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THREE ESSAYS ON BIRTHS AFTER CESAREAN SECTION

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Doctor of Philosophy

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B.S., National Taiwan University, 2002
M.S., National Taiwan University, 2004

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An Abstract of
a dissertation submitted to the Faculty of the
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in partial fulfillment of the requirements for the degree of
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Abstract

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By Ya-lin Aileen Huang

The rate of Cesarean section (C-section) delivery in the U.S. has dramatically increased over the past decade, resulting in rising hospital costs in the U.S. This increase in C-section rate was coupled with an increase in the rate of repeat C-section and can be largely attributable to the concerns about the relative safety of vaginal birth after Cesarean (VBAC). This dissertation comprises three articles investigating the practice patterns and the outcomes of this procedure.

The first chapter investigated how physicians respond differently to new information based on the influence of malpractice pressure regarding performing VBACs. Results show that higher malpractice pressure may be incentives for physicians to uptake information and adopt low-risk practice style.

The second chapter determined whether birth outcomes changed as a result of changes in the pattern of birth after C-sections over time. Selected major maternal and neonatal adverse events were compared between repeat C-sections and VBACs. I find maternal and neonatal outcomes for births after a C-section significantly improved overtime along with the secular increase in repeat C-section rates. The increased adoption of repeat C-sections may have been driven in part by the observed lower maternal complication rates and lower neonatal mortality rates.

The third chapter examined temporal trends in variation in obstetric practice patterns focusing on primary and repeat Cesarean sections among hospitals over time. There is a statistically significant downward trend in the degree of cross-hospital variation in repeat Cesarean section rates, but no similar trend for variation in primary Cesarean section rates. Practice patterns for repeat C-section become less variable over time may be a result of the diffusion of national clinical guidelines.

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CHAPTER 1

Malpractice Pressure and Physicians' Response to New Evidence on Vaginal Birth after Cesarean Section

Abstract

Little is known about how physicians respond differently to new information based on the influence of malpractice pressure. This study uses a HCUP National Inpatient Sample from 1993 through 2004 to develop a discharge-level logit model that focuses on the interaction effects of malpractice pressure and new information on the probability of vaginal birth after Cesarean (VBAC). We identify two pieces of information: a 1996 NEJM article and a 1999 ACOG guideline, both of which had critical impacts on physician decisions regarding VBAC. State-level malpractice pressure is measured by the average size of malpractice claim payments (severity) and average number of malpractice claims (frequency). Results show that higher malpractice pressure may be incentives for physicians to uptake information and adopt low-risk practice style. This study also illustrates the importance of clinical practice guidelines. Policy implication here involves dissemination of high-quality comparative-effectiveness studies and improvement of clinical practice guidelines.

1.1 Introduction

The medical malpractice system has been widely criticized for promoting costly and wasteful "defensive medicine". According to this theory, physicians prescribe tests and treatments of marginal value to immunize them against liability. However, the malpractice system may also provide incentives for physicians to keep up-to-date on new medical evidence and adapt their practices accordingly.

Previous studies have shown a positive association between noncompliance with clinical guidelines and the likelihood of malpractice (Hyans et al., 1996; Rosoff, 2001; Ransom et al., 2003). This study adopts a different approach to investigate whether the malpractice system promotes uptake of new research findings or professional consensus into clinical practice. We examined the impact of malpractice pressure, which varies by state, on physicians' reactions to two pieces of new information on the relative merits of vaginal birth after Cesarean section (VBAC) versus repeat Cesarean section (C-section), which are (1) a 1996 study in the New England Journal of Medicine and (2) a 1999 practice guideline published by American College of Obstetrics and Gynecologists (ACOG).

Using hospital-level discharge data, we investigate whether use of vaginal birth after Cesarean section declined following publication and whether the rate of decline was steeper in states where physicians experience greater malpractice pressure. In effect, we treat the 1996 study and 1999 ACOG guideline as "informational shocks" to gauge the impact of state-level variation in malpractice payments. The results of this study may provide insight into a potential benefit of malpractice pressure—encouraging physicians to uptake new information and incorporate it into their practice.

1.2 Literature Review

1.2.1 Malpractice litigation and obstetric practice patterns

Obstetricians face the highest risk of lawsuits among all specialties (IOM, 1989). Eighty nine percent of obstetrician/gynecologists report having been sued at some point during their careers (ACOG, 2006). Most obstetricians describe the fear of litigation as the single most important reason for the rise in the C-section rate in the U.S (Savage, 2007).

A handful of studies have examined the relationship between malpractice pressure and C-section rates and most of them have found a statistically significant positive association (Rock, 1988; Localio et al., 1993; Baldwin et al., 1995; Sloan et al., 1995; Dubay et al., 1999; Murthy et al., 2007; Tussing and Wojtowycz, 1992, 1997; Grant and McInnes, 2004). These studies typically use cross sectional variation in malpractice laws such as the extent of tort reforms. Variation in laws may not fully capture malpractice pressure because it often takes longer to observe behavior change due to law environment.

In addition, these studies focus on primary C-section. To the best of our knowledge, only one study has examined the impact of malpractice pressure on use of VBAC versus repeat C-section. Yang et al (2009) show that use of VBAC increases after states implement certain types of tort reform, consistent with the notion that malpractice pressure increases use of C-sections.

1.2.2 Measuring malpractice pressure

Malpractice pressure is a multidimensional concept and has been measured by various ways. Most studies use the state as the unit when measuring malpractice pressure for two reasons. First, medical malpractice lawsuits are based on tort law, which varies depending on the state's legal environment and can affect the frequency and average settlement amount of malpractice claims. Second, medical malpractice insurance is regulated by state insurance departments, and also subject to state laws.

Previous researchers used malpractice insurance premiums, the frequency of malpractice claims, the size of awards, and a state's tort reform or the extent of the reform as indicators of the legal climate of the area (Kessler et al., 2005; Baicker et al., 2006; Kim, 2008; Yang et al., 2009). As insurance premiums are often used as an indicator to malpractice risk (Dubay et al., 1999; Baicker and Chandra, 2004; Young et al., 2009), it is not clear whether the variation in premiums can well capture the malpractice environment for the doctors. While premiums do depend both on claim frequency and claim severity, they also depend on other market factors, such as interest rates and market competitiveness (Americans for Insurance Reform Report, 2002), and hence may not adequately reflect the real malpractice activities of physicians (Grant and McInnes, 2004).

In this study, we chose to use the frequency of malpractice claims per 1,000 physicians and the size of malpractice payments (including both settlements and judgments) per physician as two indicators of malpractice pressure. The former captures the risk of being sued, the latter measures physicians' expected losses, including both the risk of being sued and the damages conditional on being sued.

1.2.3 Clinical background of VBAC

Historically, physicians recommended C-sections for all women who previously gave birth via C-section based on the belief that vaginal birth was associated with a greater risk of uterine rupture at the original C-section scar site. "Once a C-section, always a C-section", as the saying goes. In 1981, the National Institutes of Health convened a conference to review the evidence and concluded that a trial of labor after C-section birth was safe for women with low transverse uterine scars (National Institutes of Health, 1981). Health policy makers promoted VBAC as a means to slow the rapidly climbing C-section rates and to contain skyrocketing medical costs in the U.S.

In 1988, the American College of Obstetricians and Gynecologists (ACOG) issued a guideline which strongly supported VBAC by stating: "*The concept of routine repeat Cesarean birth would be replaced by a specific indication for subsequent abdominal delivery…, a woman should be counseled and encouraged to attempt labor in her current pregnancy*" (ACOG, 1988). Subsequently, many insurers, especially Health Maintenance Organizations (HMOs), encouraged VBAC given lower length of stay and costs on average (Mushinski, 1998). VBAC rates steadily increased over the 1980s and early 1990s, from 3.4% in 1980 to 28% in 1996 (Martin et al., 2006).

However, the procedure soon became controversial, with conflicting reports published regarding patient safety and the risk of uterine rupture (Sachs et al., 1990; Farmer et al., 1991; Leung et al., 1993). Although the absolute rate of uterine rupture resulting from VBAC is low for low transverse Cesarean scar (0.8% - 1.1%) (Naef et al., 1995; Shepp et al., 1999), the subsequent complications can sometimes be catastrophic; including hysterectomy, blood transfusions, or serious neonatal injury. In 1996, a population-based study published in the New England Journal of Medicine concluded that major maternal complications are almost twice as likely among women with VBAC as those with repeat C-sections (McMahon et al., 1996). National VBAC rates began to drop rapidly shortly thereafter.

ACOG subsequently published several VBAC guidelines over the past few decades. Each version of the guideline confirms that the majority of women with low-transverse incisions and no contraindication to vaginal birth are candidates for a trial of labor and recommends that a trial of labor be limited to facilities capable of performing emergent C-sections if necessary (ACOG, 1994, 1995, 1998, 1999, 2004). The most significant change occurred in the 1999 guideline, stating that institutions need to have "*immediate*" availability of a physician, anesthesiologist, and surgical staff during a VBAC. Since 24-hour in-house availability of obstetricians and anesthesiologists is not available at all hospitals, the recommendation could have a profound impact on the incidence of VBAC. Previous studies have observed that VBAC deliveries decreased significantly after the release of the ACOG 1999 guideline and physicians reported that the inability of institutions to meet ACOG 1999 backup guidelines was an important reason for reducing trials of labor (Pinette et al., 2004; Gochnour et al., 2005; Zweifler et al., 2006). The rate of VBAC in the United States is currently below 10 percent and continues to fall. Over 90 percent of women with a previous cesarean section will have the same surgery for subsequent births.

1.3 Method

1.3.1 Data

The principal source of the data analyzed in this study is the National Inpatient Sample (NIS), a part of the Healthcare Cost and Utilization Project (HCUP) from 1993 through 2004. This nationwide representative inpatient database contains a 20-percent stratified sample of U.S. community hospitals from states participating in the HCUP. The number of HCUP states has grown from 17 states in 1993 to 37 states in 2004. We limited our sample to women in labor with a previous C-section. The 12-year follow-up period in our sample helps separate the information effect from time trend effects.

Malpractice pressure data was obtained from the National Practitioner Data Bank (NPDB) Public Use Data File and Area Resource File (ARF). All malpractice payers are required by law to report malpractice payments and adverse actions against licensed physicians. The NPDB Public Use Data File contains data on approximately 300,000 medical malpractice payments made since 1990 as a result of judgments and settlements on behalf of physicians. For confidentiality reasons, the smallest geographic unit identified in the file is a state, and no specialty information is reported. The ARF lists the number of physicians for each state, allowing us to calculate the denominator for the malpractice pressure measures.

1.3.2 Dependent Variables

The outcome variable in this study is the method of delivery—a dichotomous choice between VBAC and a repeated C-section. We identified any previous Cesarean delivery with all-listed ICD-9 diagnosis code 654.2x. We then used Diagnosed-Related Groups (DRGs) 370 and 371 to identify Cesarean deliveries, and DRG 372 to 375 to identify vaginal deliveries. Those who had a previous Cesarean delivery and delivered vaginally were defined as VBAC patients, while the rest were repeated C-section patients. Figure 1 demonstrates the national trends in VBAC rates from 1993 to 2004 calculated from HCUP data. Compared to the data from birth certificate, i.e. National Vital Statistical Report (NVSR), our rates of VBAC from hospital discharge data are higher.

We cannot distinguish whether or not the repeat C-section was elective or followed an unsuccessful trial of labor from the claims data. As a result, we controlled for several complications of labor and delivery that might result in a repeat C-section. These complications include prolonged labor, pregnancy-related hypertension, fetal breech presentation, fetal distress, maternal obesity, gestational diabetes, and other pregnancy complications. The associated ICD-9 codes are listed in Appendix 1.

1.3.3 Independent Variables

The intervention variables of main interest for this study are publication of the 1996 NEJM article and the 1999 ACOG guidelines. We created a binary variable to identify each event, where 0 equals the pre-event period, and 1 equals the post-event period.

For malpractice pressure, we constructed two state-level measures: (1) the average number of claims per physician (severity), and (2) the average number of liability payments per thousand physicians (frequency) for a given state-year. Our selection of these measures was motivated by research showing that physicians respond to both the number of claims and the average size of malpractice awards. Ideally, we would have counted malpractice claims against obstetricians, but the NPDB public use file does not provide specialty specific information. Identifying malpractice pressure by limiting to obstetric claims raises endogenous concerns because the treatment decision may be related to other unobserved factors, such as physician quality and practice style. For example, if doctors respond to malpractice pressure by performing more (repeat) C-sections, their practice pattern may lower the probability of a lawsuit, and as a result, decrease malpractice pressure. Therefore, we used the claims against all physicians to capture only the malpractice pressure generated by a state's legal environment.

Figure 2 (a) and (b) report the trends and variations of malpractice pressure measures by showing their median and inter-quartile. All dollar values were adjusted to 2004 dollars. Figure 2 (a) shows that the median size of malpractice payments each physician shares is about three to four thousand dollars. The trend of the claim payment frequency (Figure 2 (b)) is generally downward, with inconsistent variances across states over time. Since the NPDB data does not include cases that ended without any positive payment, our measure may underestimate the real frequency of malpractice claims. Overall, there is considerable variation both between states and within a state over time in malpractice pressure regarding the extensity and intensity.

Other independent variables include the characteristics of the women in labor and hospital characteristics. The regression model controls for maternal age (≤25, 25-35, ≥35), race (white, black, Hispanic, other), payment source (public, private, uninsured), severity of illness (number of diagnoses and procedures), and the complications mentioned above. For hospital characteristics, we included for teaching status, ownership, bed-size, rural/urban location, delivery volume, and the rate of primary vaginal birth for each hospital each year.

Table 1 summarizes the characteristics of the study sample by the method of delivery. 1,172,525 delivery claims with a previous history of C-section were identified, with 27% of the sample being VBACs. Overall, most of the patients were age 26-34, white, with household income more than $35,000, and had private insurance. Compared to VBAC patients, patients who had repeated C-sections were more likely to be over age 35, Hispanic, have higher income, and private insurance. The repeat C-section group was also more likely to be obese and have hypertension, gestation diabetes, or other complications.

Table 2 displays the hospital characteristics at the patient and hospital level, respectively. Among the 2,548 hospitals in our study sample, 20% are teaching hospitals, 62% are located in an urban area, and 17% are government owned. At the patient level, most deliveries were managed by non-teaching hospitals (59%) and those were private owned (52%), were larger (59%) and located in an urban area (88%).

1.3.4 Empirical Analyses

We estimated a discharge-level logit model to examine the effect of the article, guideline, and malpractice pressure on the likelihood of VBAC. The model was run separately for each malpractice pressure measures. Let P_{ijkt} be the probability of VBAC for i childbirth discharge in j hospital in k state in year t, and consider the following estimation:

$$ln\left(\frac{P_{ijkt}}{1-P_{ijkt}}\right)= \alpha + \beta_0 X_{it} + \beta_1 H_{jt} + \beta_2 M_{kt} + \beta_3 I_{t=1996,1999} + \beta_4 (M_{kt} \times I_{t=1996,1999}) + \mu_k + \nu_t + \varepsilon_{ijkt}.$$

X_{it} is a set of maternal demographics and medical risk factors, and H_{jt} is the vector of hospital characteristics. M_{kt} depicts the malpractice pressure in the state k in year t and the dichotomous variable $I_{t=1996,1999}$ identifies the study period before- and after- 1996 NEJM article and 1999 ACOG guidelines, respectively. The significance of the interaction term between malpractice pressure and publication is used to test the study hypothesis. State dummies (μ_k) and a linear time variable (ν_t) are included for state fixed effect and time trends. Finally, the estimation included random hospital effects, allowing the cluster corrections of error (ε_{ijkt}) to account for correlated observations within hospitals. We first estimated two logit models with the two malpractice pressure measures separately without interaction to observe their main effects. We then added the interaction terms to our logit models and present the marginal effects.

