By Xiao Xu, Aileen Gariepy, Lisbet S. Lundsberg, Sangini S. Sheth, Christian M. Pettker, Harlan M. Krumholz, and Jessica L. Illuzzi

DOI: 10.1377/hlthaff.2014.1088
HEALTH AFFAIRS 34,
NO. 7 (2015): 1212–1219

Wide Variation Found In Hospital Facility Costs For Maternity Stays Involving Low-Risk Childbirth

Xiao Xu (xiao.xu@yale.edu) is an assistant professor in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine, in New Haven, Connecticut.

Aileen Gariepy is an assistant professor in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine.

Lisbet S. Lundsberg is an associate research scientist in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine.

Sangini S. Sheth is an assistant professor in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine.

Christian M. Pettker is an associate professor in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine.

Harlan M. Krumholz is the Harold H. Hines Jr. Professor of Medicine and Epidemiology and Public Health at the Yale School of Medicine.

Jessica L. Illuzzi is an associate professor in the Department of Obstetrics, Gynecology, and Reproductive Sciences, Yale School of Medicine.

ABSTRACT Childbirth is the leading cause of hospital admission in the United States, yet there has been little research on variation in hospital costs associated with childbirth. Using data from the 2011 Nationwide Inpatient Sample, we characterized the variation in estimated facility costs of hospitalizations for low-risk childbirth across US hospitals. We found that the average estimated facility cost per maternity stay ranged from $1,189 to $11,986 (median: $4,215), with a 2.2-fold difference between the 10th and 90th percentiles. Estimated facility costs were higher at hospitals with higher rates of cesarean delivery or serious maternal morbidity. Hospitals having government or nonprofit ownership; being a rural hospital; and having relatively low volumes of childbirths, low proportions of childbirths covered by Medicaid, and long stays also had significantly higher costs. The large variation in estimated facility cost for low-risk childbirths among hospitals suggests that hospital practices might be an important contributor to variation in cost and that there may be opportunities for cost reduction. The safe reduction of cesarean deliveries, increasing the coordination of care, and emphasizing value of care through new payment and delivery systems reforms may help reduce hospital costs and cost variation associated with childbirth in the United States.

In the United States, hospital care is the most expensive component of national health spending,[1] and childbirth is the leading cause of hospital admission.[2] In 2011 childbirth accounted for 3.8 million hospitalizations and more than $15.1 billion in hospital facility costs for maternity care.[2,3] The costs include expenses incurred by hospitals in providing maternity care during childbirth hospitalization but exclude professional fees.

This makes childbirth one of the most costly conditions for inpatient care in the United States,[2,3] and the variation in hospital facility costs for childbirth may greatly influence overall costs of health care. However, there are few data about whether and to what extent facility costs of obstetric care vary across US hospitals.

The increased use of interventions and technologies around the time of delivery (such as labor induction, cesarean section, fetal monitoring, and ultrasound) has also raised concerns about potential overuse and higher associated costs.[4,5] For example, the rate of labor induction rose from 9.5 percent of all births in 1990[6] to 22.8 percent in 2012.[7] Similarly, the rate of cesarean delivery increased from 20.7 percent in 1996 to 32.8 percent in 2012, with 1.3 million women undergoing cesarean sections in 2012.[7]

Importantly, there is substantial variation in obstetric intervention rates across US hospitals, with rates of cesarean delivery ranging from 7.1 percent of all obstetric deliveries to 69.9 per-

cent (and from 2.4 percent to 36.4 percent among women with low-risk pregnancies).[8,9] These differences suggest wide variability in provision of care that may contribute to large cost discrepancies. Overall costs of hospitalization for childbirth may also be influenced by a range of other factors such as provider type (for example, obstetricians versus nurse-midwives) and organization of care (for example, whether or not postpartum home nursing assistance, which could shorten maternal length-of-stay, is available).[10] Thus, both the nature of variation in hospital facility costs for childbirth and how such variation is related to outcomes warrant further investigation. The results of that investigation could inform discussions on how to optimize the "cost to quality ratio in the delivery of maternity care services."[11(pS8)]

This study aimed to characterize variation in estimated facility costs for maternity care during childbirth hospitalizations among US hospitals. To minimize the potentially confounding effect of patient case-mix, we focused on a low-risk sample of childbirths—that is, those with no identified maternal comorbidities or obstetric risk factors. We compared average estimated facility cost per maternity stay across hospitals and examined the association between this cost and maternal outcomes. To identify hospital attributes that might influence cost variation, we assessed how estimated facility costs varied by hospital characteristics.

Study Data And Methods

DATA SOURCE Discharge data came from the 2011 Nationwide Inpatient Sample, part of the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality.[12] It is the largest publicly available all-payer inpatient care database in the United States. It includes clinical and resource utilization information from 1,049 nonfederal short-term hospitals across forty-six states. Its hospital- and discharge-level weights allow for estimates that are representative of the national population.

