Title
Rates Of Major Obstetrical Complications Vary Almost Fivefold Among US Hospitals

Journal
Health Affairs, 33(8)

ISSN
0278-2715

Authors
Glance, Laurent G
Dick, Andrew W
Glantz, J Christopher
et al.

Publication Date
2014-08-01

DOI
10.1377/hlthaff.2013.1359

By Laurent G. Glance, Andrew W. Dick, J. Christopher Glantz, Richard N. Wissler, Feng Qian, Bridget M. Marroquin, Dana B. Mukamel, and Arthur L. Kellermann

DOI: 10.1377/hlthaff.2013.1359
HEALTH AFFAIRS 33,
NO. 8 (2014): 1330–1336

Rates Of Major Obstetrical Complications Vary Almost Fivefold Among US Hospitals

Laurent G. Glance (laurent_glance@urmc.rochester.edu) is vice chair for research and a professor of anesthesiology and public health sciences at the School of Medicine and Dentistry, University of Rochester, in New York.

Andrew W. Dick is a senior economist at the RAND Corporation in Boston, Massachusetts.

J. Christopher Glantz is a professor of obstetrics and gynecology at the School of Medicine and Dentistry, University of Rochester.

Richard N. Wissler is a professor of anesthesiology at the School of Medicine and Dentistry, University of Rochester.

Feng Qian is an assistant professor of health policy and management, School of Public Health, University at Albany, in New York.

Bridget M. Marroquin is an assistant professor of anesthesiology at the School of Medicine and Dentistry, University of Rochester.

Dana B. Mukamel is a professor in the Department of Medicine, University of California, Irvine.

Arthur L. Kellermann is a professor in and dean of the F. Edward Hébert School of Medicine, Uniformed Services University of the Health Sciences, in Bethesda, Maryland.

ABSTRACT Of the approximately four million women who give birth each year in the United States, nearly 13 percent experience one or more major complications. But the extent to which the rates of major obstetrical complications vary across hospitals in the United States is unknown. We used multivariable logistic regression models to examine the variation in obstetrical complication outcomes across US hospitals among a large, nationally representative sample of more than 750,000 obstetrical deliveries in 2010. We found that 22.55 percent of patients delivering vaginally at low-performing hospitals experienced major complications, compared to 10.42 percent of similar patients delivering vaginally at high-performing hospitals. Hospitals were classified as having low, average, or high performance based on a calculation of the relative risk that a patient would experience a major complication. Patients undergoing a cesarean delivery at low-performing hospitals had nearly five times the rate of major complications that patients undergoing a cesarean delivery at high-performing hospitals had (20.93 percent compared to 4.37 percent). Our finding that the rate of major obstetrical complications varies markedly across US hospitals should prompt clinicians and policy makers to develop comprehensive quality metrics for obstetrical care and focus on improving obstetrical outcomes.

Each year about four million women give birth in the United States.[1] Childbirth is the most common cause of hospitalization in the country, accounting for nearly one-fourth of hospital discharges.[1] Hospital charges for pregnant women and newborns totaled nearly $100 billion in 2008, the most recent year for which data are available.[2] Cesarean delivery is the most common operating room procedure performed in the United States, accounting for 9 percent of all procedures in 2007.[3]

The reported incidence of pregnancy-related mortality is quite low (14.5 per 100,000 live births).[4] However, the rate of obstetric complications is nearly 13 percent,[5] which is similar to the rates of major complications for cardiac (13.4 percent)[6] and noncardiac surgery (12.3 percent).[5] Maternal complications such as hemorrhage, infection, and laceration are frequently less severe than complications following major surgery. Nonetheless, most childbearing women are healthy and expect a birth that is free from complications.[7]

Despite the substantial morbidity associated with childbirth in the United States, there is currently no national system for reporting maternal complications. We conducted the study reported here to examine variations in obstetrical outcomes across US hospitals and to determine the size of the quality gap in obstetrical care between high- and low-performing hospitals.

