.0	21.0	21.4	20.9
Unadjusted OR (99% CI)	1.00	0.89 (0.83, 0.95)†	0.91 (0.85, 0.97)†	0.88 (0.81, 0.95)†
Adjusted OR (99% CI)	1.00	0.75 (0.69, 0.82)†	1.05 (0.93, 1.17) NS	1.03 (0.89, 1.17) NS
Primary cesarean delivery‡				
Unadjusted rate (%)	17.1	15.5	15.7	15.0
Unadjusted OR (99% CI)	1.00	0.89 (0.82, 0.95)†	0.91 (0.83, 0.98)†	0.86 (0.77, 0.94)†
Adjusted OR (99% CI)	1.00	0.74 (0.67, 0.82)†	1.04 (0.90, 1.18) NS	0.99 (0.84, 1.15) NS
Episiotomy‡				
Unadjusted rate (%)	29.3	22.8	22.7	27.3
Unadjusted OR (99% CI)	1.00	0.71 (0.67, 0.76)†	0.71 (0.66, 0.75)†	0.91 (0.84, 0.97)†
Adjusted OR (99% CI)	1.00	0.91 (0.84, 0.98)†	0.94 (0.85, 1.03) NS	1.10 (0.97, 1.23) NS
Laceration associated with vaginal delivery‡				
Unadjusted rate (%)	32.7	29.7	29.2	27.7
Unadjusted OR (99% CI)	1.00	0.87 (0.82, 0.92)†	0.85 (0.79, 0.90)†	0.79 (0.73, 0.85)†
Adjusted OR (99% CI)	1.00	0.89 (0.83, 0.96)†	0.85 (0.77, 0.92)†	0.74 (0.66, 0.82)†
Any type of laceration‡				
Unadjusted rate (%)	57.6	48.8	48.6	52.5
Unadjusted OR (99% CI)	1.00	0.70 (0.66, 0.74)†	0.70 (0.66, 0.74)†	0.82 (0.76, 0.87)†
Adjusted OR (99% CI)	1.00	0.86 (0.80, 0.92)†	0.84 (0.76, 0.91)†	0.90 (0.81, 0.99)†
Serious complications index§				
Unadjusted rate (%)	5.0	8.0	8.3	5.2
Unadjusted OR (99% CI)	1.00	1.63 (1.44, 1.81)†	1.69 (1.50, 1.89)†	1.03 (0.88, 1.19) NS
Adjusted OR (99% CI)	1.00	1.24 (1.07, 1.41)†	1.75 (1.43, 2.07)†	1.21 (0.95, 1.47) NS

OR = odds ratio; CI = confidence interval; NICU = neonatal intensive care unit; NS = not significant.

* Logistic regression model adjusts for academic affiliation, age, race, NICU level, substance abuse, previous cesarean delivery, payment source, source of admission, marital status, place of residence, and number of diagnoses.

† $P < .01$. Very-high-volume quartile is the comparison group.

‡ Logistic regression models adjust for academic affiliation, age, race, NICU level, substance abuse, payment source, source of admission, marital status, place of residence, and number of diagnoses.

§ Logistic regression model adjusts for academic affiliation, age, race, NICU level, substance abuse, payment source, marital status, cesarean delivery, place of residence, and number of diagnoses.

CI .95, 1.47, which did not meet our threshold for significance).

Overall, resource utilization was higher at academic medical centers and similar at community teaching hospitals compared with community hospitals. Length of stay for community hospitals was significantly shorter than at community teaching hospitals or academic medical centers (2.2 days compared with 2.4 and 2.9 days, respectively; Table 5). The adjusted differences between the groups were smaller after accounting for hospital volume and patient case-mix. After adjustment, there was no significant difference between community hospitals and community teaching hospitals (2.2 compared with 2.3 days, respectively), although length of stay remained significantly longer at academic medical centers compared with community hospitals (2.5 days, $P < .01$).

Observed total hospital charges were higher for academic medical centers compared with community hospitals ($4802 compared with $3172, respectively, $P < .01$), but were not significantly different between unaffiliated community hospitals and community teaching hospitals ($3199) (Table 5). Once volume and case-mix were accounted for in the multiple linear regression model, these differences were attenuated. Nonetheless,

Table 5. Economic Outcomes of Interest by Academic Affiliation

Outcomes	Academic affiliation		
	Community	Community teaching	Academic medical center
Average length of stay (d)			
Unadjusted	2.2	2.4*	2.9*
Adjusted†	2.2	2.3 NS	2.5*
Average total charges ($)			
Unadjusted	3172	3199 NS	4802*
Adjusted†	2937	2838*	3564*

Abbreviations as in Tables 1–4.

* $P < .01$. Community hospitals are the comparison group.

† Linear regression models for length of stay and total charges adjust for hospital volume, age, race, NICU level, substance abuse, payment source, source of admission, marital status, DRG, place of residence, number of procedures, number of diagnoses, and serious complications.

Table 6. Economic Outcomes of Interest by Hospital Volume Group

Outcomes	Hospital volume quartiles			
	Very high	High	Medium	Low
Average length of stay (d)				
Unadjusted	2.3	2.3 NS	2.4 NS	2.0*
Adjusted†	2.3	2.2*	2.3 NS	2.2*
Average total charges ($)				
Unadjusted	3143	3295*	3582*	3037*
Adjusted†	2842	2891*	3079*	3082*

Abbreviations as in Tables 1–4.
* $P < .01$. Very-high-volume quartile is the comparison group.
† Linear regression models for length of stay and total charges adjust for academic affiliation, age, race, NICU level, substance abuse, payment source, source of admission, marital status, DRG, place of residence, number of procedures, number of diagnoses, and serious complications.

community teaching hospitals were less expensive and academic medical centers remained significantly more expensive than unaffiliated community hospitals ($2838, $3564, and $2937, respectively, $P < .01$ for both comparisons).