We identified hospitalizations for childbirth using *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM), diagnosis and procedure codes and diagnosis-related groups (DRGs) based on previously validated algorithms[13,14] (for detailed codes, see online Appendix Exhibit A1).[15] To minimize the difference in patient case-mix across hospitals, we focused on low-risk childbirths in which mothers were ages 16–34 [16,17] and did not have any of twenty-three maternal comorbidities (such as preeclampsia and other hypertensive disorders, diabetes, and obesity) or any of fifteen obstetric risk factors (such as multiple gestation, onset of labor before thirty-seven completed weeks of gestation, fetal malpresentation, and previous cesarean delivery) identified in the discharge records. These conditions were defined based on previous literature and ICD-9-CM diagnosis codes[8,13,14,18–24] (for a complete list of the conditions, see online Appendix Exhibit A2).[15]

We excluded hospitalizations that had missing data for diagnosis codes, maternal age, or charges; involved patient transfers (our data could not link records across hospitals); or were from one outlier hospital in which all hospitalizations had estimated facility costs above the 99.5 percentile of the national sample, regardless of patient characteristics. To generate stable hospital-level estimates, we included only hospitals with at least 100 low-risk childbirths.[8]

HOSPITAL FACILITY COSTS For each childbirth hospitalization, facility costs were estimated by converting charges to costs using hospital-specific cost-to-charge ratios that were adjusted by a DRG-specific factor to account for the more expensive units (for example, nursery, labor, and delivery) involved in maternity care.[25,26] To account for geographic difference in input prices, we adjusted the estimated facility costs by hospitals' area wage index.[27] We winsorized estimated costs at the 0.5 and 99.5 percentiles to reduce the influence of extreme values.[28]

MATERNAL OUTCOMES We constructed a binary indicator for serious maternal morbidity (including death), according to an algorithm defined by the Centers for Disease Control and Prevention for surveillance of maternal outcomes.[29,30] Examples of serious morbidities include amniotic fluid embolism, eclampsia, sepsis, severe anesthesia complications, and hysterectomy (for a complete list, see Appendix Exhibit A3).[15]

HOSPITAL CHARACTERISTICS In addition to teaching status, urban versus rural location, type of ownership, and census region, we measured each hospital's childbirth volume and proportion of childbirths covered by Medicaid (based on its overall childbirth hospitalizations in 2011). We also assessed each hospital's cesarean delivery rate based on ICD-9-CM procedure codes and DRG codes[8,13,14] (Appendix Exhibit A1)[15] and mean length-of-stay among low-risk childbirths.

ANALYSIS For each hospital, we calculated average estimated facility cost per childbirth hospitalization and rate of serious maternal morbidity among its low-risk childbirths. We quantified hospital variation in estimated facility costs and maternal outcomes using summary statistics and histograms. Using the hospital as the unit of analysis, we estimated a series of linear regres-

sion models by sequentially adding blocks of hospital characteristics to assess their relative contribution in explaining variation in estimated facility costs.

Hospital characteristics that were continuous measures but that showed nonlinear association with estimated facility costs were categorized into low, middle, and high groups based on tertiles of distribution or based on lower quartile, middle two quartiles, and upper quartile if they showed a stronger relationship with estimated facility costs at more extreme values. All analyses accounted for the sample design, including stratification and weighting.

LIMITATIONS Our study had several limitations. We estimated hospital facility costs for maternal care instead of overall costs because our data did not include professional fees (for example, fees for services provided by physicians, midwives, and anesthesiologists) or allow for linkage of records between mothers and their newborns. We identified comorbidities and obstetric risk factors using claims data, which might not capture all conditions. However, these indicators were used jointly to generate a low-risk sample, instead of as individual factors for risk adjustment.

We expected that hospitalizations without any of these conditions indicated should reasonably reflect a low-risk population. This definition for *low-risk childbirth* might be restrictive. Nonetheless, it helped isolate differences in hospital practices by minimizing variability in patient case-mix. Future research that includes broader samples with adequate adjustment for patient clinical characteristics will be informative.

Also, because we used cost-to-charge ratios instead of actual cost data, we refer to our measure as *estimated facility costs*. Although this estimate might not reflect the exact cost incurred by a hospital, it should be sufficient for identifying important variation across hospitals.

Finally, because we required that each hospital have a minimum of 100 low-risk childbirths, our sample included more urban hospitals than rural hospitals and more hospitals with relatively large volumes (for a comparison of characteristics between hospitals in the final analytic sample and hospitals that did not meet our inclusion criteria, see Appendix Exhibit A4).[15] Therefore, our findings might not be widely generalizable.