Hospitals' performance was classified as low, average, or high based on a calculation of the relative risk that a patient would experience a major complication.

Quantifying the magnitude of the quality gap could prove useful to physicians, policy makers, patients, third-party payers, and other stakeholders seeking to redesign obstetrical care to achieve the Institute of Medicine's vision of woman-centered care that is "safe, effective, timely, efficient, and equitable for all women and their families."[7(pS9)]

Study Data And Methods

SETTING AND PARTICIPANTS This study was based on data for about 750,000 obstetrical deliveries in 2010 from the Healthcare Cost and Utilization Project's Nationwide Inpatient Sample. The Nationwide Inpatient Sample is an all-payer inpatient care administrative database that includes all discharge data from a 20 percent stratified sample of US community hospitals.[8] The database includes information on patients' demographic characteristics; admission source; *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM), diagnostic and procedure codes; hospital identifiers; and hospital characteristics. The Institutional Review Board of the University of Rochester's School of Medicine and Dentistry exempted this study from review.

Our primary outcome of interest was a composite complication outcome that consisted of maternal hemorrhage; laceration or operative complication; infection; and all other complications, such as thrombotic complications. We used a complication mapping algorithm based on ICD-9-CM codes that was described by David Asch and coauthors.[5] Secondary analyses focused on each of the individual complications separately.

STATISTICAL ANALYSIS Each hospital's performance with patients undergoing vaginal delivery was evaluated using hierarchical logistic regression, in which the hospital was specified as a random effect. Hierarchical modeling is frequently used for provider profiling because it accounts for differences in providers' case volumes. If nonhierarchical modeling were used, these differences might lead some low-volume providers to have observed rates that appear extreme but that do not accurately reflect the providers' overall level of performance.[9]

The main outcome variable was our composite complication outcome. We controlled for differences in patient case-mix by adjusting for patients' demographic characteristics (age and race or ethnicity), payer status, elective status, transfer from another hospital, prior cesarean delivery, weekend admission, and comorbid conditions. We used a comorbidity algorithm developed by Kimberly Gregory and coauthors that maps ICD-9-CM codes to thirty-three separate clinical conditions.[10] The algorithm has been used in a recent analysis to examine the association between patient outcomes and obstetrical residency programs.[5] Because of the nonlinear association between age and the composite outcome, we specified age as a categorical variable.

The performance of individual hospitals was estimated using an adjusted odds ratio (AOR). The ratio represented the relative risk that a patient would experience a major complication after vaginal delivery.

To further define the importance of hospital performance, we examined the clinical importance of undergoing a vaginal delivery in a hospital whose performance was high (a hospital with an AOR significantly less than 1), low (an AOR significantly greater than 1), or average. We estimated a multivariable logistic regression model in which the dependent variable was the composite outcome and the exposure variable was a categorical variable specifying hospital performance, with patient case-mix controlled for.

We estimated the average marginal effects of women undergoing vaginal delivery at hospitals with high, average, and low performance. This quantified the probability of experiencing a complication conditional on hospital quality.

We repeated these analyses for each of the components of the composite complication outcome. Robust variance estimators were used to account for the clustering of observations within hospitals.

We conducted three additional analyses to quantify the proportion of hospital-level variation in performance that was related to hospitals' structural characteristics (case volume of vaginal deliveries and cesarean deliveries, cesarean delivery rate, case-mix severity, ownership, bed size, location, teaching status, and region). These analyses are described in the online Appendix.[11]

We repeated all of these analyses for women undergoing cesarean delivery. We also performed several sensitivity analyses that limited our sample to hospitals with annual volumes of at least two hundred deliveries.

Program rankings based on hospital performance with vaginal and cesarean deliveries were compared using the Spearman rank correlation. Data management and statistical analyses were performed using the statistical software Stata SE/MP, version 13.0. Hierarchical modeling was performed using GLLAMM in Stata.[12]

LIMITATIONS Our study had certain limitations. First, maternal health care must balance the needs of the mother and the fetus. Our data did not allow us to link maternal and newborn records to simultaneously examine the outcomes of mother and child.