1.4 Results

Table 3 and Table 4 show the results of the logit models. For each malpractice pressure measurement, we estimated models with (model 1 and model 3) and without interaction effects (model 2 and model 4), separately. First looking at the main effects, in model 1 and in model 3, the NEJM article and ACOG guideline each have a negative effect on the likelihood of VBAC, with marginal effects of -0.6% (p=0.073 in model 1; p=0.111

for model 3) and -2.5% ($p<0.001$ for both model 1 and 3), respectively. Both of the malpractice pressure indicators (severity and frequency) are negatively associated with the likelihood of VBAC but not statistically significant. For interpretation, a $1,000 increase in average payment is associated with a 0.96 percentage point drop in VBAC (model 1); and an increase in average claim is associated with a 0.06 percentage point drop in VBAC (model 3).

The control variables have similar signs and marginal effects in both models. Many patient and hospital characteristics are statistically significant, and have the expected sign. For example, the probability of VBAC decreases with maternal age. Women with either public or private insurance are less likely to have a VBAC compared to other groups. Most maternal complications are negatively associated with VBAC, with the exception of prolonged labor. For hospital characteristics, women are more likely to have a VBAC if they give birth in a hospital with more beds, more deliveries, and a higher rate of primary vaginal birth. On the contrary, hospitals located in rural area are significantly less likely to provide VBACs. These results are reasonable since small and rural hospitals are less likely to meet the infrastructure requirement of ACOG guidelines when compared to larger, urban hospitals. In addition, government-owned hospitals have lower VBAC rates compared to private ones.

Models 2 and 4 are the estimated logit models with interaction terms between malpractice pressure and information/guideline. Model 2 (in Table 3) shows that the interaction effect between malpractice pressure and the 1996 NEJM article is positive ($dy/dx=0.55\%$, $p=0.006$), while the interaction effect between malpractice pressure and the 1999 ACOG guideline is negatively associated with VBAC but not statistically significant ($dy/dx= -0.04\%$, $p=0.835$). For interpretation, the marginal effects of the models show that a $1,000 increase in average claim payment per physician causes VBAC to increase by 0.55

percentage points after the 1996 NEJM article was published, whereas that causes VBAC to decline by 0.04 percentage points after the 1999 ACOG guideline was published. Model 4 (in Table 4) shows the interaction effect between the malpractice claims frequency and the 1996 NEJM article is also positive (dy/dx=0.06%, p=0.215), while the interaction effect between malpractice pressure and the 1999 ACOG guideline is significantly negatively associated with VBAC (dy/dx= -0.11%, p=0.019), indicating that an increase in the claim frequency result VBAC to decrease by 0.11 percentage points after the 1999 ACOG guideline was published.

To further illustrate the interaction effects, we then graphed the trends in rates of VBAC predicted by the logit models we specified and stratified it by different levels of malpractice pressure. Figure 3(a) illustrates the trends in predicted VBAC rate with the average size of malpractice payment fixed to $1,000 and to $7,000. The predicted VBAC rates with high malpractice payment are lower than those with low malpractice payment before 1997 and the difference in the decreasing rate from low payment group after the 1999 ACOG guideline is little. Figure 3(b) presents the trends in predicted VBAC rate with average claims frequency fixed to 5 and to 35. Again the predicted VBAC rates with high frequency group are lower before 1997, but dropped in a steeper slope after 1999 than low frequency group.

1.5 Discussion

The empirical results of this study do not support our hypothesis that physicians who face higher malpractice pressure would respond to new information by changing significantly in practice pattern. However, the fact that doctors with higher malpractice pressure provide fewer VBAC than those with lower malpractice pressure occurred much earlier than the publishing of the 1996 NEJM article suggests that physicians who perceived higher liability threats may uptake information related to risks and benefits of VBAC in a earlier stage. In other words, the fear for litigation is an incentive for physicians to collect and adopt information that identifies a preferred practice pattern. In contrast, not until the benchmark scientific information being published in a prestigious journal did the doctors with lower malpractice risks began to respond to it and adjust their practice style.

On the other hand, the contexts of the 1999 ACOG guideline recommend a particular management strategy for women with a previous C-section and can be used as legal information in the court. Physicians and hospitals maybe worried that if they cannot meet the stringent definition of "immediate availability", of back up services, they will open themselves up to lawsuits, and hence respond to that information by decreasing VBACs no matter to what extent of malpractice pressure.

We acknowledge several limitations to our study. First, we only observe the endpoint of delivery mode from the claims data. Since we cannot tell if a woman who ended up with a C-section ever did a trial of labor in the first place, the true rate of attempted VBAC may be underestimated. However, controlling for maternal complications should help minimize that bias. Second, our model does not capture maternal preferences and our sample is limited to the births delivered in hospitals. More hospitals are having an official policy not to allow VBAC over time either in order to avoid litigation risk or to meet insurance company's requirement (ICAN, 2004; 2008). Such VBAC banning policy may turn women who eager for a VBAC from hospitals to birth centers or homebirth. Whether a midwife can attend an out-of-hospital VBAC without a physician is regulated by state laws, and they vary from state to state. Currently there are no sufficient data to investigate out-of-hospital VBACs. Future research is needed to assess maternal preferences in the birth process and to examine the impact of hospital VBAC banning policy on the outcomes of out-of-hospital VBACs.

Highlighting the ubiquity of variation in practice, a number of authors have urged that clinicians adopt evidence-based practices. This study illustrates that legal liability provides physicians incentives to uptake information and adopt it to low-risk practice style. Policy implication here involves dissemination of high-quality comparative-effectiveness studies for the need. In addition, this study illustrates the importance of clinical practice guideline on practice pattern. Well-developed clinical guidelines providing a standardized and more detailed clinical pathway for physician to follow are warranted to help minimum clinical uncertainty.

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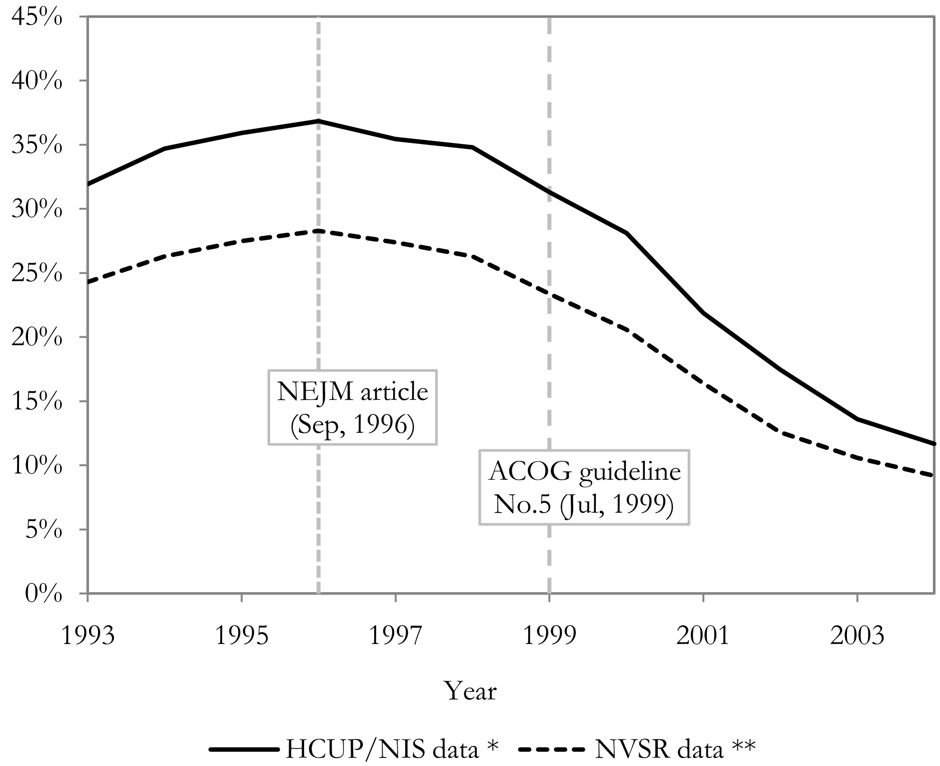
Figure 1: Trend of VBAC rate , 1993-2004.



*Calculated by the author. The VBAC rate is the number of VBACs divided by the number of births after a previous Cesarean.
** Source: National Vital Statistical Report, 1993-2004

Figure 2(a): The distribution of average size of malpractice claim payments among HCUP states, 1993-2004.

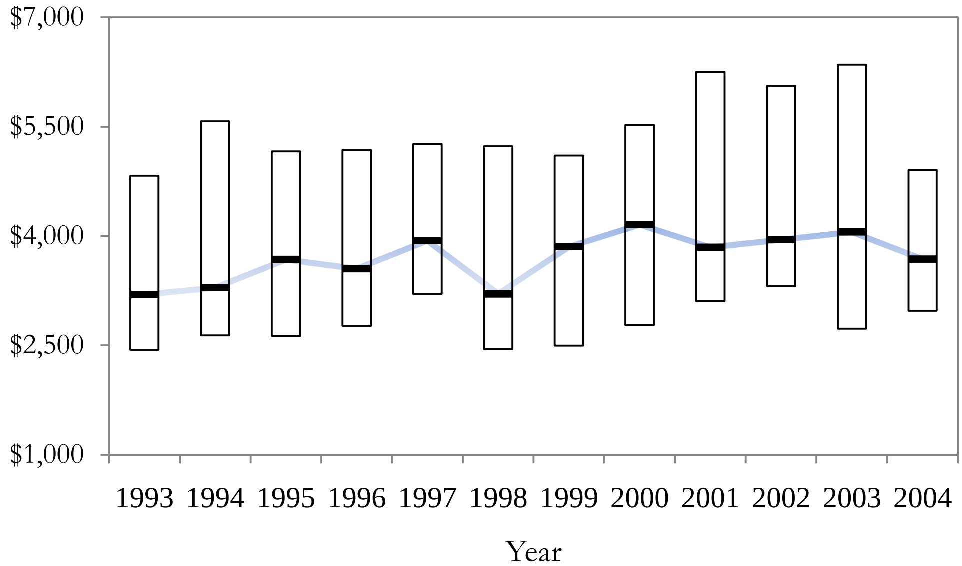
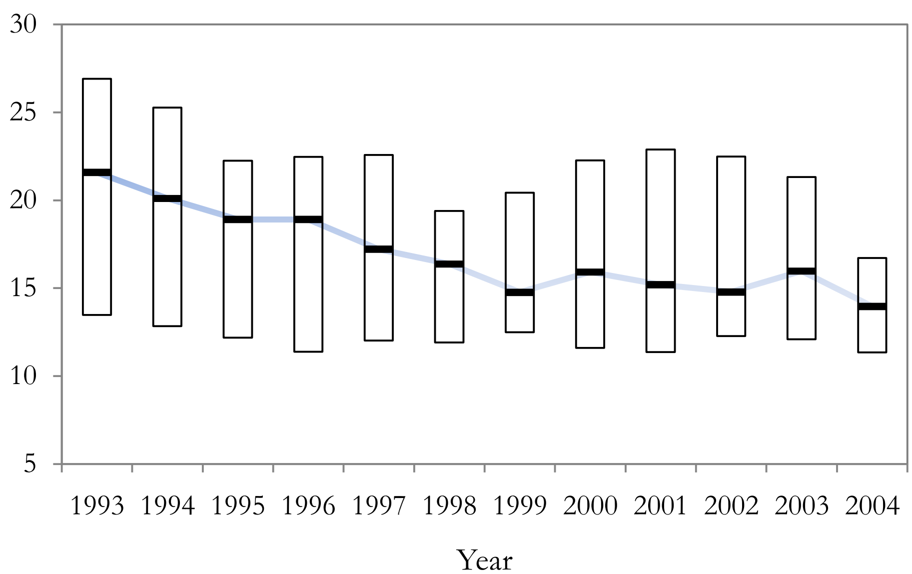


Figure 2(b): The distribution of average number of liability claim among HCUP states, 1993-2004.



*The box indicates the inter-quartile; the dark solid line indicates the median.

Table1: Sample characteristics

Variables	VBAC		Repeat Cesarean	
	N	%	N	%
Total (N=1,172,525)	313,185		859,340	
Age				
25 and below	83,405	(26.6%)	199,599	(23.2%)
26-34	185,492	(59.2%)	507,180	(59.0%)
35 and above	44,288	(14.1%)	152,561	(17.8%)
Race				
White	135,093	(43.1%)	369,175	(43.0%)
Black	37,394	(11.9%)	94,372	(11.0%)
Hispanish	45,671	(14.6%)	148,046	(17.2%)
Other	18,085	(5.8%)	46,989	(5.5%)
Missing	76,942	(24.6%)	200,758	(23.4%)
Household Income				
≥ $35,000	164,252	(52.5%)	493,119	(57.4%)
< $35,000	148,933	(47.6%)	366,221	(42.6%)
Insurance				
Public (Medicare and Medicaid)	109,481	(35.0%)	299,758	(34.9%)
Private (Including HMO)	178,848	(57.1%)	507,112	(59.0%)
Other (self-pay, no charge and other)	24,856	(7.9%)	52,470	(6.1%)
Complications				
Prolonged labor	500	(0.2%)	648	(0.1%)
Pregnancy related hypertension	4,638	(1.5%)	16,636	(1.9%)
Breech/Malpresentation	1804	(0.6%)	44,693	(5.2%)
Fetal distress	16,568	(5.3%)	28,189	(3.3%)
Obesity	1,103	(0.4%)	6,913	(0.8%)
Gestational diabetes	11,986	(3.8%)	53,491	(6.2%)
Other complications	12,209	(3.9%)	49,322	(5.7%)
Post-NEJM article (Sep. 1996)	204,624	(65.3%)	655,109	(76.2%)
Post-ACOG guideline (Jul. 1999)	113,800	(36.3%)	484,182	(56.3%)

Table2: Hospital characteristics

	Patient level		Hospital level	
Variables	N	%	N	%
Total N	1,172,455	(100.0%)	2,548	(100.0%)
Hospital teaching status				
Yes	482,242	(41.1%)	504	(19.8%)
No	690,283	(58.9%)	2,044	(80.2%)
Hospital location				
Urban	1,029,812	(87.8%)	1,571	(61.6%)
Rural	142,713	(12.2%)	980	(38.4%)
Hospital ownership				
Government	116,306	(9.9%)	440	(17.3%)
Private, non-profit	485,531	(41.4%)	992	(38.9%)
Private, investor-own	122,085	(10.4%)	286	(11.2%)
Unknown	448,603	(38.3%)	833	(32.7%)
Hospital bedsize				
Small	140,404	(12.0%)	689	(27.0%)
Medium	338,569	(28.9%)	863	(33.9%)
Large	691,482	(59.1%)	996	(39.1%)

Table 3: Predicted change in the probability of VBAC from logit model results: measuring malpractice pressure with the size of malpractice payment (US $1,000 dollars per physician)