EXHIBIT 1

Characteristics Of Sampled Hospitals With At Least 100 Low-Risk Childbirth Hospitalizations In 2011

Characteristic	Percent or median
Teaching status[a]	
Teaching	29.3%
Nonteaching	70.7
Urban or rural location[a]	
Urban	75.9%
Rural	24.1
Type of ownership[a]	
Government (nonfederal)	13.0%
Nonprofit private	70.3
Investor-owned private	16.6
Census region	
Northeast	14.7%
Midwest	25.8
South	39.5
West	19.9
Hospital volume[b], median[c]	1,049
Proportion of childbirths[b] covered by Medicaid, median[d]	45.7%

SOURCE Authors' analysis of data for 2011 from the Nationwide Inpatient Sample (see Note 12 in text). **NOTES** The sample consisted of 463 hospitals (unweighted; 2,254 weighted). The percentages and medians reflect weighted data. Percentages may not sum to 100 because of rounding. [a]Six hospitals (unweighted) had missing data. [b]Based on all childbirths, regardless of maternal comorbidities or obstetric risk factors. [c]Interquartile range: 580–2,119. [d]Interquartile range: 31.6–62.8 percent.

Study Results

SAMPLE CHARACTERISTICS The 2011 Nationwide Inpatient Sample contained 796,642 hospitalizations for childbirth at 649 hospitals across the United States (for a sample selection flowchart, see Appendix Exhibit A5).[15] There were 274,917 low-risk childbirth hospitalizations with adequate information on facility costs. Of these births 97.2 percent (267,120) occurred at 463 hospitals with at least 100 low-risk childbirths. Our final sample consisted of these 463 hospitals. After sample weights were applied, the 267,120 births represented 1.3 million births nationwide, with a median maternal age of 26 years (interquartile range: 22–30 years).

Most of the 463 hospitals were nonteaching and located in urban areas (Exhibit 1). Seventy percent were nonprofit private hospitals. The median volume was 1,049 childbirths in 2011, and the median proportion of childbirths covered by Medicaid was 45.7 percent.

VARIATION IN ESTIMATED FACILITY COSTS Exhibits 2 and 3 present the distribution of average estimated facility costs per maternity stay across hospitals for all low-risk childbirths and by type of delivery. For low-risk childbirths in general, the average cost varied from $1,189 to $11,986 among the 463 hospitals, with a mean of $4,485 and a median of $4,215 (Exhibit 3). There was more than a twofold difference between the 10th and 90th percentiles.

Even among vaginal deliveries, the average cost varied widely, ranging from $1,183 to $11,819 (for a histogram of average estimated facility costs per maternity stay for low-risk childbirths delivered vaginally, see Appendix

Exhibit A6).[15] Variability across hospitals was larger for cesarean deliveries, whose average costs ranged from $1,249 to $13,688 (for a histogram of average estimated facility costs per maternity stay for low-risk childbirths delivered via cesarean section, see Appendix Exhibit A7).[15]

HOSPITAL CHARACTERISTICS ASSOCIATED WITH COSTS Exhibit 4 shows the results of regression analyses on the association of hospital characteristics with estimated facility costs of maternity stay for low-risk childbirths (for full specifications of the models, see Appendix Exhibit A8).[15] Models 1–3 sequentially adjusted for additional hospital characteristics to assess their relative contribution in explaining variation in estimated facility costs. These costs were significantly higher at rural hospitals (all of them were nonteaching) than at urban nonteaching hospitals. However, costs at urban teaching and urban nonteaching hospitals were comparable.

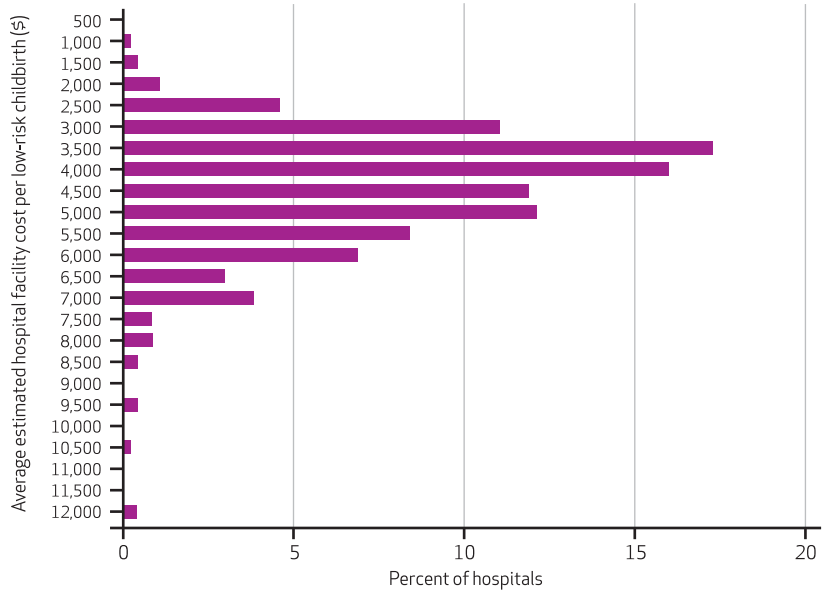
Compared with investor-owned private hospitals, nonfederal government hospitals and nonprofit private hospitals had significantly higher estimated facility costs (Exhibit 4). In addition, hospitals with low volumes and those with low proportions of childbirths covered by Medicaid had significantly higher estimated costs than hospitals with higher volumes and those with more childbirths covered by Medicaid, respectively. Estimated hospital facility costs did not differ significantly by census region.