Second, administrative data have been used to examine health care quality over the past three decades.[13] However, these data have significant limitations, including the lack of important risk factors (such as parity—that is, the number of pregnancies carried to birth—and body mass index), laboratory values, and information on other diagnostic tests; problems with coding accuracy (for example, the extent to which comorbidities and complications are properly coded);[14,15] and variability in data quality across hospitals.[16,17]

Third, it is likely that some of the variation in outcomes was the result of residual confounding caused by differences in unmeasured risk factors or reporting across hospitals.[18] The Centers for Medicare and Medicaid Services (CMS) uses administrative data in its Hospital Compare database as the basis for public reporting and value-based purchasing. The American College of Surgeons,[19] the Society of Thoracic Surgeons,[20] and the American College of Cardiology[21] have argued that quality reporting should be based on clinical, not administrative, data. However, others have shown that hospital profiling based on administrative data produces quality estimates similar to those based on clinical data.[22,23]

Because we lacked access to comprehensive clinical data, our findings should be considered preliminary. Nevertheless, since the magnitude of observed differences in outcomes was so large, it is unlikely to be explained away by unmeasured severity.

Finally, our study was primarily designed to explore the variability in hospital outcomes. Future studies will be needed to determine the relative contribution of providers' characteristics such as type (obstetrician, family practice physician, or nurse midwife), training, and prior experience that might influence outcomes. It is likely that a significant portion of hospital variation in performance is a result of differences in providers' performance, as is the case for cardiac and noncardiac surgeries.[24]

Study Results

STUDY SAMPLE AND VARIABILITY IN OUTCOMES

Characteristics of hospitals in the study sample are presented in Appendix Exhibit A1.[11] The majority are private nonprofit facilities (64.7 percent), located in urban settings (60.2 percent), and nonteaching institutions (76.0 percent).

Forty-six percent of the patients in the study were white, 13.4 percent were black, and 19.9 percent were Hispanic. The majority of the women were covered by Medicaid (45.2 percent) or private insurance (48.1 percent). One-half percent of the patients had been transferred from another hospital (Appendix Exhibit A2).[11]

DIFFERENCES BETWEEN HIGH- AND LOW-PERFORMING HOSPITALS

Women delivering vaginally at a low-performing hospital had twice the rate of any major complications (22.55 percent) than women delivering vaginally at a high-performing hospital (10.42 percent) (Exhibit 1). The largest absolute differences in adjusted complication rates between high- and low-performing hospitals were seen for maternal hemorrhage and vaginal lacerations.

Women undergoing a cesarean delivery at a low-performing hospital were nearly five times more likely to experience a major complication (20.93 percent) than women undergoing a cesarean delivery at a high-performing hospital (4.37 percent) (Exhibit 1). The greatest absolute difference in adjusted complication rates between high- and low-performing hospitals was seen for maternal hemorrhage.

Our findings for both vaginal and cesarean deliveries were unchanged when we excluded hospitals with annual volumes of fewer than two hundred deliveries.

Patients in hospitals with greater numbers of vaginal deliveries experienced approximately 10 percent fewer complications with vaginal de-

EXHIBIT 1

Adjusted Rates Of Maternal Complications By Hospital Quality

	Quality					
	Low		Average	High		Difference between high and low quality
Complication	Adjusted rate	AOR	Adjusted rate	Adjusted rate	AOR	
VAGINAL DELIVERIES						
Composite	22.55	1.64	15.10	10.42	0.65	12.13
Hemorrhage	10.01	1.82	5.78	3.52	0.59	6.49
Laceration	13.22	1.48	9.36	6.75	0.70	6.47
Infection	0.58	1.19	0.49	0.40	0.83	0.18
Other	0.78	1.43	0.55	0.34	0.61	0.44
CESAREAN DELIVERY						
Composite	20.93	2.86	8.61	4.37	0.48	16.56
Hemorrhage	17.50	3.42	5.91	2.68	0.44	14.82
Operative	0.85	1.37	0.62	0.37	0.59	0.48
Infection	3.29	1.53	2.18	1.28	0.58	2.01
Other	1.03	1.58	0.68	0.46	0.66	0.57