	Model 1: without interaction			Model 2: with interaction		
	dy/dx	std	P-value	dy/dx	std	P-value
Information effect						
Post NEJM article (Sep 1996)	-0.69%	(0.39%)	0.073	-3.06%	(0.96%)	0.001
Post ACOG guideline (Jul 1999)	-2.47%	(0.41%)	0.000	-2.30%	(0.85%)	0.007
Malpractice pressure effect	-0.96%	(1.47%)	0.514	-0.53%	(0.21%)	0.010
Interaction effect						
Post NEJM*Malpractice_pressure				0.55%	(0.20%)	0.006
Post ACOG*Malpractice_pressure				-0.04%	(0.17%)	0.835
Patient characteristics						
Age (ref: 25 and below)						
26-34	-2.99%	(0.16%)	0.000	-2.99%	(0.16%)	0.000
35 and above	-6.03%	(0.21%)	0.000	-6.04%	(0.21%)	0.000
Race (ref: missing)						
White	0.17%	(0.72%)	0.809	0.20%	(0.71%)	0.783
Black	0.91%	(0.80%)	0.249	0.94%	(0.79%)	0.232
Hispanish	-1.15%	(0.82%)	0.165	-1.10%	(0.81%)	0.181
Other	3.79%	(0.88%)	0.000	3.82%	(0.87%)	0.000
Income (ref: < $35,000)						
≥ $35,000	0.84%	(0.30%)	0.005	0.85%	(0.30%)	0.004
Insurance (ref: other)						
Public (Medicare and Medicaid)	-3.20%	(0.44%)	0.000	-3.21%	(0.44%)	0.000
Private (including HMO)	-4.25%	(0.50%)	0.000	-4.26%	(0.49%)	0.000
Complications						
Prolonged labor	7.85%	(2.57%)	0.001	7.84%	(2.56%)	0.001
Pregnancy related hypertension	-3.91%	(0.35%)	0.000	-3.91%	(0.35%)	0.000
Breech/Malpresentation	-22.18%	(0.25%)	0.000	-22.18%	(0.25%)	0.000
Fetal distress	-0.94%	(0.70%)	0.183	-0.95%	(0.70%)	0.176
Obesity	-11.79%	(0.57%)	0.000	-11.78%	(0.57%)	0.000
Gestioal diabetes	-7.34%	(0.22%)	0.000	-7.33%	(0.22%)	0.000
Other complications	-8.84%	(0.40%)	0.000	-8.84%	(0.40%)	0.000
Number of diagnoses	-0.77%	(0.09%)	0.000	-0.77%	(0.09%)	0.000
Number of procedures	7.69%	(0.36%)	0.000	7.68%	(0.36%)	0.000
Hospital characteristics						
Hospital with teaching status	2.22%	(0.68%)	0.001	2.32%	(0.68%)	0.001
Hospital located in rural area	-3.75%	(0.76%)	0.000	-3.77%	(0.76%)	0.000
Hospital ownership (ref: unknown)						
Government	-4.17%	(1.00%)	0.000	-4.03%	(0.99%)	0.000
Private, non-profit	-2.22%	(0.60%)	0.000	-2.01%	(0.60%)	0.001
Private, investor-own	-3.36%	(0.85%)	0.000	-3.20%	(0.85%)	0.000
Hospital bedsize (ref: small)						
medium	0.59%	(0.65%)	0.356	0.65%	(0.64%)	0.312
large	1.54%	(0.73%)	0.034	1.63%	(0.73%)	0.025
Hospital births (log of)	1.58%	(0.39%)	0.000	1.56%	(0.39%)	0.000
Hospital primary vaginal birth rate	138.82%	(7.14%)	0.000	138.94%	(7.13%)	0.000
Year trend (y-1992)	2.39%	(0.24%)	0.000	2.40%	(0.24%)	0.000
Year trend squared $(y\text{-}1992)^2$	-0.28%	(0.02%)	0.000	-0.28%	(0.02%)	0.000

Note: Marginal effects for each state are not reported.

Table 4: Predicted change in the probability of VBAC from logit model results: measuring malpractice pressure with the frequency of malpractice claims (per physician)

	Model 3: without interaction			Model 4: with interaction		
	dy/dx	std	P-value	dy/dx	std	P-value
Information effect						
Post NEJM article (Sep 1996)	-0.63%	(0.39%)	0.111	-1.81%	(1.00%)	0.068
Post ACOG guideline (Jul 1999)	-2.45%	(0.41%)	0.000	-0.44%	(0.90%)	0.625
Malpractice pressure effect	-0.06%	(0.05%)	0.281	-0.05%	(0.06%)	0.454
Interaction effect						
Post NEJM*Malpractice_pressure				0.06%	(0.05%)	0.215
Post ACOG*Malpractice_pressure				-0.11%	(0.05%)	0.019
Patient characteristics						
Age (ref: 25 and below)						
26-34	-2.99%	(0.16%)	0.000	-3.00%	(0.16%)	0.000
35 and above	-6.03%	(0.21%)	0.000	-6.03%	(0.21%)	0.000
Race (ref: missing)						
White	0.19%	(0.72%)	0.794	0.20%	(0.72%)	0.779
Black	0.93%	(0.80%)	0.243	0.95%	(0.80%)	0.231
Hispanish	-1.14%	(0.82%)	0.168	-1.13%	(0.82%)	0.174
Other	3.80%	(0.88%)	0.000	3.81%	(0.88%)	0.000
Income (ref: < $35,000)						
≥ $35,000	0.84%	(0.30%)	0.005	0.85%	(0.30%)	0.004
Insurance (ref: other)						
Public (Medicare and Medicaid)	-3.20%	(0.44%)	0.000	-3.19%	(0.45%)	0.000
Private (including HMO)	-4.26%	(0.50%)	0.000	-4.26%	(0.50%)	0.000
Complications						
Prolonged labor	7.85%	(2.57%)	0.001	7.86%	(2.57%)	0.001
Pregnancy related hypertension	-3.91%	(0.35%)	0.000	-3.91%	(0.35%)	0.000
Breech/Malpresentation	-22.18%	(0.25%)	0.000	-22.18%	(0.25%)	0.000
Fetal distress	-0.94%	(0.70%)	0.182	-0.94%	(0.70%)	0.180
Obesity	-11.79%	(0.57%)	0.000	-11.79%	(0.57%)	0.000
Gestioal diabetes	-7.34%	(0.22%)	0.000	-7.34%	(0.22%)	0.000
Other complications	-8.84%	(0.40%)	0.000	-8.84%	(0.40%)	0.000
Number of diagnoses	-0.77%	(0.09%)	0.000	-0.77%	(0.09%)	0.000
Number of procedures	7.69%	(0.36%)	0.000	7.70%	(0.36%)	0.000
Hospital characteristics						
Hospital with teaching status	2.23%	(0.68%)	0.001	2.20%	(0.68%)	0.001
Hospital located in rural area	-3.75%	(0.76%)	0.000	-3.75%	(0.76%)	0.000
Hospital ownership (ref: unknown)						
Government	-4.15%	(1.00%)	0.000	-4.21%	(1.01%)	0.000
Private, non-profit	-2.19%	(0.60%)	0.000	-2.27%	(0.60%)	0.000
Private, investor-own	-3.33%	(0.85%)	0.000	-3.40%	(0.85%)	0.000
Hospital bedsize (ref: small)						
medium	0.58%	(0.65%)	0.364	0.57%	(0.65%)	0.374
large	1.53%	(0.73%)	0.036	1.52%	(0.73%)	0.037
Hospital births (log of)	1.59%	(0.39%)	0.000	1.59%	(0.39%)	0.000
Hospital primary vaginal birth rate	138.75%	(7.14%)	0.000	138.67%	(7.14%)	0.000
Year trend (y-1992)	2.33%	(0.24%)	0.000	2.38%	(0.25%)	0.000
Year trend squared $(y\text{-}1992)^2$	-0.28%	(0.02%)	0.000	-0.29%	(0.02%)	0.000

Note: Marginal effects for each state are not reported.

Figure 3(a): Predicted VBAC rate with high and low amount of malpractice payment per physician, 1993-2004.

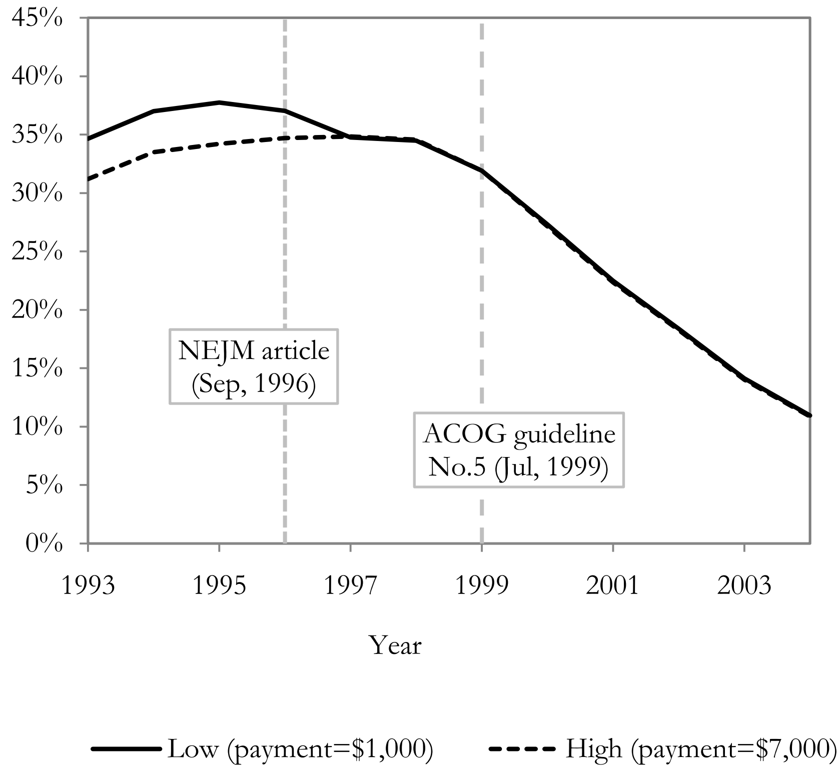
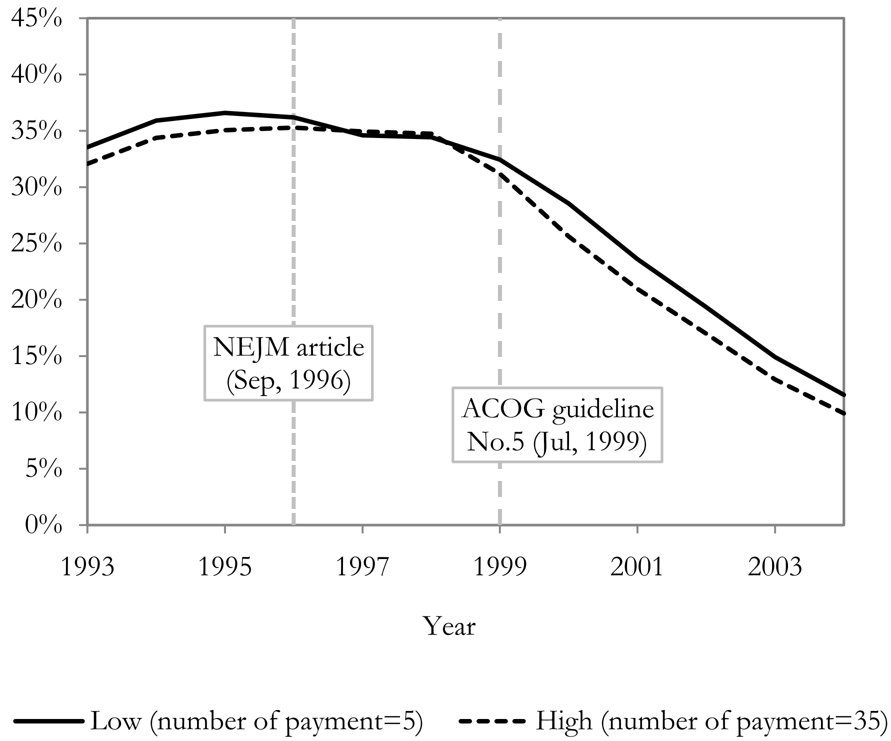


Figure 3(b): Predicted VBAC rate with high and low frequency of malpractice claim per physician, 1993-2004.



Appendix 1: Complications and associated ICD-9-CM codes

Condition	ICD-9-CM codes
Prolonged labor	662.1
Pregnancy-related hypertension	642.3
Fetal breech presentation	652.2 761.7
Fetal distress	656.3 726.2/768.4
Maternal obesity	649.10/649.14 278.00 278.01
Gestational diabetes	648.8
Other pregnancy complications	646*

Appendix 2: Hospitals with zero VBACs

A survey on hospitals that have labor and delivery wards by International Cesarean Awareness Network (ICAN) found that 10% of them don't allow VBACs in 2004. That rate further increased to 28% in 2008. Considering that new information may not have influences on those hospitals, we conducted analysis using the sample excluding hospitals with zero VBACs. 7%-18% of hospitals were excluded for each year (Table 5) and resulted total sample number to 1,159,373. We found that the estimates of the logit models with this sample (Table 5 and Table 6) are similar to the one with original sample (Table 3 and Table 4).

Table 5: Number of hospitals in the sample for each year

year	Hospitals with at least 1 patient with previous Cesarean-section	Hospitals with zero VBAC cases	
	N	N	%
1993	639	72	11.3%
1994	644	55	8.5%
1995	670	48	7.2%
1996	657	56	8.5%
1997	726	68	9.4%
1998	715	60	8.4%
1999	719	51	7.1%
2000	720	61	8.5%
2001	702	72	10.3%
2002	710	84	11.8%
2003	686	122	17.8%
2004	684	108	15.8%

Table 6: Predicted change in the probability of VBAC from logit model results: measuring malpractice pressure with the size of malpractice payment (US $1,000 dollars per physician) using sample excluding hospitals with zero VBAC cases (N=1,159,373).

	Model 1: without interaction			Model 2: with interaction		
	dy/dx	std	P-value	dy/dx	std	P-value
Information effect						
Post NEJM article (Sep 1996)	-0.67%	(0.39%)	0.087	-3.07%	(0.97%)	0.001
Post ACOG guideline (Jul 1999)	-2.54%	(0.41%)	0.000	-2.18%	(0.86%)	0.011
Malpractice pressure effect	-0.83%	(1.49%)	0.576	-0.49%	(0.21%)	0.019
Interaction effect						
Post NEJM*Malpractice_pressure				0.55%	(0.20%)	0.006
Post ACOG*Malpractice_pressure				-0.08%	(0.18%)	0.639
Patient characteristics						
Age (ref: 25 and below)						
26-34	-3.05%	(0.17%)	0.000	-3.05%	(0.17%)	0.000
35 and above	-6.10%	(0.22%)	0.000	-6.10%	(0.22%)	0.000
Race (ref: missing)						
White	0.10%	(0.72%)	0.894	0.11%	(0.72%)	0.873
Black	0.89%	(0.80%)	0.262	0.92%	(0.80%)	0.247
Hispanish	-1.14%	(0.83%)	0.173	-1.09%	(0.82%)	0.187
Other	3.80%	(0.89%)	0.000	3.83%	(0.88%)	0.000
Income (ref: < $35,000)						
≥ $35,000	0.88%	(0.30%)	0.003	0.90%	(0.30%)	0.003
Insurance (ref: other)						
Public (Medicare and Medicaid)	-3.19%	(0.44%)	0.000	-3.20%	(0.44%)	0.000
Private (including HMO)	-4.27%	(0.49%)	0.000	-4.28%	(0.49%)	0.000
Complications						
Prolonged labor	7.70%	(2.57%)	0.001	7.70%	(2.57%)	0.001
Pregnancy related hypertension	-3.96%	(0.36%)	0.000	-3.96%	(0.36%)	0.000
Breech/Malpresentation	-22.50%	(0.25%)	0.000	-22.50%	(0.25%)	0.000
Fetal distress	-0.95%	(0.71%)	0.182	-0.97%	(0.71%)	0.175
Obesity	-11.94%	(0.58%)	0.000	-11.93%	(0.58%)	0.000
Gestioal diabetes	-7.41%	(0.23%)	0.000	-7.41%	(0.23%)	0.000
Other complications	-8.92%	(0.41%)	0.000	-8.93%	(0.40%)	0.000
Number of diagnoses	-0.80%	(0.09%)	0.000	-0.80%	(0.09%)	0.000
Number of procedures	7.77%	(0.36%)	0.000	7.77%	(0.36%)	0.000
Hospital characteristics						
Hospital with teaching status	2.45%	(0.68%)	0.000	2.53%	(0.69%)	0.000
Hospital located in rural area	-3.47%	(0.77%)	0.000	-3.49%	(0.77%)	0.000
Hospital ownership (ref: unknown)						
Government	-3.94%	(1.00%)	0.000	-3.82%	(1.00%)	0.000
Private, non-profit	-2.15%	(0.60%)	0.000	-1.96%	(0.61%)	0.001
Private, investor-own	-3.49%	(0.86%)	0.000	-3.35%	(0.86%)	0.000
Hospital bedsize (ref: small)						
medium	0.40%	(0.64%)	0.530	0.46%	(0.64%)	0.477
large	1.50%	(0.73%)	0.040	1.58%	(0.72%)	0.030
Hospital births (log of)	1.03%	(0.40%)	0.010	1.01%	(0.40%)	0.011
Hospital primary vaginal birth rate	138.17%	(7.29%)	0.000	138.26%	(7.29%)	0.000
Year trend (y-1992)	2.35%	(0.24%)	0.000	2.35%	(0.24%)	0.000
Year trend squared $(y-1992)^2$	-0.28%	(0.02%)	0.000	-0.28%	(0.02%)	0.000

Note: Marginal effects for each state are not reported.