Cesarean delivery rates among low-risk childbirths varied widely across hospitals (median rate: 10.6 percent; range: 2.0–39.0 percent). Model 2 shows that for low-risk births, average estimated facility costs of maternity stay were $432.28 higher in hospitals with a high cesarean delivery rate than in those with a low rate (Exhibit 4). However, in model 3, which adjusted for mean length-of-stay, the association between cesarean delivery rate and estimated facility costs was no longer significant. This suggests that longer length-of-stay might be one of the main mechanisms through which cesarean delivery rate influenced hospital facility costs. An alternative model that included the rate as a continuous measure showed no significant linear association with estimated facility costs.

Serious maternal morbidity rates varied from 0.0 percent to 4.8 percent among hospitals (Exhibit 3; for a histogram of serious maternal morbidity rates for low-risk childbirths, see Appendix Exhibit A9).[15] The rate of serious maternal morbidity was significantly associated with estimated hospital facility costs in bivariate anal-

EXHIBIT 2

Average Estimated Hospital Facility Costs Per Low-Risk Childbirth, 2011



SOURCE Authors' analysis of data for 2011 from the Nationwide Inpatient Sample (see Note 12 in text). **NOTES** The data reflect variation across hospitals with at least 100 low-risk childbirth hospitalizations. The sample consisted of 463 hospitals (unweighted; 2,254 weighted). The statistics reflect weighted data.

EXHIBIT 3

Distribution Of Average Estimated Hospital Facility Costs And Serious Maternal Morbidity Rate Across Hospitals For Low-Risk Childbirths, 2011

Measure	Mean	Median	Interquartile range	Range	10–90 interpercentile range	90-to-10 percentile ratio
Serious maternal morbidity rate	0.5%	0.3%	0.0–0.6%	0.0–4.8%	0.0–1.1%	—[a]
AVERAGE ESTIMATED HOSPITAL FACILITY COST FOR LOW-RISK CHILDBIRTHS						
All deliveries	$4,485	$4,215	$3,469–$5,252	$1,189–$11,986	$2,902–$6,266	2.2
Vaginal deliveries	4,192	3,960	$3,227–$4,905	$1,183–$11,819	$2,666–$5,916	2.2
Cesarean deliveries	6,945	6,499	$5,238–$8,159	$1,249–$13,688	$4,363–$10,021	2.3

SOURCE Authors' analysis of data for 2011 from the Nationwide Inpatient Sample (see Note 12 in text). **NOTES** The data reflect variation across hospitals with at least 100 low-risk childbirth hospitalizations. The sample consisted of 463 hospitals (unweighted; 2,254 weighted). The statistics reflect weighted data. Serious maternal morbidity is defined in the text. [a]The 90-to-10 percentile ratio cannot be calculated because the 10th percentile is 0.0.

EXHIBIT 4

Association Of Hospital Characteristics With Estimated Facility Costs Of Maternity Stay For Low-Risk Childbirths

Characteristic	Coefficient estimate		
	Model 1	Model 2	Model 3
TEACHING STATUS AND LOCATION[a]			
Rural[a]	425.01**	409.09**	493.20**
Urban teaching	310.07*	261.16	229.08
Urban nonteaching	Ref.	Ref.	Ref.
TYPE OF OWNERSHIP			
Government (nonfederal)	736.41***	653.60**	638.38**
Nonprofit private	578.63**	574.74**	556.49**
Investor-owned private	Ref.	Ref.	Ref.
CENSUS REGION[b]			
Northeast	44.38	−64.52	−369.03
Midwest	−88.53	−116.94	−264.29
South	26.47	−61.49	−200.57
West	Ref.	Ref.	Ref.
HOSPITAL VOLUME[c]			
Low (<580)	Ref.	Ref.	Ref.
Middle (580–2,119)	−467.88**	−438.43**	−443.19**
High (>2,119)	−505.30**	−459.04**	−485.24**
PROPORTION OF CHILDBIRTHS COVERED BY MEDICAID[d]			
Low (<36.8%)	Ref.	Ref.	Ref.
Middle (36.8–56.9%)	−464.49***	−488.19***	−452.01***
High (>56.9%)	−347.55**	−389.86**	−370.11**
AMONG LOW-RISK CHILDBIRTHS			
Cesarean delivery rate[c]			
Low (<8.1%)	—[e]	Ref.	Ref.
Middle (8.1–13.8%)	—[e]	148.04	99.99
High (>13.8%)	—[e]	432.28**	289.37
Serious maternal morbidity rate[f]	—[e]	315.85**	296.32**
Mean length-of-stay (days)	—[e]	—[e]	868.08***