SOURCE Authors' analysis. **NOTES** The reference category is intermediate quality. Adjusted odds ratios (AORs) were adjusted for patient demographics, payer status, elective status, transfer from another hospital, prior cesarean delivery, weekend admission, and comorbid conditions. All differences between high- and low-quality hospitals were significant ($p < 0.001$). The composite complication included all complications.

liveries, compared to patients delivering in hospitals with low volumes of vaginal deliveries. However, patients admitted to hospitals with higher volumes of cesarean deliveries did not have fewer complications with cesarean deliveries than patients delivering in hospitals with low volumes of cesarean deliveries.

After we adjusted for differences in case-mix, we found that women delivering in hospitals with higher case-mix severity were 60 percent more likely to experience a major complication after a vaginal delivery and more than twice as likely to experience one after a cesarean delivery (Exhibit 2). Patients delivering in hospitals with the highest rate of cesarean deliveries were less likely to experience a major complication, whether they had a vaginal or a cesarean delivery. Women admitted to teaching hospitals experienced slightly higher rates of major complications following a vaginal delivery—but not following a cesarean delivery—than women delivering in nonteaching hospitals.

Hospital ownership, bed size, and rural location were not associated with a higher rate of complications following vaginal or cesarean deliveries (Exhibit 2). Hospital structural variables explained approximately 14 percent of the hospital-level variation in complications for vaginal deliveries and 17 percent of the variation in complications for cesarean deliveries. However, the strength of the observed associations between major maternal complications and hospital performance was essentially unchanged after we controlled for these variables (Model 2 in Exhibit 2).

Hospitals' level of performance, based on the composite complication outcome, was similar for patients undergoing both types of deliveries (correlation coefficient 0.55; $p < 0.001$). For example, hospitals with low rates of major complications following vaginal deliveries also tended to have low rates of major complications following cesarean deliveries.

Discussion

A major benefit of performance benchmarking is that it gives hospitals and physicians incentives to improve health care quality. To estimate the potential impact of quality reporting, it is first necessary to examine the variability in outcomes across providers.

Recent work by Asch and coauthors demonstrated that where an obstetrician was trained was associated with substantial differences in the incidence of maternal complications.[5] However, until now the extent to which maternal outcomes vary in different hospitals in the United States was unknown. To the best of our knowledge, this is the first nationally representative study to systematically examine the impact of US hospital performance on a woman's risk of experiencing major complications of childbirth.

Working with a large nationally representative sample of more than 750,000 obstetrical deliveries in 2010, we found substantial differences in rates of major complications in US hospitals. Women delivering vaginally in a low-performing hospital were twice as likely to experience a major complication, and those delivering by cesarean section were nearly five times more likely to experience a major complication, compared to women giving birth in a high-performing hospital.

EXHIBIT 2

Association Of Major Maternal Complications And Hospital Characteristics In Vaginal And Cesarean Deliveries

	Adjusted odds ratios			
	Vaginal deliveries		Cesarean deliveries	
Characteristic	Model 1	Model 2	Model 1	Model 2
HOSPITAL QUALITY[a]				
Low	—[b]	1.63***	—[b]	2.78***
High	—[b]	0.67***	—[b]	0.51***
HOSPITAL OWNERSHIP[c]				
Private, for-profit	1.10	1.06	0.98	1.00
Government (nonfederal)	0.99	0.99	1.04	0.98
HOSPITAL CESAREAN DELIVERY RATE[d]				
Quartile 2	1.01	1.01	0.99	1.04
Quartile 3	1.01	1.01	0.97	1.11
Quartile 4	0.87**	0.99	0.68****	1.01
HOSPITAL CASE-MIX SEVERITY[e]				
Quartile 2	1.32****	1.12****	1.15	0.93
Quartile 3	1.39****	1.09**	1.15	1.03
Quartile 4	1.60****	1.18****	2.41****	1.23
HOSPITAL BED SIZE[f]				
Small	1.11	1.03	1.24	1.18**
Medium	0.99	1.02	0.95	1.05
HOSPITAL LOCATION[g]				
Urban	0.90	0.95	0.81	0.89
TEACHING STATUS[h]				
Teaching	1.19****	1.03	1.15	0.98
REGION[i]				
Midwest	1.08	0.99	1.03	1.08
South	1.05	0.99	0.88	1.15
West	1.05	0.95	0.92	1.15
MODEL PERFORMANCE				
C statistic	0.59	0.64	0.66	0.72
Hosmer-Lemeshow statistic	19.39	21.52	65.99	19.13