Table 7: Predicted change in the probability of VBAC from logit model results: measuring malpractice pressure with the frequency of malpractice claims (per physician) using sample excluding hospitals with zero VBAC cases (N=1,159,373)

	Model 3: without interaction			Model 4: with interaction		
	dy/dx	std	P-value	dy/dx	std	P-value
Information effect						
Post NEJM article (Sep 1996)	-0.61%	(0.40%)	0.127	-1.82%	(1.01%)	0.068
Post ACOG guideline (Jul 1999)	-2.52%	(0.42%)	0.000	-0.39%	(0.91%)	0.671
Malpractice pressure effect	-0.06%	(0.05%)	0.313	-0.04%	(0.06%)	0.514
Interaction effect						
Post NEJM*Malpractice_pressure				0.06%	(0.05%)	0.207
Post ACOG*Malpractice_pressure				-0.12%	(0.05%)	0.013
Patient characteristics						
Age (ref: 25 and below)						
26-34	-3.05%	(0.17%)	0.000	-3.05%	(0.17%)	0.000
35 and above	-6.10%	(0.22%)	0.000	-6.10%	(0.22%)	0.000
Race (ref: missing)						
White	0.11%	(0.72%)	0.878	0.13%	(0.72%)	0.861
Black	0.91%	(0.80%)	0.255	0.93%	(0.80%)	0.242
Hispanish	-1.13%	(0.83%)	0.176	-1.11%	(0.83%)	0.183
Other	3.82%	(0.89%)	0.000	3.83%	(0.89%)	0.000
Income (ref: < $35,000)						
≥ $35,000	0.88%	(0.30%)	0.003	0.89%	(0.30%)	0.003
Insurance (ref: other)						
Public (Medicare and Medicaid)	-3.19%	(0.44%)	0.000	-3.19%	(0.44%)	0.000
Private (including HMO)	-4.27%	(0.49%)	0.000	-4.27%	(0.49%)	0.000
Complications						
Prolonged labor	7.71%	(2.57%)	0.001	7.72%	(2.58%)	0.001
Pregnancy related hypertension	-3.96%	(0.36%)	0.000	-3.96%	(0.36%)	0.000
Breech/Malpresentation	-22.50%	(0.25%)	0.000	-22.50%	(0.25%)	0.000
Fetal distress	-0.95%	(0.71%)	0.181	-0.96%	(0.71%)	0.179
Obesity	-11.94%	(0.58%)	0.000	-11.94%	(0.58%)	0.000
Gestioal diabetes	-7.42%	(0.23%)	0.000	-7.42%	(0.23%)	0.000
Other complications	-8.92%	(0.41%)	0.000	-8.93%	(0.40%)	0.000
Number of diagnoses	-0.80%	(0.09%)	0.000	-0.80%	(0.09%)	0.000
Number of procedures	7.77%	(0.36%)	0.000	7.78%	(0.36%)	0.000
Hospital characteristics						
Hospital with teaching status	2.46%	(0.68%)	0.000	2.43%	(0.69%)	0.000
Hospital located in rural area	-3.46%	(0.77%)	0.000	-3.46%	(0.77%)	0.000
Hospital ownership (ref: unknown)						
Government	-3.92%	(1.01%)	0.000	-3.98%	(1.01%)	0.000
Private, non-profit	-2.11%	(0.61%)	0.001	-2.20%	(0.61%)	0.000
Private, investor-own	-3.46%	(0.86%)	0.000	-3.53%	(0.86%)	0.000
Hospital bedsize (ref: small)						
medium	0.39%	(0.64%)	0.540	0.38%	(0.64%)	0.555
large	1.48%	(0.73%)	0.042	1.47%	(0.73%)	0.043
Hospital births (log of)	1.03%	(0.40%)	0.009	1.04%	(0.40%)	0.009
Hospital primary vaginal birth rate	138.09%	(7.30%)	0.000	138.02%	(7.30%)	0.000
Year trend (y-1992)	2.30%	(0.25%)	0.000	2.35%	(0.25%)	0.000
Year trend squared $(y\text{-}1992)^2$	-0.28%	(0.02%)	0.000	-0.28%	(0.02%)	0.000

Note: Marginal effects for each state are not reported.

CHAPTER 2

The Impact of Repeat Cesarean Section on Birth Outcomes over Time

Abstract

The purpose of this study is to determine whether birth outcomes changed as a result of changes in the pattern of birth after Cesarean sections (C-section) over time. Using discharge data from New Jersey State Inpatient Database (SID), 1999-2006, selected major maternal and neonatal adverse events were compared between repeat C-sections and vaginal births after Cesarean (VBAC). Logistic regression is used to estimate the adjusted predicted risk of adverse events by delivery method. The results show that maternal and neonatal outcomes for births after a C-section significantly improved overtime along with the secular increase in repeat C-section rates. Overall, birth outcomes for both repeat C-sections and VBACs improved overtime. However, women undergoing repeat C-sections had a lower rate of maternal complications, but a higher rate of neonatal complications than those undergoing VBACs controlling for other factors. The increased adoption of repeat C-sections may have been driven in part by the observed lower maternal complication rates and lower neonatal mortality rates. Implication for policy makers suggests decreasing the use of C-sections without compromising birth outcomes by focusing on decreasing elective primary C-sections.

2.1 Introduction

The rate of Cesarean delivery in the U.S. has dramatically increased over the past decade, resulting in rising hospital costs for childbirth (HCUP, 2009). This increase in Cesarean section (C-section) rate was coupled with an increase in the rate of repeat C-section. According to an Agency for Healthcare Research and Quality (AHRQ) report, the percentage of pregnant women undergoing a repeat C-section delivery jumped from 65 percent to 90 percent between 1997 and 2006 nationally (AHRQ report, 2009).

The tendency to repeat Cesarean delivery for births after a previous C-section is largely attributable to the concerns about the relative safety of vaginal birth after Cesarean (VBAC) as articulated by several American College of Obstetricians and Gynecologists (ACOG) documents and key studies over a fifteen year period (ACOG, 1999; McMohan et al., 1996; Sach et al., 1999; Cohen and Atkins, 2001; Socol, 2003; Landon et al., 2004; Guise , 2004). The rate of VBAC rose in the mid-1980s in response to national policy recommendations and clinical research findings supporting its relative safety and clinical benefits (NIH, 1981; Flamm et al., 1991). In the late 1990's, however, renewed controversy in the clinical literature over maternal safety during VBAC resulted in a rapid decline in the number of VBACs. Attention has focused primarily on uterine rupture, a potentially catastrophic event, which can have serious consequences to both the mother and the neonate (Mozurkewich and Hutton, 2000).

The majority of the literature about birth risks with VBAC are based on small samples with various definition of uterine rupture from study to study and hence make the results difficult to interpret. In 1996, McMahon et al.'s population-based study being published at New England Journal of Medicine gained a lot attention for suggesting that the rate of serious maternal morbidity was significantly increased with a trial of labor as compared to elective repeat Cesarean delivery (McMohan et al., 1996). Meanwhile, several high-profile legal claims for neonatal complications associated with uterine rupture also led obstetricians to advocate repeat C-sections. The safety debate along with liability concerns prompted the ACOG to recommend that VBAC be attempted only when a physician can be "immediately available throughout active labor" in case an emergency Cesarean delivery is needed (ACOG, 1999). This ACOG practice guideline has therefore significantly limited access to attempted VBACs in many hospitals (Santerre and College, 1996; Pinette et al., 2004; Gochnour et al., 2005; Zweifler et al., 2006). Since its publication, the pattern of birth after Cesarean has shifted to more repeat C-sections and the rate keeps climbing.

A handful of previous studies have compared the related benefit and harms of VBAC and repeat C-section by examining the cross sectional variances in selected birth outcomes between the two modes of delivery. Information about the risk of adverse outcomes is helpful to inform physician and patient decision making about the preferred method of delivery. However, as the rate of repeat C-section climbs, it is not entirely clear what the overall impact on birth outcome has been. I address this gap in the literature by using the temporal variation in rate of repeat C-section to explore the association between mode of delivery and maternal and neonatal birth outcomes.

2.2 Methods

2.2.1 Data Sources

Data for this analysis came from the 1999-2006 New Jersey State Inpatient Databases (SID), part of the Healthcare Cost and Utilization Project (HCUP), developed by the Agency for Healthcare Research and Quality (AHRQ). SID contains the universe of inpatient discharge records from all nonfederal acute care hospitals in the state, with clinical and non-clinical information on all patients. New Jersey was selected for this analysis because their data contains an identifier that link maternal and newborn records, providing the ability to examine both maternal and neonatal outcomes by mode of delivery over time.

2.2.2 Sample Construction

All hospital deliveries (DRG codes 370-375) in New Jersey between 1999 and 2006, with an ICD-9 diagnosis code of 654.2 indicating a previous Cesarean delivery were extracted for this study. Each delivery was linked to the corresponding newborn record using a unique identifier. The final study sample consists of 127,812 mother-newborn pairs with prior Cesarean histories.

2.2.3 Birth Outcomes

Birth outcomes were identified as the occurrence of an adverse event by the mother or newborn (Gregory et al., 2009). Maternal complications include third- or fourth-degree perineal tear, bladder laceration, high vaginal laceration, other obstetrical laceration, uterine rupture, uterine dehiscence, hysterectomy, postpartum hemorrhage, transfusion, pelvic hematoma, maternal infection, wound infection, anesthesia complications, other maternal morbidity, maternal length of stay more than 5 days, and maternal death. Neonatal complications include birth trauma, respiratory distress syndrome, other respiratory problems, hypoxia, neonatal infection, convulsions, intracranial bleed, neonate length of stay more than 5 days, neonatal transfer, and neonatal death. Death, length of stay, and neonatal transfer are directly determined from the discharge data. The other conditions are identified using ICD-9 diagnosis or procedure codes listed in Appendix 1. Since the absolute rates for each of the complications are relatively low, the principal outcomes for this study were two binary indicators measured at the patient level: (1) any maternal complication; and (2) any neonatal complication. From mother's perspective, an "ideal" delivery should be one without any maternal or neonatal complications. Thus an indicator for an ideal delivery is conducted if none of any maternal or neonatal complication was present.

2.2.4 Measurements

The principle independent variable is the method of delivery. I divided deliveries with a prior history of C-section into two groups using the diagnosis related groups on hospital records; DRGs 370 and 371 indicate a repeat C-section and DRGs 372-375 indicate a VBAC. A VBAC is referred to a successful trial of labor. For a repeat C-section, it can be either an elective surgery or a result of an unsuccessful trial of labor. Hence, for repeat C-section, I created an indicator for a trial of labor to distinguish a medically indicated C-section from an elective one, if any of the ICD-9 diagnosis codes consistent with labor was present: 653 (disproportion), 660 (obstructed labor), 661 (abnormal uterine forces), 662 (long labor), 652.1 (successful version), 659 (failed induction), 656.3 (fetal distress), or 663 (cord complications). This indicator for trial of labor is based on a previous developed and verified algorithm (Henry et al, 1995; Gregory et al, 2002).

For each delivery, I identified antenatal conditions, such as hypertension, diabetes, or malpresentation, etc., that have been associated with maternal and neonatal childbirth complications in women with prior C-section (Gregory et al., 2008). The full list of those high risk conditions and associated ICD-9 codes are described in Appendix 2. Women were classified into one of two risk groups: those with none of the antenatal conditions (low risk) and those with at least one of those conditions (high risk).

Other covariates included in the model are maternal age (≤35, >35), race (white, black, Hispanic, other), insurance type (Medicaid, private insurance, other), and urban versus rural residence, all of which are reported in the SID data. U.S. Census data was linked to the patient's residence by Federal Information Processing Standards (FIPS) state/county codes to estimate socio-economic status. These proxy variables included median household income and percentage of persons with a college education. Finally, a variable indicating birth volume for each hospital-year is calculated from the SID data to control for volume-outcome association.

2.2.5 Statistical Analysis

The number of specific adverse events was used to calculate the absolute unadjusted risk of a complication. Chi-square analysis was used to determine whether the risk of maternal and neonatal complications differed significantly between the repeat C-section group and the VBAC group.

To observe the impact of changes in mode of delivery on changes in birth outcomes overtime, I graphed trends in the rate of repeat C-section, rate of maternal and neonatal complications, rate of ideal delivery, and the prevalence of high risk deliveries. Trend lines were tested by the Patrick Royston's trend test with a null hypothesis of zero slope.

Multivariate logistic regression analysis was used to investigate the impact of mode of delivery on birth outcomes, controlling for covariates. Two separate models were estimated, any maternal complication and any neonatal complication, and the logistic regression results are presented as odds ratios with 95% confidence intervals. For each of the models, an adjusted predicted complication rate was calculated for the overall population. Predicted complication rates for each mode of delivery were calculated by averaging the other covariates and assumed that all women in the standard population had same procedure.

2.3 Results

Characteristics of the sample are displayed in Table 1. There were 127,812 deliveries with a history of prior Cesarean delivery during the study period, of whom 109,084 became repeat C-sections. As VBAC patients are indicated to have a successful trial of labor, 36% of the repeat C-sections are indicated having an unsuccessful trial of labor. A higher percentage of the repeat C-section group was high risk than the VBAC group (39% versus 25%). Women undergoing repeat C-sections were more likely to be over age 35, have private insurance, and reside in an urban area than those undergoing VBACs.

Table 2 reports the unadjusted risk for maternal and neonatal complications stratified by mode of delivery. Risks for complications varied significantly by mode of delivery except for hysterectomy, maternal death, hypoxia, and convulsions. The repeat C-section group had a lower rate of maternal complications than the VBAC group (6.7% versus 15.4%), whereas the rate of neonatal complications was lower (10.3% versus 8.9%). The rate of ideal delivery rate for the repeat C-section group is 85%, higher than that for the VBAC group (78%).

Figure 1 displays the temporal trend for repeat C-section, any maternal complications, and any neonatal complications. New Jersey had a rising rate of repeat C-section from 1999 to 2006, which paralleled national trends for the same period. The rate of repeat C-section increased significantly from 72.8% in 1999 to 92.9% in 2006 (χ^2 =366.054, $P_{\text{trend}} < 0.001$). The rates of maternal complications and neonatal complications both decreased significantly during the study period, by 4% and 1%, respectively. The graph shows that as the rate of repeat C-section increased over time, there were trends toward decreases in both maternal and neonatal complications.

The trend for ideal delivery was graphed in Figure 2 along with the trend for repeat C-section and for the prevalence of high risk population. The rate of ideal delivery climbed from 81.0% in 1999 to 85.4% in 2006 (χ^2 =18.709, $P_{\text{trend}} < 0.001$) while the risk profile of the population stay constant (χ^2 =3.285, P_{trend} =0.07).

Table 3 reports results from the multivariate logistic models which examine the impact of repeat C-section on the occurrence of any maternal and neonatal complication controlling for other covariates and time trend. Maternal complications are less likely to occur in women undergoing repeat C-sections than those undergoing VBACs (OR=0.37, p<0.001). In contrast, neonatal complications are more likely to occur with repeat C-sections (OR=1.11, p<0.001). The indicators for trials of labor and for high risk antenatal conditions are significantly positively associated with both maternal and neonatal complications, as expected. Women above age 35 are more likely to have maternal complications (OR=1.06, p=0.021), but less likely to have neonatal complications (OR=0.96, p=0.051). I also observed a counterintuitive volume-outcome relationship in both models, with childbirth complications more likely to occur in hospitals with higher birth volumes (model 1: OR=1.22, p<0.001; model 2: OR=1.08, p<0.001). This may be related to referral of high risk pregnancies to larger birth centers and/or clustering of high risk births in urban safety net hospitals.