SOURCE Authors' analysis of data for 2011 from the Nationwide Inpatient Sample (see Note 12 in text). **NOTES** Analyses were based on multivariable general linear regression models of hospitals with at least 100 low-risk childbirth hospitalizations. The sample consisted of 463 hospitals (unweighted; 2,254 weighted). Six hospitals (unweighted) were excluded from the multivariable regression analyses because of missing data on hospital teaching status, urban or rural location, and type of ownership. Thus, the sample size was 457 for all models. Models 1–3 sequentially adjusted for additional hospital characteristics to assess their relative contribution in explaining variation in estimated facility costs. R-square values were 0.082, 0.110, and 0.130 for models 1–3, respectively. Intercept estimates were 4432.10, 4184.84, and 2490.67 for models 1–3, respectively ($p < 0.001$ for all intercepts). Complete results from these models are reported in Appendix Exhibit A8 (see Note 15 in text). [a]There were no teaching hospitals in rural areas in our sample. [b]For census region, p values ranged from 0.154 to 0.878. [c]Low, middle, and high groups were defined based on lower quartile, middle two quartiles, and upper quartile. [d]Low, middle, and high groups were defined based on tertiles of distribution. [e]Variable not adjusted for in the corresponding model. [f]Measured as the percentage of low-risk childbirths with serious maternal morbidity (explained in the text). *$p < 0.10$ **$p < 0.05$ ***$p < 0.01$

ysis (correlation coefficient: 0.16; $p < 0.001$). Model 3 shows that after other hospital characteristics were adjusted for, a 1-percentage-point increase in the serious maternal morbidity rate was associated with a $296.32 increase in a hospital's average estimated facility cost for a maternity stay across its low-risk births (Exhibit 4). Together, hospital characteristics examined in our analysis explained only 13 percent of the variation in estimated facility costs.

Discussion

For low-risk births without identified maternal or obstetric risk factors, we observed wide variation in average estimated facility costs for a maternity stay across our sample of 463 hospitals. Having relatively low volumes of childbirths, low proportions of childbirths covered by Medicaid, and long stays and being a rural (as opposed to an urban nonteaching) hospital and having nonfederal government or nonprofit (as opposed to investor-owned private) ownership were all associated with higher estimated facility costs. Higher rates of serious maternal morbidity and cesarean delivery were also associated with significantly higher estimated costs.

Few data are available on variation in childbirth-related costs among US hospitals, despite growing evidence of hospital differences in obstetric intervention rates.[8,9] One UK study of 136 hospitals reported a difference of nearly £1,500 (US$2,653)[31] in the mean cost of obstetric admissions during 2005–06 between low- and high-cost hospitals after patient characteristics and input prices were adjusted for.[32]

Similar research in the United States was lacking until recently, when Renee Hsia and coauthors reported marked variation among California hospitals in maternal charges for uncomplicated vaginal and cesarean deliveries for privately insured women (ranges: $3,344–$43,715 and $7,905–$72,569, respectively).[17] Using a national, all-payer sample (including Medicaid, which finances nearly half of all US births)[33] and estimating hospital facility costs instead of charges, our study reveals variations in the cost of childbirth among US hospitals that have important implications for cost containment strategies.

Moreover, contrary to the common belief that spending more leads to improved outcomes or at least maintains quality of care, we found a significant positive association between estimated hospital facility cost and serious maternal morbidity rate for low-risk childbirths. This finding is consistent with a 1985 study based on a small sample (eight hospitals in Southern California) that reported increased neonatal mortality in hospitals with higher costs.[34]

More recent studies have focused on relationships between obstetric intervention rates (instead of costs) and maternal or neonatal outcomes. For example, research from California showed higher rates of maternal infection in hospitals with cesarean delivery rates that were below or above expected confidence intervals than in hospitals with rates that were within expected confidence intervals.[35] In contrast, several European studies found no association between hospital maternal morbidity rates and ob-

stetric intervention rates.[36,37]

The causes of our observed cost-morbidity relationship remain unclear and require further research. Hospitals might incur higher facility costs for different reasons, such as investments to improve care and expand services, inefficient and expensive care with poor value, or poor quality of care (resulting in complications that lead to additional care). It is also likely that there is residual difference in patient case-mix among the hospitals in our study, although we focused on a sample of low-risk childbirths.

As expected, a hospital's higher rate of cesarean delivery was associated with higher estimated facility costs for maternity stays. This appeared to be largely due to longer stays for cesarean deliveries. However, cesarean delivery rate, maternal morbidity rate, length-of-stay, and conventional hospital characteristics (for example, teaching status, location, size, and ownership) together explained only 13 percent of the variation in these costs among hospitals. Continued efforts are needed to identify other factors that could explain the remaining majority of variation in childbirth hospitalization costs.

We recognize that examining overall costs of childbirth hospitalizations—accounting for both facility and professional costs and including both maternal and newborn care—might show different patterns than the ones we found for estimated facility costs for maternity care alone. For example, costs of services by anesthesiologists may significantly alter the relationship between mode of delivery and cost of intrapartum care, and neonatal complications could substantially increase the overall cost of childbirth. In addition, since hospitals with lower inpatient costs may have higher postdischarge costs, and vice versa, extending the time horizon to compare costs of the entire episode of care for childbirth would be informative.