Differences in resource utilization among hospital volume groups, although statistically significant for most comparisons, may have limited clinical relevance. As shown in Table 6, there was not a clear volume–outcome relationship for adjusted length of stay, which ranged from 2.2 to 2.3 days. There was a dose–response relationship among hospital volume groups for average total charges, although the total differences were small. The difference between the highest and lowest average charges was $240.

Discussion

This study found that academic affiliation was a stronger independent predictor of both clinical and economic maternal outcomes associated with childbirth than was hospital volume. Moreover, academic medical centers exhibited better clinical outcomes than did unaffiliated community hospitals, whereas outcomes among community teaching hospitals were similar to those among community hospitals. Community hospitals performed best on measures of resource utilization, although the differences were not as great as had been hypothesized: the difference in adjusted length of stay between the academic medical centers and community hospitals was 0.3 days, whereas the difference in total charges between the two was $627.

It was more surprising that hospital volume did not show a stronger association with either resource utilization measures or clinical outcomes. One potential explanation is that even low-volume institutions had a dedicated obstetric service that provided care to a significant number of patients, performing nearly 750 deliveries per year. This effect is different from that observed for other medical procedures, for which a high-volume institution may perform 50–100 procedures per year.[8–21]

There was a strong dose–response relationship between hospital volume and complications of delivery; the likelihood of complications decreased as volume increased. A positive association was found between hospital volume and laceration associated with vaginal delivery and total lacerations. Very-high volume institutions, which in this study were predominantly large hospitals, may perhaps serve a demographically distinct population and deliver larger newborns,[32] which increases the risk of pelvic trauma.

In our study, the risk of episiotomy was greatest among community hospitals and lowest for academic medical centers. A separate analysis of any type of perineal laceration, which included vaginal lacerations and episiotomy, was performed to assess whether the lower episiotomy rate at academic medical centers was responsible for the higher risk of vaginal lacerations. The variable "any type of laceration" was designed to avoid double counting women who had both an episiotomy and vaginal laceration. From this analysis it was evident that perineal lacerations remain significantly less frequent among women who received care at academic medical centers. The factors influencing this difference need further exploration, although these findings call into question the scientific basis of elective episiotomy.

Cesarean birth and related indicators are important measures of quality for hospitals. Indeed, the National Committee on Quality Assurance has used this metric as an indicator of hospital performance. The assumption is that lower cesarean delivery rates are associated with better quality of clinical care, less morbidity, and significant economic savings. Such measures are bound to vary depending on the population being studied.

The rate of cesarean birth is influenced by a variety of factors. Regional geographic variation has been recognized for many years and continues to be an issue of interest. In general, cesarean delivery is more common in the southern United States than in other regions.[33] Based on birth certificate data, the total and primary cesarean rates in the state of Maryland are estimated to be 23.2% and 17.2%, respectively.[33] In this study using the Maryland Health Services Cost Review Commission data, the total and primary cesarean rates were 21.6% and 16.2%. Regional variation may reflect differences in racial and age group composition, differences in reimbursement and organizational patterns, local medical standards, as well as the medico-legal environment.

The significance of differences noted in length of stay and total hospital charges associated with childbirth are less clear. It is arguable that a difference of 0.3 days is clinically relevant when comparing across hospitals. Likewise, a difference of $627 between academic medical centers and community hospitals is relatively small. However, in an increasingly price-sensitive marketplace such variation may place academic medical centers at a competitive disadvantage.

A cost–volume relationship also appears to exist. The difference in total charges, between the highest and lowest volume hospitals, account for a savings of $240. This relationship is more robust for complex and relatively rare procedures.[19,21] Given these data, it may be reasonable to postulate that by attracting larger obstetric volumes, while still maintaining superior clinical outcomes, academic medical centers could attain the economies of scale and organization that would make them more attractive partners in the health care marketplace.

The use of this type of administrative data set has certain inherent limitations. A first limitation is using data not originally intended for this type of analysis. The relative lack of detailed clinical data must be balanced with the benefits, namely that secondary data, such as administrative and billing data, allow for population-based comparisons across much larger populations than are possible through primary data collection. A second limitation concerns coding accuracy. Although coding accuracy has long been thought to be an issue, recent audits of the Maryland discharge abstract registry have found coding accuracy in excess of 91%, with coding errors largely confined to the misordering of diagnoses and procedures.[22]

The principal limitations for this study are the inability to link maternal and infant data and to identify multiple admissions for the same individual. These limitations are due to the blinding process created to protect the confidentiality of the Maryland health services cost review commission data. Thus, neither infant outcomes nor readmissions could be evaluated. We would hypothesize, however, that improved maternal outcomes would be highly correlated with infant outcomes and inversely related to readmission for complications. Future studies must link maternal and neonatal data to better assess their relationship with resource utilization and clinical outcomes.

In the past, there has been an implicit assumption that the quality and cost of providing obstetric services at academic medical centers is distinctly different from community-based hospitals. Academic departments have been characterized as inherently inefficient, and as offering relatively little added value to care associated with childbirth. These conclusions have been drawn based on anecdotal experience and little empiric data. The present study has demonstrated better childbirth outcomes among academic medical centers, despite caring for a demographically higher-risk population. This advantage was accomplished using marginally greater resources than community institutions.

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