SOURCE Authors' analysis. **NOTES** Both models include patient risk factors and hospital structural characteristics. Model 2 also includes hospital quality. Odds ratios were adjusted for patient demographics, payer status, elective status, transfer from another hospital, prior cesarean delivery, weekend admission, and comorbid conditions. Significance denotes difference from reference category. [a]Ref: average quality. [b]Not applicable. [c]Ref: private, nonprofit. [d]Ref: quartile 1, lowest hospital case-mix severity. [e]Ref: quartile 1, lowest rate of cesarean deliveries. [f]Ref: large size. [g]Ref: rural location. [h]Ref: nonteaching. [i]Ref: Northeast. **$p < 0.05$ ***$p < 0.01$ ****$p < 0.001$

Hospital rankings based on outcomes for vaginal deliveries and cesarean deliveries were generally consistent, although not perfectly correlated. The magnitude of the differences in complication rates between low- and high-performing hospitals is clinically important, with absolute differences in complication rates of 12.13 percentage points for vaginal deliveries and 16.56 percentage points for cesarean deliveries, after differences in patient risk are controlled for (Exhibit 1).

Our data did not include descriptive information on obstetrical processes of care. Therefore, we could not examine every possible clinical explanation for the observed variation in outcomes. However, hospital ownership, bed size, teaching status, rural location, cesarean delivery rates, and hospital case-mix accounted for less than 20 percent of the observed variation in obstetrical outcomes. Thus, it is very likely that the outcome differences we observed were the result of differences in clinical performance.

Many people assume that higher-volume hospitals are better than lower-volume ones. However, we found that procedure volume was a poor proxy for a hospital's obstetrical quality.

Our findings are consistent with the results of previous studies of hospital variations in obstetrical complications using single-state data,[25–27] as well as the findings of a multicenter trial that examined the impact of teamwork training on obstetrical outcomes.[28] Asch and coauthors reported that obstetricians trained at high-performing residency programs had lower complication rates than obstetricians trained at lower-performing programs (13.6 percent versus 10.3 percent).[5]

Another recent report identified tremendous variability in rates of cesarean deliveries in US hospitals: Cesarean rates varied tenfold across hospitals and fifteenfold among women with low-risk pregnancies.[29] Interestingly, we found that hospitals with higher cesarean delivery rates had lower complication rates for women having either a vaginal or a cesarean delivery, compared to hospitals with lower cesarean rates. It is possible that hospitals delivering a higher proportion of babies using cesarean section have fewer high-risk vaginal deliveries. Variability is likely to exist in other areas of obstetrical decision making as well, and this may account for some of the variability in clinical outcomes that we found.

Policy And Quality Implications

Our finding of a large gap in quality in obstetrical care between high- and low-performing hospitals has important policy implications for maternal health. If this performance gap could be narrowed, it could lead to substantial improvements in obstetrical outcomes for large numbers of women.

The momentum for quality reporting in obstetrics is increasing.