Policy Implications

OPPORTUNITIES FOR COST REDUCTION With nearly four million births in the United States each year,[7] the large variation in estimated hospital facility costs points to an opportunity for cost containment. If hospitals above the 75th percentile of facility costs in our sample could reduce their costs to the 75th percentile, collectively these hospitals could have saved $290 million in 2011 among low-risk childbirths alone.

Experience from existing payment and delivery system reforms could inform strategies to reduce costs in obstetric care. For example, pilot bundled payment programs for perinatal care have been initiated by nonprofit organizations in California and by Medicaid and private insurers in Arkansas.[38] The "perinatal bundle initiative" of Geisinger Health System, in Pennsylvania, showed promising results in lowering the primary cesarean delivery rate (that is, the rate of first-time cesarean deliveries).[38] Similar approaches may be adopted by other organizations and by state Medicaid programs, which funded 48 percent of US births in 2010.[33]

SAFE REDUCTION OF CESAREAN DELIVERIES Because of concerns about patient safety and overutilization, the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine have called for the safe reduction of primary cesareans.[39] This seems feasible, given our observation that some hospitals' cesarean delivery rates were as high as 39 percent in our low-risk patient sample.

Establishing standardized definitions and management guidelines for common indications for cesarean delivery, such as labor dystocia (slow or obstructed labor) and abnormal fetal heart rate tracing, could help lower cesarean delivery rates[39] and reduce variation. Regular review, feedback, and improvement of care processes at the hospital and physician level might also be instrumental in reducing cesarean rates.[4]

In addition, increased patient education about the short- and long-term consequences of early elective deliveries and cesarean deliveries may be important, as demonstrated in the Strong Start for Mothers and Newborns program.[38] And public reporting of information about maternity care services—including rates of cesarean delivery, as recently requested by the Joint Commission[40]—could theoretically help steer patients to institutions with low intervention rates as well.

OTHER FACTORS THAT MIGHT ACCOUNT FOR VARIATION IN COSTS Substantial variation in estimated facility costs remained after we controlled for customary hospital characteristics. Therefore, efforts to identify causes of cost variation should look beyond conventional factors. The large difference we found in estimated facility costs for a low-risk population also suggests that hospital practices instead of patient clinical characteristics may be an important contributor to cost variation.

For example, previous research showed that the provision of postpartum home nursing assistance was associated with shorter maternal hospital stays.[10] This suggests that peripartum care coordination may play a role in influencing hospital facility costs and cost variation. In this regard, accountable care organizations (ACOs) may merit particular attention in future research, since they facilitate coordinated care. Bundling payments across facilities and care settings in ACO models could also mitigate cost shifting across providers. Moreover, physicians,

midwives, and other providers involved in maternity care may also influence resource utilization and hence hospital facility costs. Measuring all of these factors requires the collection of data (for example, institutional protocols and information about staffing and the process and organization of care) not traditionally available in perinatal care research.

EMPHASIZING VALUE OF CARE Cost reduction initiatives by hospitals may have unintended negative consequences on quality of care if patient outcomes are not taken into consideration. Further investigation is needed to identify the exact reason for our observed positive cost-morbidity relationship. Nonetheless, reducing preventable maternal morbidity is one area with clear benefits for patients and hospitals.[41] Multiple such national efforts are currently in place. For example, several organizations (such as the National Partnership for Maternal Safety) have recommended birthing facilities to implement safety bundles for obstetric hemorrhage, severe hypertension in pregnancy, and peripartum venous thromboembolism.[41] Healthy People 2020 also calls for a reduction of maternal complications during childbirth hospitalizations.[42]

The adoption of value-based payment models in obstetric care may also be fruitful.[38] However, the effectiveness of these models depends on the quality metric used. Continuing efforts are needed to identify the performance measures with the most impact on patient outcomes.[11]

Conclusion

We found wide variation among US hospitals in the estimated facility costs of maternity stays for low-risk childbirths, which suggests that there is an opportunity for strategies to reduce costs. The impact of current payment and delivery system reforms on costs and outcomes in obstetric care should be closely monitored.

Estimated facility costs were higher at hospitals with higher rates of cesarean delivery or serious maternal morbidity. The safe reduction of cesarean deliveries may help reduce facility costs and cost variation for childbirth-related hospitalizations. Yet the hospital characteristics that we studied explained only 13 percent of the variation in estimated facility costs. Additional research is needed to identify other sources of variation in hospital facility costs, to clarify the relationship we observed between high cost and high morbidity, and to inform strategies for improving efficiency, value, and patient outcomes in obstetric care. ■

Preliminary results of this study were presented at the AcademyHealth Annual Research Meeting in San Diego, California, June 10, 2014. They were also presented at research seminar at Stanford University School of Medicine/California Perinatal Quality Care Collaborative Perinatal Epidemiology and Health Services Research Group, in Stanford, California, May 4, 2015. This study was supported by funds from the McDevitt Award for Excellence in Research awarded by the Blue Cross Blue Shield of Michigan Foundation. The funder had no role in the design and conduct of the study; in the collection, management, analysis, and interpretation of the data; in the preparation, review, or approval of the manuscript; or in the decision to submit the manuscript for publication. Harlan Krumholz is the chair of the Cardiac Scientific Advisory Board for UnitedHealthcare and has contracts with Medtronic Inc. and Johnson and Johnson.