Figure 3 and Figure 4 display the temporal trend of predicted adjusted rates for maternal and neonatal complications estimated from the logistic regressions. The adjusted complication rates were predicted for the overall population and by different modes of delivery. If all women with prior Cesarean had repeat C-sections for their next births, the maternal complication rate would have decreased from 7.9% in 1999 to 6.2% in 2006 (Figure 3). On the other hand, if instead all women had VBACs, the maternal complication rate would decrease from 18.7% in 1999 to 14.9% in 2006. An increase in the rate of repeat C-section overtime led to a lower rate of maternal complications over the study period. The downward trend in maternal complication rates for both procedures led to better maternal birth outcomes overtime. For neonatal complications (Figure 4), the trend was generally downward, but there were increases in 2001 and 2005 for unclear reasons. In general, neonatal birth outcome improved overtime for both the repeat C-sections and VBACs but repeat C-sections were consistently associated with a higher rate of neonate complications.

Figure 5 display the temporal trend of predicted ideal delivery rates from the logistic regressions with ideal delivery as the dependent variable. The adjusted ideal delivery rates were predicted for the overall population and by different modes of delivery. If all women with prior Cesarean had repeat C-sections for their next births, the ideal delivery rate would have decreased from 82.9% in 1999 to 85.8% in 2006. If instead all women had VBACs, the ideal delivery rate would lower, range from 76.1% in 1999 to 79.9% in 2006.

2.4 Discussion

This study suggests that birth outcomes for mothers with a prior C-section in New Jersey with a reduction in both maternal and neonatal complication rates. Part of the improvement in outcomes can be attributed to an increase in the number of repeat C-sections and a marked decrease in its associated complication rates over the study period. The former factor reflects a shift in delivery practice patterns, whereas the latter implies a learning effect or technological advancement as clinicians provide more primary and repeat C-sections.

Using multivariate logistic regression to adjust for potential confounders, I was able to predict the adjusted risk of complications for the two different modes of delivery. I observed lower maternal complication rates and higher neonatal complication rates in the repeat C-section group than in the VBAC group. These findings are consistent with previous clinical research (McMohan et al., 1996; Landon et al., 2004). Obstetricians usually recognize Cesarean surgeries as a means to avoid serious adverse perinatal outcomes which can lead to expensive litigation (Savage, 2007). However, when elective and medically indicated repeat C-sections are combined together, they have a higher rate of neonate adverse events overall despite a lower rate of neonate death.

Several limitations are inherent in this study. First, relying on ICD-9 codes and DRG codes to define clinical and obstetric history using secondary administrative data may allow a risk for misclassification due to coding errors or lack of specificity. Using data from multiple years helps reduce the possibility of systematic misclassification. Second, I was not able to obtain some clinical data, such as parity, the number of prior Cesareans, or labor management, which have been shown to be associated with uterine rupture during a trial of labor. Third, our composite outcome measurement contains a wide range of adverse events. For example, respiratory distress syndrome can be mild or severe; and increased LOS would be deemed less relevant compared to death. Lacking scientific evidence to weight the relevance of those events, this analysis treats them all as equal.

One of our findings suggesting that repeat C-section increases neonatal complications seems counterintuitive to the argument that high C-section rates in the U.S. are driven by high malpractice pressure, because the society generally have very low tolerance regarding adverse birth outcomes. However, by looking at individual neonatal adverse events (Table 2), we find that while repeat C-section is associated with higher rate in neonatal respiratory problems than VBAC, its risk for neonatal death is half of that of VBAC. The tradeoff between declined mortality rate versus increased respiratory distress and other adverse neonatal outcomes may be evaluated by physicians when making decisions. For this reason, the tradeoff between maternal versus neonatal outcomes are probably skewed toward higher priority for maternal outcomes and neonatal mortality.

From an economic perspective, to increase extra 1% in ideal delivery rate among births with previous C-sections costs in-average about 1,400 more repeat C-sections and $ 2.66 million in 2006 dollars (estimated from the cost difference between uncomplicated repeat Cesarean ($4,500) and uncomplicated vaginal delivery ($2,600) and times 1,400 repeat C-section).In another word, it costs approximately $2,000 for every extra ideal delivery ($2.66 million divided by 1,278 ideal deliveries). The cost seems in an acceptable range considering trading-off with the possible consequences of having an imperfect delivery—being sued and paying outrageous expensive liability awards. More detailed research to assess the cost-effectiveness of the procedure is needed.

In conclusion, this study fills an important gap in the literature by documenting the temporal change in composite measures for adverse birth outcomes in women with prior Cesareans. While some experts may worry that the rates of surgical childbirth in the United States are too high, our findings suggest current trends in repeat C-section have actually improved birth outcomes in particular by lowering the likelihood of maternal complications among the population with prior Cesarean scar and neonatal mortality. The Healthy People report published in 2000 set a goal of 15% for primary Cesarean rate and 63% for repeat C-section rates by 2010 (Health People, 2000). Our study illustrates the tradeoffs entailed for the increase in repeated Cesareans and argues that advocating more VBAC as a means to decrease overall Cesarean deliveries is not necessarily beneficial for the population with previous C-sections. Health policy makers should make more rigorous efforts to decrease elective primary C-sections by improving payment system, developing better-quality guidelines and pathways for obstetricians, and promoting education program on patient informed choice. Only by focusing on deceasing primary C-sections will the need for repeated C-section ultimately decrease without compromising birth outcomes.

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Table 1: Sample Characteristics for women with prior Cesarean, 1999-2006

Variables	Repeat Cesarean n	(%)	VBAC n	(%)	*P* Value
N	109,084		18,728		<0.001
Indicator for trial of labor	39,558	(36.26)	18,728	(100.00)	
Indicator for high risk	42,545	(39.00)	4,672	(24.95)	<0.001
Age					<0.001
Age ≤ 35	81,177	(74.42)	14,627	(78.10)	
Age > 35	27,907	(25.58)	4,101	(21.90)	
Race					<0.001
white	57,110	(52.35)	9,410	(50.25)	
Black	14,940	(13.70)	3,301	(17.63)	
Hispanic	21,262	(19.49)	3,184	(17.00)	
Other	15,772	(14.46)	2,833	(15.13)	
Insurance type					<0.001
Medicaid	10,755	(9.86)	1,923	(10.27)	
Private insurance	87,805	(80.49)	14,725	(78.63)	
Other	10,524	(9.65)	2,080	(11.11)	
% College Education					<0.001
<15%	22,832	(20.93)	3,633	(19.40)	
15%-20%	41,631	(38.16)	7,377	(39.39)	
>20%	44,621	(40.91)	7,718	(41.21)	
Median Household Income					<0.001
1st quartile	26,420	(24.22)	4,348	(23.22)	
2nd quartile	27,912	(25.59)	4,871	(26.01)	
3rd quartile	23,934	(21.94)	4,408	(23.54)	
4th quartile	30,818	(28.25)	5,101	(27.24)	
Location					<0.001
Urban	96,103	(88.10)	16,160	(86.29)	
Rural	12,981	(11.90)	2,568	(13.71)	

Table 2: Crude maternal and neonatal complication rates for women with prior Cesarean during 1999-2006

Outcomes	Repeat Cesarean Events, *n*	Repeat Cesarean Risk, %	VBAC Events, *n*	VBAC Risk, %	*P* Value
N	109,084		18,728		
Ideal delivery	92,684	(84.97)	14,549	77.69)	<0.001
Any maternal complications	7,339	(6.73)	2,883	(15.39)	<0.001
Any neonatal complication	11,194	(10.26)	1,673	(8.93)	<0.001
Maternal complications					
Third- or fourth-degree perineal tear	21	(0.02)	1,259	(6.72)	<0.001
Bladder laceration	337	(0.31)	505	(2.70)	<0.001
High vaginal laceration	11	(0.01)	295	(1.58)	<0.001
Other obstetrical laceration	136	(0.12)	69	(0.37)	<0.001
Uterine rupture	309	(0.28)	22	(0.12)	<0.001
Uterine dehiscence	293	(0.27)	7	(0.04)	<0.001
Hysterectomy	13	(0.01)	1	(0.01)	0.427
Postpartum hemorrhage	1,074	(0.98)	460	(2.46)	<0.001
Transfusion	950	(0.87)	89	(0.48)	<0.001
Pelvic hematoma	66	(0.06)	32	(0.17)	<0.001
Maternal infection	539	(0.49)	38	(0.20)	<0.001
Wound infection	713	(0.65)	27	(0.14)	<0.001
Anesthesia comps	1,010	(0.93)	57	(0.30)	<0.001
Other maternal morbidity	493	(0.45)	33	(0.18)	<0.001
Maternal LOS > 5 d	2,848	(2.61)	231	(1.23)	<0.001
LOS, mean (±SD)	3.60	(±1.92)	2.39	(±1.59)	
Maternal death	8	(0.01)	0	(0.00)	0.241
Neonatal complications					
Birth trauma	755	(0.69)	247	(1.32)	<0.001
Respiratory distress syndrome	1,192	(1.09)	112	(0.60)	<0.001
Other respiratory problems	6,754	(6.19)	845	(4.51)	<0.001
Hypoxia	198	(0.18)	34	(0.18)	0.999
Neonatal infection	1,054	(0.97)	220	(1.17)	0.008
Convulsions	123	(0.11)	14	(0.07)	0.142
Intracranial bleed	42	(0.04)	13	(0.07)	0.060
Neonatal LOS > 5 d	4,316	(3.96)	566	(3.02)	<0.001
Neonatal transfer	1,078	(0.99)	126	(0.67)	<0.001
Neonatal death	192	(0.18)	69	(0.37)	<0.001

Figure 1: Rate of repeat Cesarean, rate of any maternal complications, and rate of any neonatal complications in New Jersey, 1999-2006.

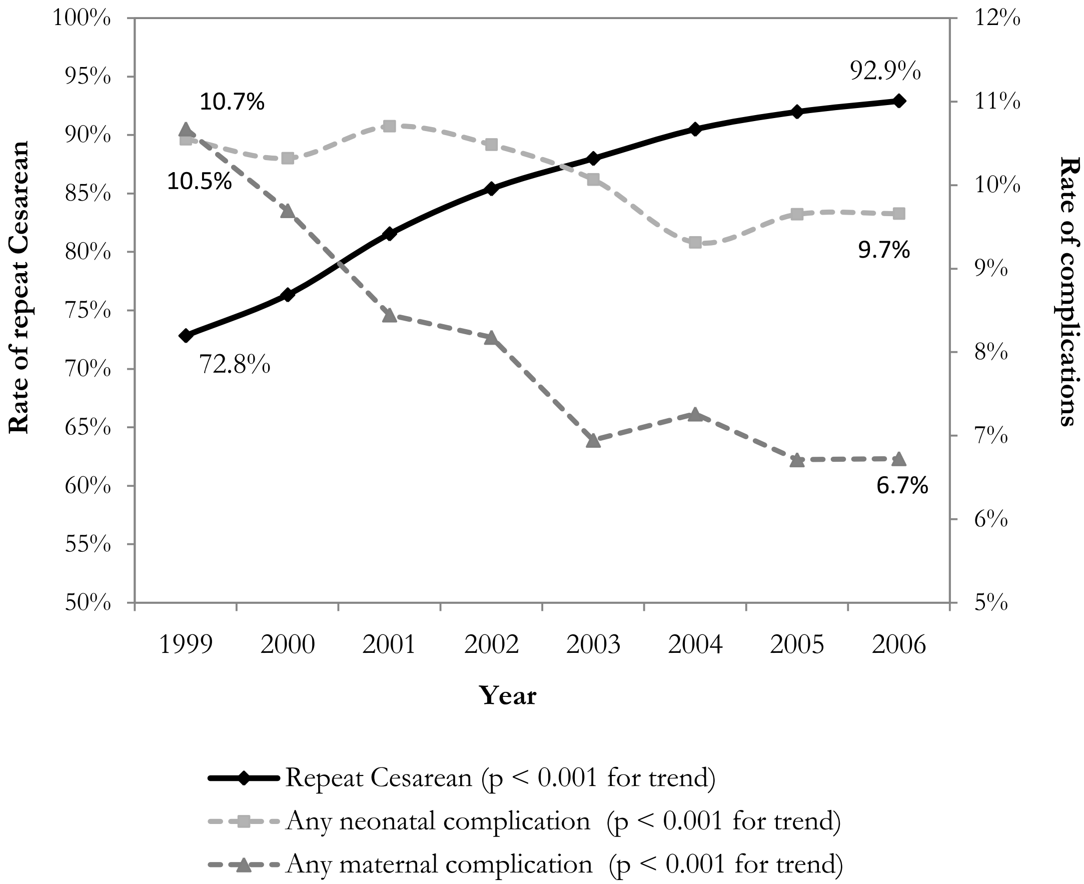


Figure 2: Rate of repeat Cesarean and rate of ideal delivery in New jersey, 1999-2006.

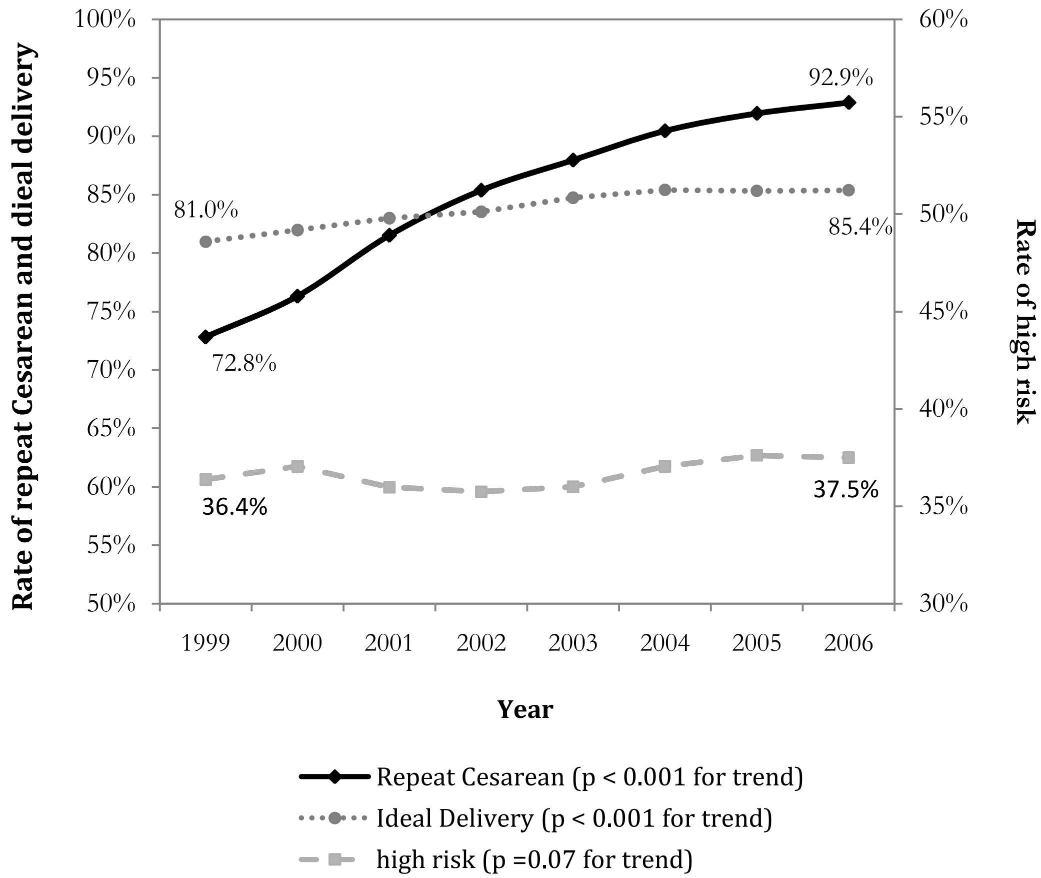
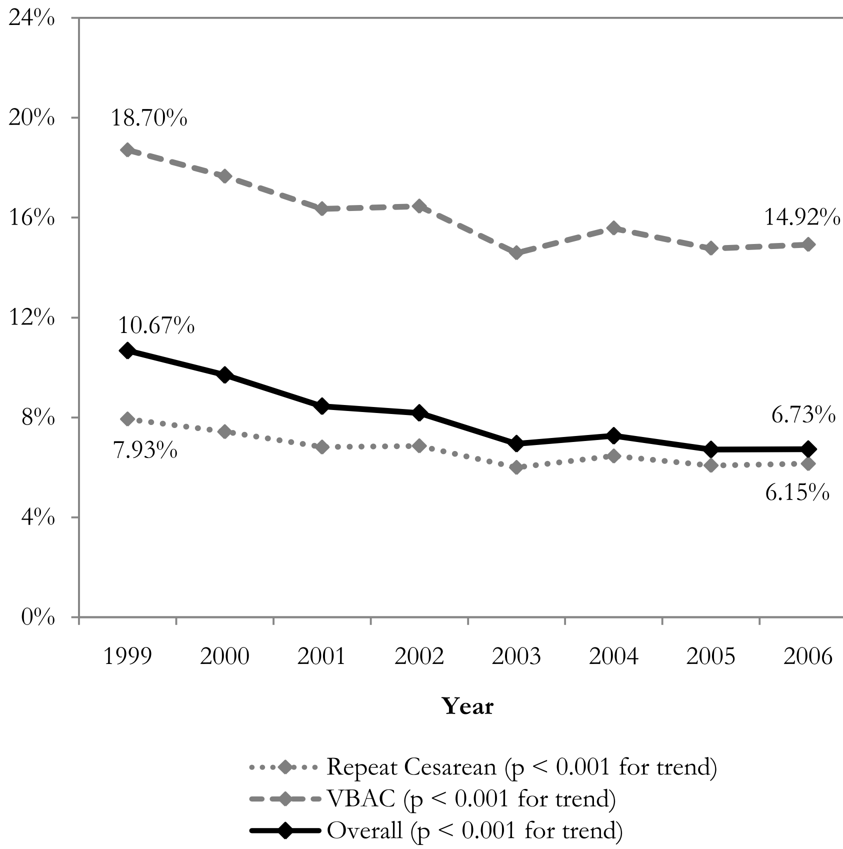