The number of obstetrical deliveries far exceeds other common causes of hospitalizations for which performance reporting already exists, but the quality of obstetrical care is not systematically reported in the United States. The Joint Commission collects a small number of quality measures, but maternal outcomes are not publicly reported.[30]

The momentum for quality reporting in obstetrics is increasing. CMS's National Quality Strategy to achieve better health care at lower cost is operationalized in the hospital and physician components of value-based purchasing.[31] However, the strategy does not yet include obstetrical outcomes. This is ironic, since Medicaid paid for 48 percent of all US births in 2010.[32] Recently, a multiple-stakeholder working group outlined its vision of a "high-quality, high-value maternity care system," describing quality measurement and public reporting as critical foundations for quality improvement.[33]

Key barriers to performance measurement include the lack of both suitable quality metrics and the necessary data infrastructure.[33] If public reporting of maternity care became available, it would allow patients to identify higher-performing hospitals and clinicians, would make it possible for payers to encourage patients to select high-value providers, and would reward providers of high-quality obstetrical care.[34] The early track record for pay-for-performance is mixed.[35] However, report cards have been shown to lead to quality improvement.[36,37]

The goal of quality measurement is to improve outcomes. Therefore, performance reporting may be most effective when coupled with evidence-based risk-reduction strategies. Several transformational approaches have been suggested to improve obstetrical care.

One approach, modeled after trauma care and neonatal care,[38] is to regionalize maternal health care by creating tiered maternal-fetal-neonatal care networks. In this way, high-risk obstetrical

patients could be triaged to designated referral centers with the resources to care for high-risk populations (for example, around-the-clock coverage by in-hospital obstetricians and anesthesiologists).[39] However, the regionalization of perinatal care has led to hospital closures.[40] Thus, efforts to create a maternal-fetal network should seek to minimize the risk of disrupting access to obstetrical care, especially in rural communities.

Using similar approaches developed in trauma care, it may be possible to risk-stratify patients and apply targeted strategies to reduce postpartum hemorrhage and other complications.[41] Surgical safety checklists have reduced complications among surgical patients[42] and may reduce obstetrical complications as well.[43] Finally, local quality improvement efforts using data-driven approaches may prove effective.

Conclusion

Obstetrical outcomes vary widely across hospitals in the United States. This information should spur clinicians, hospital administrators, and policy makers to develop comprehensive quality metrics and invest in the necessary data infrastructure to measure and publicly report hospital obstetrical outcomes.

The American Congress of Obstetricians and Gynecologists (ACOG),[31,44] and groups of researchers[25] have started to build the framework for maternal quality indicators. ACOG should work with the American Society of Anesthesiologists, the American Academy of Family Physicians, nursing organizations (such as the Association of Women's Health, Obstetric and Neonatal Nurses, and the American College of Nurse-Midwives), and patient advocacy groups (such as the National Partnership for Women and Families) to further develop and operationalize a quality measurement platform for obstetrical patients.

Public reporting with timely feedback to front-line clinicians could be a powerful tool in the effort to narrow and ultimately close the obstetrical quality gap across US hospitals and improve the health of mothers and their newborn children. ■

The authors acknowledge the Departments of Anesthesiology and of Obstetrics and Gynecology at the University of Rochester School of Medicine for funding and support. The views expressed do not necessarily represent those of the Uniformed Services University of the Health Sciences or the US Department of Defense.

NOTES

1 Sakala C, Corry MP. Evidence-based maternity care: what it is and what it can achieve [Internet]. New York (NY): Milbank Memorial Fund; 2008 [cited 2014 Jun 9]. Available from: http://www.childbirthconnection.org/pdfs/evidence-based-maternity-care.pdf

2 Wier LM, Andrews RM. The national hospital bill: the most expensive conditions by payer, 2008 [Internet]. Rockville (MD): Agency for Healthcare Research and Quality; 2011 Mar [cited 2014 Jun 9]. (Healthcare Cost and Utilization Project Statistical Brief No. 107). Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb107.pdf

3 Elixhauser A, Andrews RM. Profile of inpatient operating room procedures in US hospitals in 2007. Arch Surg. 2010;145(12):1201–8.