NOTES

1 Martin AB, Hartman M, Whittle L, Catlin A, National Health Expenditure Accounts Team. National health spending in 2012: rate of health spending growth remained low for the fourth consecutive year. Health Aff (Millwood). 2014;33(1):67–77.
2 Torio CM, Andrews RM. National inpatient hospital costs: the most expensive conditions by payer, 2011 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2013 Aug [cited 2015 Apr 21]. (Healthcare Cost and Utilization Project Statistical Brief No. 160). Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb160.pdf
3 Moore JE, Witt WP, Elixhauser A. Complicating conditions associated with childbirth, by delivery method and payer, 2011 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2014 May [cited 2015 Apr 21]. (Healthcare Cost and Utilization Project Statistical Brief No. 173). Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb173-Childbirth-Delivery-Complications.pdf
4 Main EK, Morton CH, Melsop K, Hopkins D, Giuliani G, Gould JB. Creating a public agenda for maternity safety and quality in cesarean delivery. Obstet Gynecol. 2012;120(5):1194–8.
5 Glantz JC. Obstetric variation, intervention, and outcomes: doing more but accomplishing less. Birth. 2012;39(4):286–90.
6 Caughey AB, Sundaram V, Kaimal AJ, Cheng YW, Gienger A, Little SE, et al. Maternal and neonatal outcomes of elective induction of labor [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2009 Mar [cited 2015 Apr 21]. (AHRQ Publication No. 09-E005). Available from: http://www.ahrq.gov/research/findings/evidence-based-reports/eil-evidence-report.pdf
7 Martin JA, Hamilton BE, Osterman MJK, Curtin SC, Mathews TJ. Births: final data for 2012 [Internet]. Hyattsville (MD): National Center for Health Statistics; 2013 [cited 2015 Apr 21]. Available from: http://www.cdc.gov/nchs/data/nvsr/nvsr62/nvsr62_09.pdf
8 Kozhimannil KB, Law MR, Virnig BA. Cesarean delivery rates vary tenfold among US hospitals; reducing variation may address quality and cost issues. Health Aff (Millwood). 2013;32(3):527–35.
9 Glantz JC, Guzick DS. Can differences in labor induction rates be explained by case mix? J Reprod Med. 2004;49(3):175–81.
10 Bellanger MM, Or Z. What can we learn from a cross-country compar-