Table 3: Logistic Regression Models

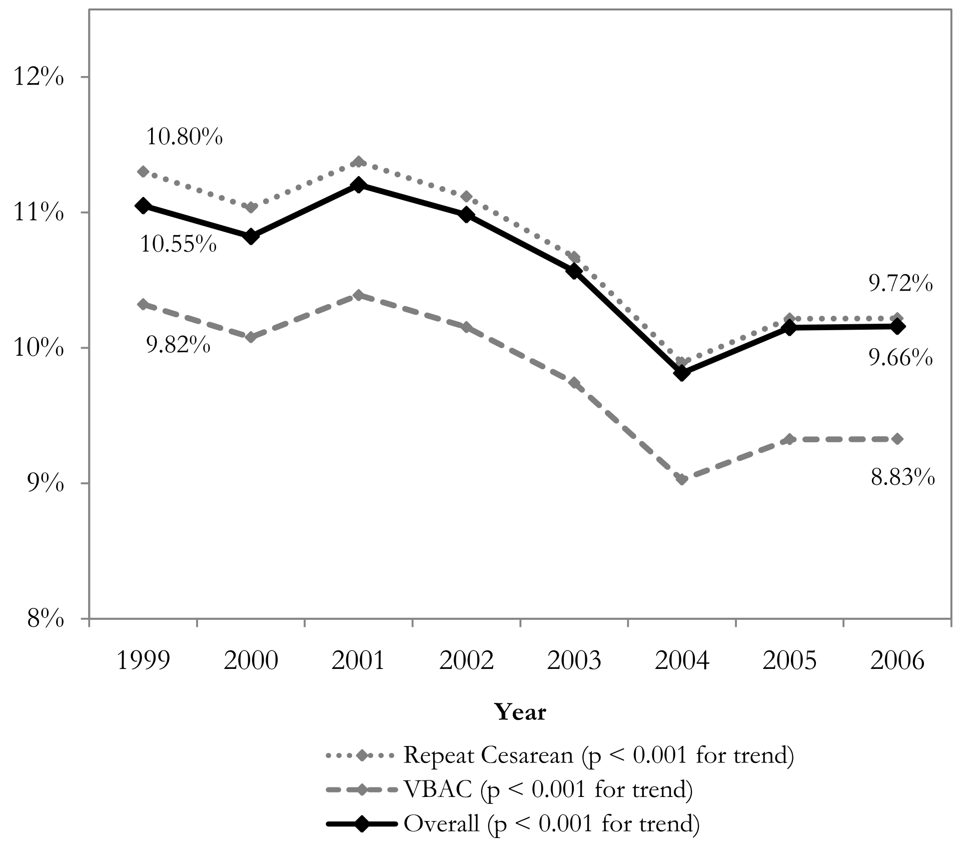
	Model 1			Model 2		
	Any maternal complications			Any neonatal complications		
Variables	Odds Ratio	(95% CI)	P Value	Odds Ratio	(95% CI)	P Value
Repeat Cesarean	0.37	(0.35-0.39)	<0.001	1.11	(1.05-1.18)	<0.001
Indicator for trial of labor	1.15	(1.10-1.21)	<0.001	1.09	(1.04-1.13)	<0.001
Indicator for high risk	1.83	(1.75-1.91)	<0.001	1.63	(1.57-1.70)	<0.001
Age (ref: age ≤ 35)						
Age > 35	1.06	(1.01-1.11)	0.021	0.96	(0.91-1.00)	0.051
Race (ref: white)						
Black	1.48	(1.39-1.57)	<0.001	1.45	(1.37-1.53)	<0.001
Hispanic	1.10	(1.03-1.17)	0.003	0.95	(0.89-1.00)	0.052
Other	1.14	(1.07-1.21)	<0.001	0.96	(0.90-1.01)	0.120
Insurance type (ref: Medicaid)						
Private insurance	0.78	(0.73-0.83)	<0.001	0.83	(0.78-0.89)	<0.001
Other	0.90	(0.82-0.98)	0.017	0.92	(0.85-1.00)	0.045
% College Education (ref: <15%)						
15%-20%	1.15	(1.08-1.23)	<0.001	0.94	(0.88-0.99)	0.020
>20%	0.95	(0.86-1.05)	0.291	0.92	(0.84-1.00)	0.049
Median Household Income (ref: 1st quartile)						
2nd quartile	1.08	(1.01-1.15)	0.019	0.92	(0.86-0.97)	0.004
3rd quartile	1.20	(1.10-1.30)	<0.001	1.02	(0.95-1.10)	0.518
4th quartile	1.16	(1.04-1.28)	0.005	0.86	(0.78-0.94)	0.001
Rural location	1.17	(1.09-1.26)	<0.001	1.03	(0.97-1.10)	0.317
Hospital birth volume (log)	1.22	(1.18-1.26)	<0.001	1.08	(1.04-1.11)	<0.001
Year(ref: 1999)						
2000	0.91	(0.84-0.98)	0.017	0.96	(0.89-1.04)	0.324
2001	0.83	(0.77-0.90)	<0.001	1.01	(0.93-1.08)	0.851
2002	0.83	(0.77-0.90)	<0.001	0.98	(0.91-1.06)	0.689
2003	0.71	(0.65-0.77)	<0.001	0.93	(0.86-1.00)	0.059
2004	0.76	(0.70-0.82)	<0.001	0.84	(0.78-0.91)	<0.001
2005	0.70	(0.65-0.76)	<0.001	0.86	(0.80-0.93)	<0.001
2006	0.69	(0.64-0.75)	<0.001	0.85	(0.79-0.91)	<0.001

Figure 3: Predicted adjusted risk* for any maternal complication by delivery method, 1999-2006.



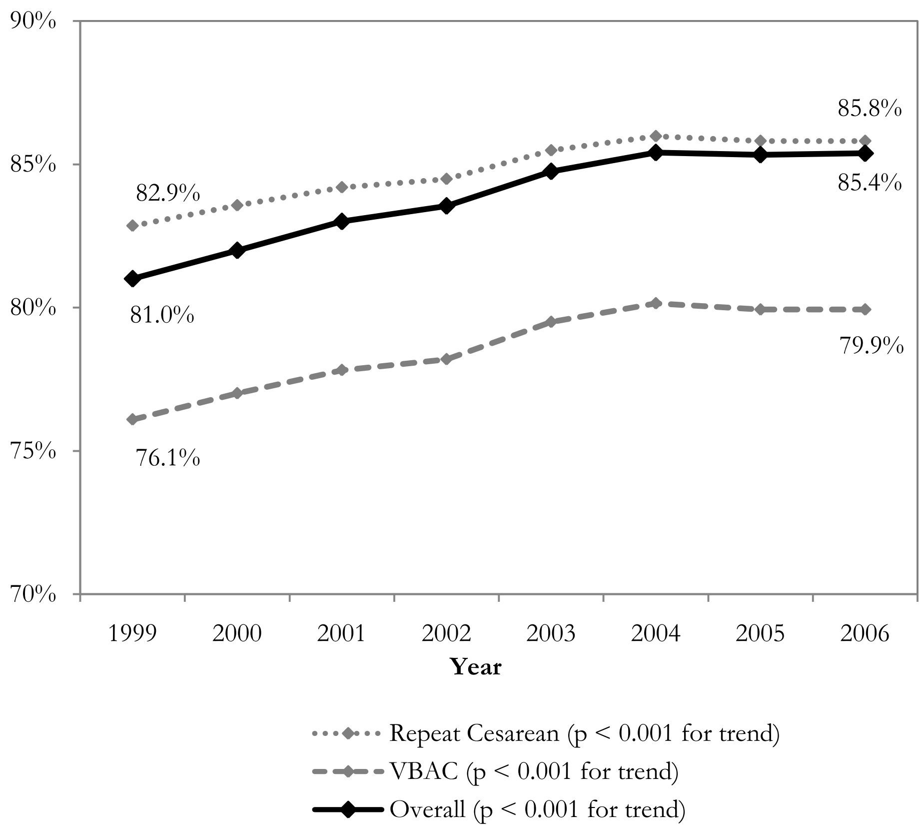
* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educated, median household income, urban vs. rural location and hospital birth volume.

Figure 4: Predicted adjusted risk* for any neonatal complication by delivery method, 1999-2006.



* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educated, median household income, urban vs. rural location and hospital birth volume.

Figure 5: Predictive ideal delivery rate* by delivery method, 1999-2006.



* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educated, median household income, urban vs. rural location and hospital birth volume.

Appendix 1: Maternal and neonatal delivery complications and associated ICD-9-CM codes

Complications	**ICD-9-CM codes**
Maternal	
Third- or fourth-degree perineal tear	664.2 664.3
Bladder laceration	665.5
High vaginal laceration	665.4
Other obstetrical laceration	664.4 664.8 664.9 665.8
Uterine rupture	665.0 665.1
Uterine dehiscence	674.1
Hysterectomy	683* 684* 686* 689*
Postpartum hemorrhage	666.0 666.1 666.2 666.3
Transfusion	*Procedure: 99.0**
Pelvic hematoma	665.7 664.5
Maternal infection	670* 038* 658.4 659.2 659.3
Wound infection	674.2 674.3
Anesthesia complications	668* 349*
Other maternal morbidity	671.4 673.0/673.3 998* 669.0/669.4 518.01 518.02 518.04 518.05 518.07/518.09 518.1* 518.2* 518.3* 518.4* 518.5* 518.6* 518.7* 518.81 518.82 518.85/518.88 518.9*
Maternal LOS > 5 d	NA
Maternal death	NA
Neonatal	
Birth trauma	763.0/763.4 767.2/767.8
Respiratory distress syndrome	769*
Other respiratory problems	770.1/770.9
Hypoxia	768.0/768.6 768.9
Neonatal infection	770.0 771.8 038*
Convulsions	779.0 779.2
Intracranial bleed	767.0 772.1 772.2
Neonatal LOS > 5 d	NA
Neonatal transfer	NA
Neonatal death	NA

Source: Gregory. Global measures of quality- and patient safety-related childbirth outcomes. Am J Obstet Gynecol 2009.

Appendix 2: High-risk clinical conditions and associated ICD-9 codes

Condition	**ICD-9-CM codes**
Unengaged head at term	652.5
Soft tissue disorder	654.0 654.1 654.4/654.7
Malpresentation	652.0 652.2/652.4 652.6/652.9
Oligohydramnios	658.0
Severe hypertension	642.5 642.6
Other hypertension	642.0/642.4 642.7/642.9
Antepartum bleeding	641
Liver disorders	646.7
Substance use	648.3
Mental illness	648.4
Polyhydramnios	657
Herpes	054 647.6
Kidney disorder	646.2
Thyroid disorder	644.81
Asthma	493
Heart disease	648.5 648.6
Isoimmune disease	656.1 656.2
Diabetes (includes gestational)	648.0 648.8
Macrosomia	656.6
Intrauterine growth restriction	656.5
Chromosome abnormality	655.0 655.1
Cerebral hemorrhage	431 432 433 434

Source: Gregory, et al. Vaginal birth after Cesarean: clinical risk factors associated with adverse outcome. Am J Obstet Gynecol 2008.

Appendix 3: Trend in maternal and neonatal complication rates among women with prior Cesareans

Outcome (%)	1999	2000	2001	2002	2003	2004	2005	2006	Slope	Trend* P Value
Any complications	19.0	18.0	17.0	16.5	15.2	14.6	14.7	14.6	-	<0.001
Any maternal complications	10.7	9.7	8.4	8.2	6.9	7.3	6.7	6.7	-	<0.001
Any neonatal complication	10.5	10.3	10.7	10.5	10.1	9.3	9.6	9.7	-	<0.001
Maternal complications										
Third- or fourth-degree perineal tear	2.4	1.8	1.3	0.8	0.6	0.5	0.4	0.3	-	<0.001
Bladder laceration	1.0	1.0	0.7	0.7	0.5	0.6	0.4	0.4	-	<0.001
High vaginal laceration	0.6	0.3	0.3	0.3	0.2	0.2	0.1	0.1	-	<0.001
Other obstetrical laceration	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	-	0.267
Uterine rupture	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.1	-	<0.001
Uterine dehiscence	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.2	-	<0.001
Hysterectomy (‰)	0.1	0.1	0.1	0.2	0.0	0.1	0.2	0.1	+	0.651
Postpartum hemorrhage	1.4	1.4	1.1	1.1	1.2	1.1	1.1	1.2	-	0.003
Transfusion	0.7	0.6	0.7	0.8	0.8	0.8	0.9	1.1	+	<0.001
Pelvic hematoma	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	-	0.360
Maternal infection	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	-	<0.001
Wound infection	0.6	0.6	0.6	0.7	0.5	0.5	0.6	0.5	-	0.159
Anesthesia comps	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.8	+	0.325
Other maternal morbidity	0.5	0.3	0.4	0.4	0.4	0.4	0.5	0.4	+	0.612
Materanl LOS > 5 d	2.9	2.6	2.6	2.7	2.2	2.2	2.1	2.2	-	<0.001
LOS, mean (±SD)	3.3 (±2.0)	3.4 (±1.9)	3.4 (±1.9)	3.4 (±1.9)	3.4 (±2.2)	3.5 (±2.1)	3.5 (±1.7)	3.5 (±1.7)		
Maternal death (‰)	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	+	0.903
Neonatal complications										
Birth trauma	1.3	1.0	1.0	0.8	0.8	0.5	0.5	0.6	-	<0.001
Respiratory distress syndrome	0.9	0.9	1.1	0.9	1.2	1.0	1.0	1.1	+	0.048
Other respiratory problems	5.5	5.8	6.2	6.2	5.9	5.8	6.0	6.1	+	0.162
Hypoxia	0.3	0.3	0.2	0.0	0.2	0.1	0.2	0.2	-	<0.001
Neonatal infection	1.6	1.8	1.8	1.7	1.0	0.2	0.1	0.2	-	<0.001
Convulsions	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-	0.155
Intracranial bleed	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-	<0.001
Neonatal LOS > 5 d	3.9	3.5	3.7	4.1	3.8	3.7	4.0	3.9	+	0.217
Neonatal transfer	1.0	1.1	1.0	0.9	1.1	0.8	0.8	0.8	-	<0.001
Neonatal death (‰)	2.3	3.8	2.0	2.0	1.8	2.3	1.3	1.1	-	<0.001

Appendix 4: Analysis for primary C-section and primary vaginal delivery

For comparison purpose, I also conducted same analysis for primary births. There were 741,308 primary births during the study period, of whom 22.2% was primary C-section. Table (a) reports the unadjusted risk for maternal and neonatal complications stratified by mode of delivery. Risks for complications varied significantly between primary C-section and primary vaginal delivery. Unlike the repeat C-section group, the primary C-section group had a higher rate of maternal complications (12.7%) than the primary vaginal delivery group (12.4%). The primary C-section group also shows a much higher rate in neonatal complications (14.4%) than the primary vaginal delivery group (7.6%). The rate of ideal delivery rate for the primary C-section group is 78%, lower than that for the primary vaginal birth group (81%). By looking at the rate for each of the maternal and neonatal complication rate can find that compared to primary vaginal delivery group, VBAC result higher rates of most complications, for example, uterine rupture (0.12% versus 0.01%), and higher rate of longer maternal and neonatal LOS. In contrast, the repeat C-section group result lower rates of most complications.