4 Berg CJ, Callaghan WM, Syverson C, Henderson Z. Pregnancy-related mortality in the United States, 1998 to 2005. Obstet Gynecol. 2010;116(6):1302–9.

5 Asch DA, Nicholson S, Srinivas S, Herrin J, Epstein AJ. Evaluating obstetrical residency programs using patient outcomes. JAMA. 2009;302(12):1277–83.

6 Shroyer AL, Coombs LP, Peterson ED, Eiken MC, DeLong ER, Chen A, et al. The Society of Thoracic Surgeons: 30-day operative mortality and morbidity risk models. Ann Thorac Surg. 2003;75(6):1856–64.

7 Transforming Maternity Care Vision Team, Carter MC, Corry M, Delbanco S, Foster TC, Friedland R, et al. 2020 vision for a high-quality, high-value maternity care system. Womens Health Issues. 2010;20(1 Suppl):S7–17.

8 Healthcare Cost and Utilization Project [home page on the Internet]. Rockville (MD): Agency for Healthcare Research and Quality; [last modified 2014 Jun 5; cited 2014 Jun 9]. Available from: http://www.hcup-us.ahrq.gov/

9 Krumholz HM, Brindis RG, Brush JE, Cohen DJ, Epstein AJ, Furie K, et al. Standards for statistical models used for public reporting of health outcomes: an American Heart Association scientific statement from the Quality of Care and Outcomes Research Interdisciplinary Writing Group: cosponsored by the Council on Epidemiology and Prevention and the Stroke Council. Endorsed by the American College of Cardiology Foundation. Circulation. 2006;113(3):456–62.

10 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.

11 To access the Appendix, click on the Appendix link in the box to the right of the article online.

12 Rabe-Hesketh S, Skrondal A. Multilevel and longitudinal modeling using Stata. College Station (TX): Stata Press; 2005.

13 Sarrazin MS, Rosenthal GE. Finding pure and simple truths with administrative data. JAMA. 2012;307(13):1433–5.

14 Romano PS, Yasmeen S, Schembri ME, Keyzer JM, Gilbert WM. Coding of perineal lacerations and other complications of obstetric care in hospital discharge data. Obstet Gynecol. 2005;106(4):717–25.

15 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.

16 Iezzoni LI. Assessing quality using administrative data. Ann Intern Med. 1997;127(8 Pt 2):666–74.

17 Jollis JG, Ancukiewicz M, DeLong ER, Pryor DB, Muhlbaier LH, Mark DB. Discordance of databases designed for claims payment versus