ison of the costs of child delivery? Health Econ. 2008;17(1 Suppl): S47–57.
11 Transforming Maternity Care Vision Team, Carter MC, Corry M, Delbanco S, Foster TC, Friedland R, Gabel R, et al. 2020 vision for a high-quality, high-value maternity care system. Womens Health Issues. 2010; 20(1 Suppl):S7–17.
12 Healthcare Cost and Utilization Project. Nationwide Inpatient Sample 2011 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; [last modified 2014 Nov 6; cited 2015 Apr 21]. Available from: http://www.hcup-us.ahrq.gov/nisoverview.jsp
13 Kuklina EV, Whiteman MK, Hillis SD, Jamieson DJ, Meikle SF, Posner SF, et al. An enhanced method for identifying obstetric deliveries: implications for estimating maternal morbidity. Matern Child Health J. 2008;12(4):469–77.
14 Yasmeen S, Romano PS, Schembri ME, Keyzer JM, Gilbert WM. Accuracy of obstetric diagnoses and procedures in hospital discharge data. Am J Obstet Gynecol. 2006;194(4): 992–1001.
15 To access the Appendix, click on the Appendix link in the box to the right of the article online.
16 Faraci M, Renda E, Monte S, Di Prima FAF, Valenti O, De Domenico R, et al. Fetal growth restriction: current perspectives. J Prenat Med. 2011;5(2):31–3.
17 Hsia RY, Akosa Antwi Y, Weber E. Analysis of variation in charges and prices paid for vaginal and caesarean section births: a cross-sectional study. BMJ Open. 2014;4(1): e004017.
18 Gregory KD, Korst LM, Gornbein JA, Platt LD. Using administrative data to identify indications for elective primary cesarean delivery. Health Serv Res. 2002;37(5):1387–401.
19 Janakiraman V, Lazar J, Joynt KE, Jha AK. Hospital volume, provider volume, and complications after childbirth in U.S. hospitals. Obstet Gynecol. 2011;118(3):521–7.
20 Kahn EB, Berg CJ, Callaghan WM. Cesarean delivery among women with low-risk pregnancies: a comparison of birth certificates and hospital discharge data. Obstet Gynecol. 2009;113(1):33–40.
21 McDonald SD, Vermeulen MJ, Ray JG. Risk of fetal death associated with maternal drug dependence and placental abruption: a population-based study. J Obstet Gynaecol Can. 2007;29(7):556–9.
22 Salihu HM, Mogos MF, August EM, Dejoy S, de la Cruz C, Alio AP, et al. HIV infection and its impact on fetal outcomes among women of advanced maternal age: a propensity score weighted matching approach. AIDS Res Hum Retroviruses. 2013; 29(3):581–7.
23 Srinivas SK, Fager C, Lorch SA. Evaluating risk-adjusted cesarean delivery rate as a measure of obstetric quality. Obstet Gynecol. 2010;115(5):1007–13.
24 Healthcare Cost and Utilization Project. Comorbidity Software, version 3.6 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; [last modified 2015 Mar 6; cited 2015 Apr 21]. Available from: http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp
25 Salemi JL, Comins MM, Chandler K, Mogos MF, Salihu HM. A practical approach for calculating reliable cost estimates from observational data: application to cost analyses in maternal and child health. Appl Health Econ Health Policy. 2013;11(4): 343–57.
26 Sun Y, Friedman B. Tools for more accurate inpatient cost estimates with HCUP databases, 2009. Errata added October 25, 2012 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2012 Oct 29 [cited 2015 Apr 21]. (HCUP Methods Series Report No. 2011-04). Available from: http://www.hcup-us.ahrq.gov/reports/methods/2011_04.pdf
27 Gottlieb D, Zhou W, Song Y, Andrews KG, Skinner J, Sutherland J. Technical report: a standardized method for adjusting Medicare expenditures for regional differences in prices [Internet]. Lebanon (NH): Dartmouth Institute for Health Policy and Clinical Practice; 2010 Jan [cited 2015 Apr 21]. Available from: http://www.dartmouthatlas.org/downloads/papers/std_prc_tech_report.pdf
28 Dixon WJ, Yuen KK. Trimming and winsorization: a review. Statistische Hefte. 1974;15(2–3):157–70.
29 Centers for Disease Control and Prevention. Severe maternal morbidity in the United States [Internet]. Atlanta (GA): CDC; [last updated 2014 Jan 22; cited 2015 Apr 21]. Available from: http://www.cdc.gov/reproductivehealth/MaternalInfantHealth/SevereMaternalMorbidity.html
30 Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol. 2012;120(5): 1029–36.
31 Based on an exchange rate of US $1.7686 per pound in January 2006. Board of Governors of the Federal Reserve System. Federal Reserve statistical release: G.5: foreign exchange rates (monthly) [Internet]. Washington (DC): Federal Reserve; [last updated 2006 Feb 1; cited 2015 Apr 30]. Available from: http://www.federalreserve.gov/releases/g5/20060201/
32 Laudicella M, Olsen KR, Street A. Examining cost variation across hospital departments—a two-stage multi-level approach using patient-level data. Soc Sci Med. 2010;71(10): 1872–81.
33 Markus AR, Andres E, West KD, Garro N, Pellegrini C. Medicaid covered births, 2008 through 2010, in the context of the implementation of health reform. Womens Health Issues. 2013;23(5):e273–80.
34 Finkler MD, Wirtschafter DD. Cost-effectiveness and obstetric services. Med Care. 1991;29(10):951–63.
35 Bailit JL, Love TE, Dawson NV. Quality of obstetric care and risk-adjusted primary cesarean delivery rates. Am J Obstet Gynecol. 2006; 194(2):402–7.
36 Alran S, Sibony O, Oury JF, Luton D, Blot P. Differences in management and results in term-delivery in nine European referral hospitals: descriptive study. Eur J Obstet Gynecol Reprod Biol. 2002;103(1):4–13.
37 Pallasmaa N, Alanen A, Ekblad U, Vahlberg T, Koivisto M, Raudaskoski T, et al. Variation in cesarean section rates is not related to maternal and neonatal outcomes. Acta Obstet Gynecol Scand. 2013; 92(10):1168–74.
38 Lally S. Transforming maternity care: a bundled payment approach [Internet]. Oakland (CA): Integrated Healthcare Association; 2013 Sep [cited 2015 Apr 21]. (Issue Brief No. 10). Available from: http://www.iha.org/pdfs_documents/bundled_payment/Maternity-Issue-Brief-September-2013.pdf
39 American College of Obstetricians and Gynecologists, Society for Maternal-Fetal Medicine, Caughey AB, Cahill AG, Guise J-M, Rouse DJ. Safe prevention of the primary cesarean delivery. American journal of obstetrics and gynecology. 2014; 210(3):179–93.
40 Joint Commission. Questions and answers: the perinatal care core measure set [Internet]. Oakbrook Terrace (IL): Joint Commission; 2013 Nov [cited 2015 Apr 21]. Available from: http://www.jointcommission.org/assets/1/6/S11.pdf
41 D'Alton ME, Main EK, Menard MK, Levy BS. The National Partnership for Maternal Safety. Obstet Gynecol. 2014;123(5):973–7.
42 HealthyPeople.gov. Maternal, infant, and child health [Internet]. Washington (DC): Department of Health and Human Services; [last updated 2014 Apr 21; cited 2015 Apr 21]. Available from: http://www.healthypeople.gov/2020/topics-objectives/topic/maternal-infant-and-child-health/objectives