clinical information systems. Implications for outcomes research. Ann Intern Med. 1993;119(8):844–50.
18 Romano PS, Schembri ME, Rainwater JA. Can administrative data be used to ascertain clinically significant postoperative complications? Am J Med Qual. 2002;17(4):145–54.
19 Birkmeyer JD, Shahian DM, Dimick JB, Finlayson SR, Flum DR, Ko CY, et al. Blueprint for a new American College of Surgeons: National Surgical Quality Improvement Program. J Am Coll Surg. 2008;207(5):777–82.
20 Shahian DM, Edwards FH, Jacobs JP, Prager RL, Normand SL, Shewan CM, et al. Public reporting of cardiac surgery performance: Part 2—implementation. Ann Thorac Surg. 2011;92(3 Suppl):S12–23.
21 Drozda JP Jr, Hagan EP, Mirro MJ, Peterson ED, Wright JS. ACCF 2008 health policy statement on principles for public reporting of physician performance data: a report of the American College of Cardiology Foundation Writing Committee to develop principles for public reporting of physician performance data. J Am Coll Cardiol. 2008;51(20):1993–2001.
22 Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006;113(13):1683–92.
23 Krumholz HM, Lin Z, Drye EE, Desai MM, Han LF, Rapp MT, et al. An administrative claims measure suitable for profiling hospital performance based on 30-day all-cause readmission rates among patients with acute myocardial infarction. Circ Cardiovasc Qual Outcomes. 2011;4(2):243–52.
24 Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. N Engl J Med. 2003;349(22):2117–27.
25 Korst LM, Fridman M, Friedlich PS, Lu MC, Reyes C, Hobel CJ, et al. Hospital rates of maternal and neonatal infection in a low-risk population. Matern Child Health J. 2005;9(3):307–16.
26 Lu MC, Fridman M, Korst LM, Gregory KD, Reyes C, Hobel CJ, et al. Variations in the incidence of postpartum hemorrhage across hospitals in California. Matern Child Health J. 2005;9(3):297–306.
27 Gregory KD, Fridman M, Shah S, Korst LM. Global measures of quality- and patient safety–related childbirth outcomes: should we monitor adverse or ideal rates? Am J Obstet Gynecol. 2009;200(6):681.
28 Mann S, Pratt S, Gluck P, Nielsen P, Risser D, Greenberg P, et al. Assessing quality obstetrical care: development of standardized measures. Jt Comm J Qual Patient Saf. 2006;32(9):497–505.
29 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.
30 Gee RE, Winkler R. Quality measurement: what it means for obstetricians and gynecologists. Obstet Gynecol. 2013;121(3):507–10.
31 VanLare JM, Conway PH. Value-based purchasing—national programs to move from volume to value. N Engl J Med. 2012;367(4):292–5.
32 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.
33 Transforming Maternity Care Symposium Steering Committee, Angood PB, Armstrong EM, Ashton D, Burstin H, Corry MP, et al. Blueprint for action: steps toward a high-quality, high-value maternity care system. Womens Health Issues. 2010;20(1 Suppl):S18–49.
34 Von Gruenigen VE, Deveny TC. Health care reform: will quality remodeling affect obstetrician-gynecologists in addition to patients? Obstet Gynecol. 2011;117(5):1167–9.
35 Werner RM, Kolstad JT, Stuart EA, Polsky D. The effect of pay-for-performance in hospitals: lessons for quality improvement. Health Aff (Millwood). 2011;30(4):690–8.
36 Hall BL, Hamilton BH, Richards K, Bilimoria KY, Cohen ME, Ko CY. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals. Ann Surg. 2009;250(3):363–76.
37 O'Connor GT, Plume SK, Olmstead EM, Morton JR, Maloney CT, Nugent WC, et al. A regional intervention to improve the hospital mortality associated with coronary artery bypass graft surgery. The Northern New England Cardiovascular Disease Study Group. JAMA. 1996;275(11):841–6.
38 Lasswell SM, Barfield WD, Rochat RW, Blackmon L. Perinatal regionalization for very low-birth-weight and very preterm infants: a meta-analysis. JAMA. 2010;304(9):992–1000.
39 Hankins GD, Clark SL, Pacheco LD, O'Keeffe D, D'Alton M, Saade GR. Maternal mortality, near misses, and severe morbidity: lowering rates through designated levels of maternity care. Obstet Gynecol. 2012;120(4):929–34.
40 Ryan GM Jr, Fielden JG. The impact of regionalization programs on patterns of perinatal care. Obstet Gynecol. 1979;53(2):187–9.
41 Lu MC, Korst LM, Fridman M, Muthengi E, Gregory KD. Identifying women most likely to benefit from prevention strategies for postpartum hemorrhage. J Perinatol. 2009;29(6):422–7.
42 De Vries EN, Prins HA, Crolla RM, den Outer AJ, van Andel G, van Helden SH, et al. Effect of a comprehensive surgical safety system on patient outcomes. N Engl J Med. 2010;363(20):1928–37.
43 Spector JM, Agrawal P, Kodkany B, Lipsitz S, Lashoher A, Dziekan G, et al. Improving quality of care for maternal and newborn health: prospective pilot study of the WHO safe childbirth checklist program. PLoS One. 2012;7(5):e35151.
44 American Congress of Obstetricians and Gynecologists. reVITALize [home page on the Internet]. Washington (DC): ACOG; c2014 [cited 2014 Jun 10]. Available from: http://www.acog.org/revitalize