Figure (a) and (b) displays the temporal trend for repeat C-section, any maternal complications, any neonatal complications, ideal delivery, and high risk population. New Jersey had a rising rate of primary C-section from 18.5% in 1999 to 26.1% 2006. The rates of maternal complications and neonatal complications both decreased significantly during the study period, by 2.4% and 1.2%, respectively. During the study period, the proportion of population with high risk conditions rose from 30% in 1999 to 37%, and the ideal delivery rate climbed from 79% to 82%.

Figure (c), (d) and (e) display the temporal trend of predicted adjusted rates for maternal complication, neonatal complications, and ideal delivery estimated from the logistic regressions. The adjusted complication rates were predicted for the overall population and by different modes of delivery. Unlike the sample of births after C-section, the significantly higher rates in neonatal complication of the repeat C-section group result lower rates of ideal delivery.

Table (a) : Crude maternal and neonatal complication rates for women with primary birth during 1999-2006

	Primary C-section		Primary vaginal delivery		*P* Value
Outcomes	Events, *n*	Risk, %	Events, *n*	Risk, %	
N	164,811		576,497		
Ideal delivery	128,489	(77.96)	469,157	(81.38)	<0.001
Any maternal complications	20,988	(12.73)	71,650	(12.43)	<0.001
Any neonatal complication	23,668	(14.36)	43,956	(7.62)	<0.001
Maternal complications					
Third- or fourth-degree perineal tear	99	(0.06)	30,982	(5.37)	<0.001
Bladder laceration	262	(0.16)	13,075	(2.27)	<0.001
High vaginal laceration	83	(0.05)	6,989	(1.21)	<0.001
Other obstetrical laceration	184	(0.11)	1,905	(0.33)	<0.001
Uterine rupture	147	(0.09)	69	(0.01)	<0.001
Uterine dehiscence	166	(0.10)	4	(0.00)	<0.001
Hysterectomy	19	(0.01)	25	(0.00)	0.001
Postpartum hemorrhage	2,678	(1.62)	13,054	(2.26)	<0.001
Transfusion	2,194	(1.33)	1,792	(0.31)	<0.001
Pelvic hematoma	108	(0.07)	859	(0.15)	<0.001
Maternal infection	2,346	(1.42)	738	(0.13)	<0.001
Wound infection	976	(0.59)	439	(0.08)	<0.001
Anesthesia comps	1,228	(0.75)	1,620	(0.28)	<0.001
Other maternal morbidity	1,217	(0.74)	833	(0.14)	<0.001
Maternal LOS > 5 d	14,231	(8.63)	4,900	(0.85)	<0.001
LOS, mean (±SD)	4.42	(±3.67)	2.35	(±1.42)	
Maternal death	39	(0.02)	23	(0.00)	<0.001
Neonatal complications					
Birth trauma	1,918	(1.16)	7,140	(1.24)	<0.001
Respiratory distress syndrome	2,469	(1.50)	3,461	(0.60)	<0.001
Other respiratory problems	11,325	(6.87)	23,540	(4.08)	<0.001
Hypoxia	789	(0.48)	972	(0.17)	<0.001
Neonatal infection	2,456	(1.49)	5,085	(0.88)	<0.001
Convulsions	244	(0.15)	511	(0.09)	<0.001
Intracranial bleed	147	(0.09)	304	(0.05)	<0.001
Neonatal LOS > 5 d	12,234	(7.42)	14,012	(2.43)	<0.001
Neonatal transfer	1,886	(1.14)	4,384	(0.76)	<0.001
Neonatal death	520	(0.32)	1,292	(0.22)	<0.001

Figure (a): Rate of primary Cesarean, rate of any maternal complications, and rate of any neonatal complications in New Jersey, 1999-2006.

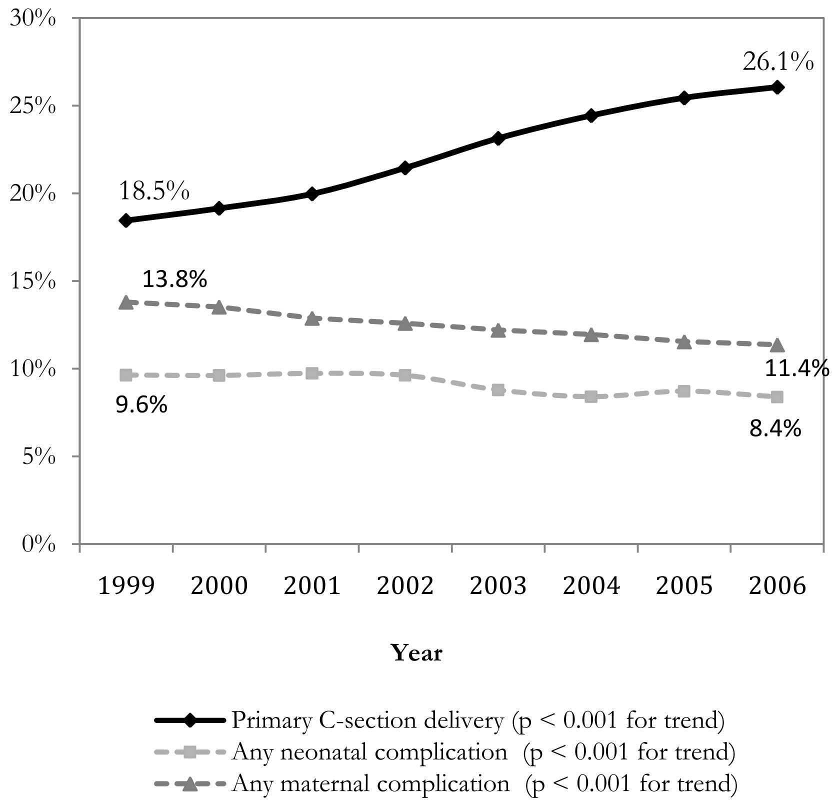


Figure (b): Rate of primary Cesarean and rate of ideal delivery in New jersey, 1999-2006.

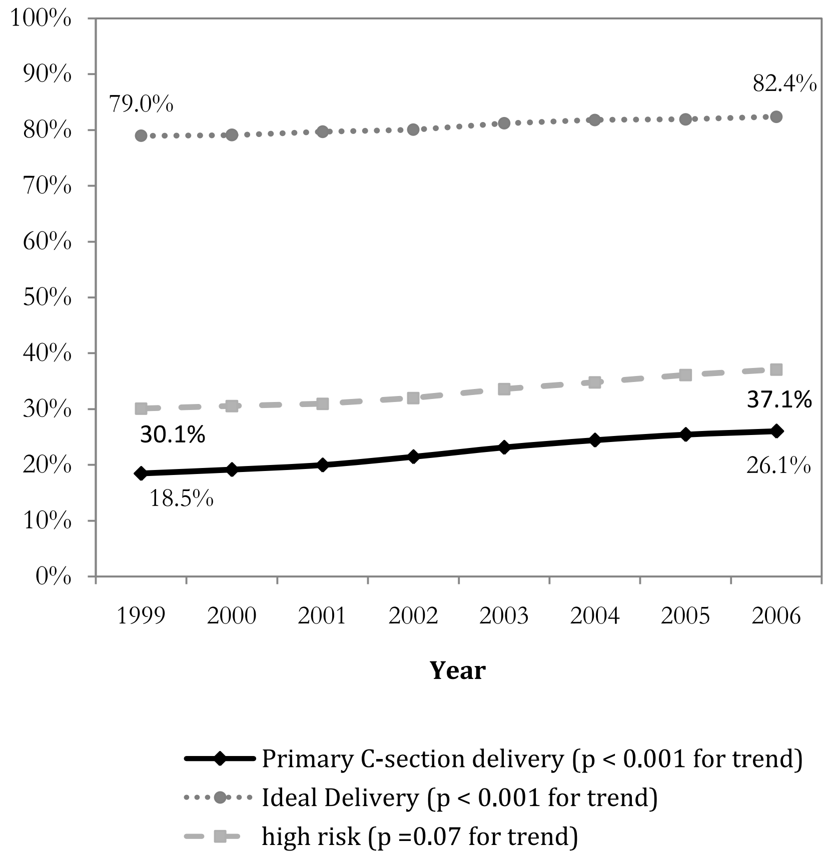
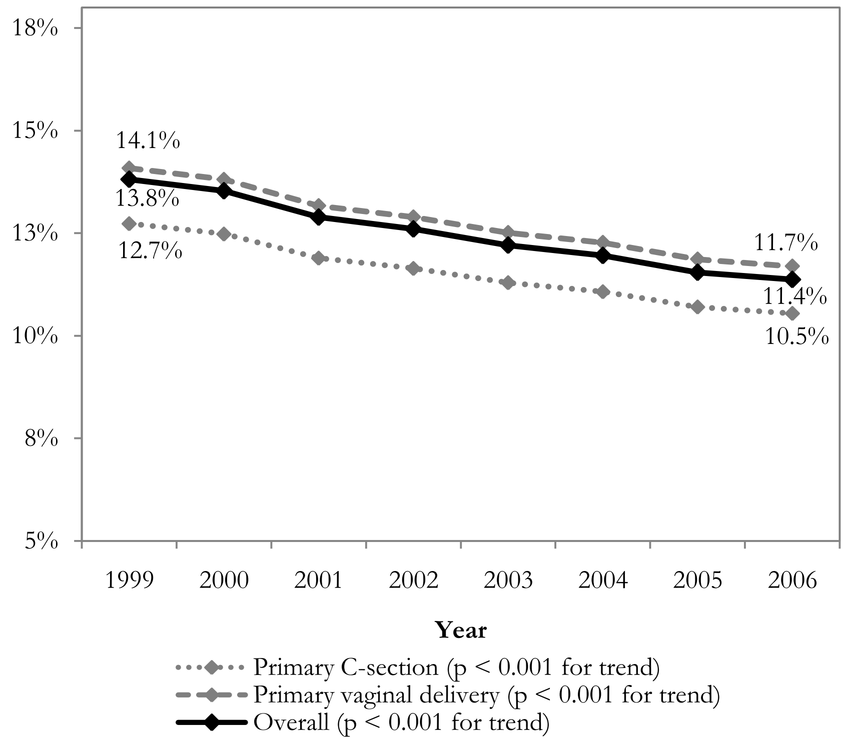
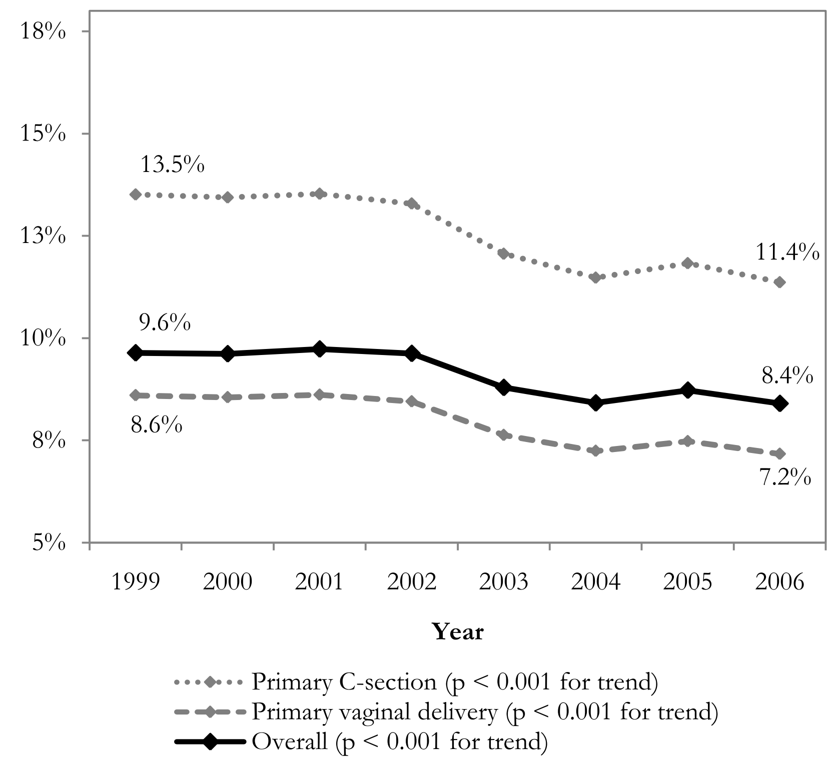


Figure (c): Predicted adjusted risk* for any maternal complication by delivery method, 1999-2006.



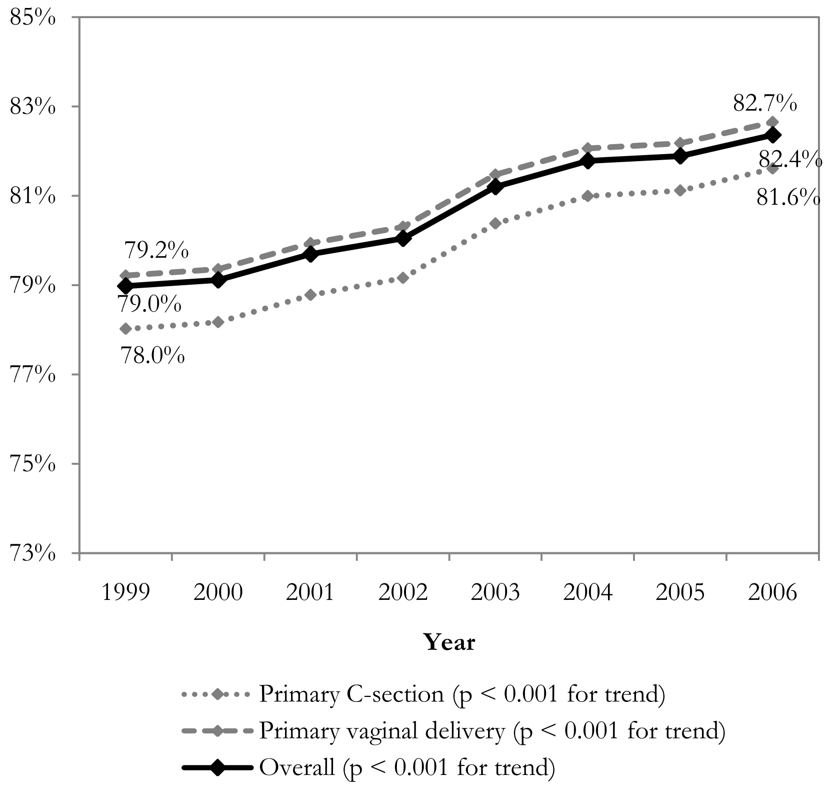
* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educatied, median household income, urban vs. rurla location and hospital birth volume.

Figure (d): Predicted adjusted risk* for any neonatal complication by delivery method, 1999-2006.



* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educatied, median household income, urban vs. rurla location and hospital birth volume.

Figure (e): Predicted ideal delivery rate* by delivery method, 1999-2006.



* Adjusted for trial of labor, high risk clinical condition, age, race, insurance type, percentage college educatied, median household income, urban vs. rurla location and hospital birth volume.

CHAPTER 3

Time Trends in Variations in Method of Delivery across Hospitals

Abstract

As consensus guidelines are disseminated, practice patterns are believed to become more consistent across providers. One example is the growing literature regarding trial of labor after Cesarean section. The purpose of this study is to examine temporal trends in variation in obstetric practice patterns focusing on primary and repeat Cesarean sections across hospitals over time. Using aggregate panel data at hospital level from New Jersey State Inpatient Database (SID), 1999-2006, I conducted a retrospective study with hierarchical linear models to test for temporal trends in the degree of variation. There is a statistically significant downward trend in the degree of cross-hospital variation in repeat Cesarean section rates (correlation coefficient=-0.72, $p<0.001$), but no similar trend for variation in primary Cesarean section rates (correlation coefficient=0.08, $p=0.069$). Practice patterns for repeat C-section became less variable over time as indicated by a decreasing temporal trend in the variation between hospitals perhaps as a result of the diffusion of national clinical guidelines. On the other hand, the continued large variation across hospitals in primary C-section rates suggests that opportunities exist for safe reduction in C-section rates. More protocols and guidelines regarding the procedure and payment incentive systems are needed to reduce primary C-section rates. Further investigation into the impact of medical practice variation on patient maternal and neonatal outcomes is warranted.

3.1 Introduction

Obstetrical practice patterns have changed considerably over the past two decades. Two examples are an increasing number of elective surgical births and changes in hospitals' vaginal birth after Cesarean (VBAC) policies due to professional society guideline recommendations and medical liability concerns (Menacker et al., 2006). Not surprisingly, Cesarean section (C-section) is currently the most commonly performed operating room procedure in U.S. hospitals (HCUP fact, 2007) and is responsible for the majority of excess U.S. medical costs (Hamilton et al, 2006) relative to other OECD countries. Birth outcomes relative to other OECD countries, however, have not improved (OECD, 2009).

The increasing adoption of both primary and repeat C-section as a birth method may indicate that practice patterns are becoming more consistent across providers. It has been argued that medical decision-making and practice patterns have become more standardized due to more nationally developed guidelines, protocols and professional society consensus statements over the past few decades (Ritzer and Walczak, 1988). Although the availability of consensus clinical guidelines does not guarantee an individual doctor's adherence, it is believed that this movement towards standardization has impacted medical practice (Lomas, 1989). From patients' perspectives, medical practitioners are expected to apply the best care based on solid scientific grounds and treat comparable patients equally which would imply low levels of practice variation. Third-party payers are interested in practice variations because of the costs associated with different procedures or practice styles. From a hospital's perspective, hospitals are concerned when their rate in certain procedures are significantly higher or lower than the average. The Joint Commission has used VBAC rates, despite a lack of consensus on an ideal rate, as one of its measures to assess and compare hospital inpatient care (The Joint Commission website, accessed: http://manual.jointcommission.org/releases/TJC2010A/index.html).

Several studies since the 1970's have shown that there are considerable birth practice variations among physicians, institutions and small geographic areas even after adjusting for patient-specific factors (Menard, 1999). Nonclinical factors such as type of hospital, physician practice style, patient socio-economic status, payer source, and legal concerns have been shown to be associated with C-section rates (Ham, 1988; Andersen and Mooney, 1990; Learman, 1998; Menard, 1999). Most studies on practice variation have concentrated on cross-sectional variation (Ashton et al, 1999), while time trends in practice variation have seldom been studied. A better understanding of how variation changes between institutions over time is essential for the design of successful quality improvement and cost containment policies.

The overall rate of C-sections is composed of primary C-sections and repeat C-sections. Both physician convenience and fear of litigation have been cited as reasons for the dramatically climbing rate of repeat C-section (Sheikh et al., 2008). The tendency to repeat Cesarean delivery for births after a previous C-section is related to the concerns about the relative safety of vaginal birth after Cesarean (VBAC) as articulated by several American College of Obstetricians and Gynecologists (ACOG) documents and key studies over a fifteen year period (ACOG, 1999; McMohan et al., 1996; Sach et al., 1999; Cohen and Atkins, 2001; Socol, 2003; Landon et al., 2004; Guise , 2004). Attention has focused primarily on uterine rupture, a potentially catastrophic event, which can have serious consequences to both the mother and the neonate (Mozurkewich and Hutton, 2000).

The safety debate along with liability concerns prompted the ACOG to recommend in 1999 that VBAC be attempted only when a physician can be "immediately available throughout active labor" in case an emergency Cesarean delivery is needed (ACOG, 1999). This ACOG practice guideline has therefore significantly limited access to attempted VBACs in many hospitals. Since its publication, the rate of repeat C-section has consistently risen (Santerre and College, 1996; Pinette et al., 2004; Gochnour et al., 2005; Zweifler et al., 2006).

On the contrary, there is no equivalent definitive guideline for primary C-section. As patient informed choices are increasingly being valued, there are also increasing elective C-sections among women with their primary delivery. There is a cultural shift on patients' preferences and medical education regarding the choice of delivery mode. Physician professional groups have opposing opinions as to the ethics of performing a C-section for nonmedical reasons (ACOG, SCOG) leaving physicians without a consensus guideline.

The objective of this study is to examine temporal trends in the variation of obstetrical practice pattern across hospitals. I compared primary and repeat C-section rates across hospitals in New Jersey between 1999 and 2006. I hypothesized that practice variation for repeat C-section across hospitals would diminish overtime after the publication of the 1999 ACOG obstetric practice guideline (ACOG, 1999). Given the lack of a standardized recommendation for primary C-section, I expect that no change in variation over the time period. In addition, I explored whether hospitals with certain characteristics contribute more variation over time.

3.2 Methods

3.2.1 Data Sources

Data on births and methods of delivery in individual hospitals along with statewide totals were obtained from 1999-2006 New Jersey State Inpatient Databases (SID), part of the Healthcare Cost and Utilization Project (HCUP), developed by the Agency for

Healthcare Research and Quality (AHRQ). SID contains the universe of inpatient discharge records at all nonfederal acute care hospitals in the state. There were approximately seventy hospitals in the New Jersey SID each year.

3.2.2 Sample Construction

Included in the sample are hospitals reporting every year and with at least 100 deliveries for each year. Hospitals with fewer deliveries were excluded since their rates would be much more variable; and with limited birth volume, the labor management strategy may also be different from whose with higher birth volume. The final sample included birth panel data for 59 hospitals. These hospitals accounted for more than 95 percent of all hospital births in New Jersey over this time period.

3.2.3 Measurements

I used the diagnosis related groups (DRGs) from the hospital discharge summaries to identify the method of delivery; DRGs 370 and 371 for C-section deliveries and DRGs 372-375 for vaginal delivery. The ICD-9 diagnosis code 654.2 identified women with a previous C-section. Primary Cesarean rates were calculated as the number of Cesarean deliveries without prior Cesareans divided by the number of births without prior Cesarean history. Repeat Cesarean rates were calculated as the number of Cesarean deliveries with prior Cesareans divided by the number of births with prior Cesarean history. The rates were calculated by hospital and statewide over time. The coefficient of variation (CV) is the descriptive indicator of dispersion. CV measures the standard deviation of hospital discharge rates relative to the mean rate and multiplied by 100. A decline in the coefficient of variation therefore indicated a decline in variation.

For each hospital-year, I also measured hospital characteristics using the proportion of certain population characteristics in the SID because of the inability to obtain more specific hospital details such as ownership and teaching status. I measured the percentage of white patients, black patients, Hispanic patients, patients with Medicaid, patients over age 35, and patients with high medical risk conditions. High risk medical conditions were defined as maternal antenatal conditions; such as hypertension, diabetes, or malpresentation, that have previously been associated with complicated deliveries (Gregory et al., 2008). Hospital characteristics were coded as of 1999. The full list of those high risk conditions and associated ICD-9 codes are included in the Appendix 1. Women were identified being high risk if any of the risk factors were present. I also studied hospital variation as a function of rural or urban location and birth volume.

3.2.4 Analysis

The analyses were performed in two steps. First, time trends in variation across hospital-specific observed rates of (1) primary C-section and (2) repeat C-section are described using coefficient of variation (CV) and inter-quartile range. Hierarchical linear modeling (HLM) (Snijders, 1996; Albright, 2007) was then performed for statistical analysis. HLM is required since the 8 yearly rates for each hospital cannot be assumed to be independent. The trend analysis was therefore performed using the following two-level model:

$$r_{it} = \mu_0 + \beta_1 t^1 + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + \beta_5 t^5 + \beta_6 X_{t=1999} + \mu_i + \beta_i t + \varepsilon_{it} ,$$

where r_{it} is the hospital rate for primary and repeat Cesarean section in hospital i and year t. t is the year number (1999=0) and $\beta_1 t^1, \dots , \beta_5 t^5$ is a polynomial function of time to capture the general trend in rates over years. X is a set of hospital characteristic: rural location, birth volume, the proportions of white patients, black patients, Hispanic patients, Medicaid patients, patient with age above 35, and patient with high risk medical conditions. The random intercept μ_i, the random slope with time β_i, as well as the error terms ε_{it} , are assumed independent and normally distributed with constant covariance. In this model, the time trend of hospital variation is given by the correlation of the intercept μ_i and the slope with time β_i at level two. If the correlation is negative and statistically significant, this means that the hospital disparities have become smaller over time.

In the second part of the analysis, trends in hospital rates are stratified by different hospital characteristics to investigate which type of hospitals contribute most to variation over time. For example, I ranked the proportion of high risk patients among 59 hospitals based on 1999 data and grouped them into three levels: highest third, middle third, and lowest third. I then stratified hospital primary and repeat C-section rates by the levels of high risk patients and graphed the rates over time.

3.3 Results

Table 1 shows statewide and sample hospitals primary and repeat C-section mean rates as well as the coefficient of variation (CV) among sample hospitals over time. Between 1999 and 2006, the statewide primary Cesarean section rate increased from 18% to 26%, and the statewide repeat Cesarean rates increased from 73% to 93%, both of which parallel national trends over the same period. The rates for individual sample hospitals were quite varied, ranging by up to 30 percentage points. For example, the lowest hospital rate of primary C-section in 2006 is 12%, whereas the highest hospital rate is 50%; the lowest rate of repeat C-section in 2006 is 67%, whereas the highest rate is 100%. For primary Cesarean section rates, the coefficient of variation between 1999 and 2006 increased from 18.9 to 26.1; whereas the coefficient of variation for repeat Cesarean section rate decreased from 12.7 to 6.7. For illustrative purpose, Figure 1(a) and 1(b) show the inter-quartile ranges of primary and repeat Cesarean section rates across hospitals over time. The variation in primary Cesarean section rates has widened as the average rates increased while the variation in repeat Cesarean section rates has narrowed while average rates increased.

Table 2 displays the outputs from the hierarchical linear models and the correlation between hospital variation and time. The main study results came from the correlation between the random intercept and the random slope with time. For primary C-section, the correlation is positive 0.08 but not significant at $p=0.05$ ($p=0.069$). On the other hand, the correlation is -0.72 ($p<0.001$) for repeat Cesarean section rates, indicating a statistically significant downward trend in cross-hospital variation.

Figures 2 through 7 illustrate the trend in hospital primary C-section rates and hospital repeat C-section rates stratified by different levels of hospital characteristics. Figure 2(a) shows that hospitals with lower proportion of high risk patients in 1999 started with higher primary Cesarean section rate which increased at a slower rate; and hospitals with higher proportion of risk patients adopted primary Cesarean section at a faster rate over the years. In contrast, as Figure 2(b) shown, hospitals with more high risk patients initially had much higher rates in repeat Cesarean section than other hospitals in 1999 and the difference has narrowed over time.

Figures 3(a) and (b) illustrate the effect of different proportions of Medicaid patients. Hospitals with more Medicaid patients have a steeper slope in primary Cesarean section rates and the difference relative to hospitals with few Medicaid patients increases over time (Figure 3(a)). For repeat C-sections, however, no such pattern is seen.

Figures 4(a) and (b) show the effects of hospital birth volume. For repeat Cesarean section rates, there is a positive association between birth volume and likelihood of having a repeat C-section in 1999, however, the effect gradually disappear as the rates became identical for all hospital volumes. Primary C-sections show a very different pattern. Hospitals with lower birth volume have higher primary Cesarean section rates though out the study period.

Figures 5(a) and (b) show the impact of urban versus rural location. For primary Cesarean section rates, rural hospitals had lower rates but a steeper slope after 2002. For repeat Cesarean sections, the difference between urban and rural hospital rates disappears after 2002.

Figures 6(a) and (b) illustrate the effect of the proportion of patients over age 35. For repeat Cesarean section rates, hospitals with a higher proportion of patients over age 35 have a higher rate in the beginning of the study period. However, the differences between three groups seem to shrink over time. For primary C-sections, there is no clear pattern.

Figures 7(a) and (b) show the effect of the proportion of white patients. No clear

The proportion of white patients does not have a consistent effect on either the rate of primary or repeat C-section.

3.4 Discussion

This study finds a significant downward trend in hospital variation in repeat C-section rates as hypothesized and an unexpected upward trend in primary C-section rates over the study period. The variation in primary and repeat C-section rates also varied by hospital characteristics, as measured by patient characteristics (race, age over 35, high risk medical conditions, Medicaid), and hospital characteristics (birth volume and rural/urban location). These differences, however, shrink for repeat C-sections rates over time.

Among the limited studies focusing on trends in practice variation, the majority show a trend towards less variation over time (Katz et al., 1996; Westert et al., 2004). The decline in institutional variation in repeat C-section suggests that the increasing evidence base for preferred mode of delivery and shared standards of practice have become more uniform. The diffusion of new knowledge has been recognized as a cause for changes in practice variation over time (Griggs et al., 2009). The fact that more clinical practice guidelines and professional society consensus statements about births after Cesarean delivery have been published in recent years (Lian, 2003) helps diminish the uncertainties around medical decision making and consequently push physicians and hospitals toward standardization. In addition, insurers can use published guidelines to guide reimbursement rules and encourage institutions to shift to their preferred practice style (Brunsson and Jacobson, 2000).

It is interesting that the variation in primary C-section rates has not narrowed over time and in fact may be increasing. In contrast to the rich obstetrical literature and professional consensus regarding repeat Cesarean section and VBAC, there is no comparable evidence-based literature on primary Cesarean delivery. Most discussions have centered on changing societal attitudes which have paralleled the growing rate of elective primary C-section rates in recent years (Meikle et al., 2005; Menacker et al., 2003). At the same time, physician professional groups also have opposing opinions as to the ethics of performing a C-section for nonmedical reasons (ACOG, 2004; FIGO, 1998). Lacking consensus on practice standards may complicate the decision making regarding the procedure and therefore increase the variation between hospitals.

One limitation of this study is the limited information available about hospital characteristics. Previous literature has identified a number of factors that explain the variation in Cesarean section rates among hospitals. This analysis is unable to evaluate the impact of variables such as teaching status, ownership, and bed size that might capture more institutional effects on the choices of delivery mode. Measuring hospital characteristics by the proportions of specific patients' characteristics was an attempt to control for some of these differences.

In conclusion, this study finds that repeat C-section practices have become more uniform since the 1999 ACOG guideline. There is a downward trend in the cross-hospital variation in repeat C-section rates over time. Our finding that variations across hospitals in primary C-section rates are increasing suggests that opportunity exists for safe reductions in C-section rates, especially for those without an identified medical need. Primary Cesarean deliveries are an important target for reduction as they increasingly guarantee subsequent Cesarean deliveries. Protocols and guidelines regarding the medical indication for elective C-section and payment incentives may be used to reduce primary C-section rates. At the same time, more study is needed as to changes in medical practice variation on maternal and neonatal outcomes.

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Table 1: Mean C-section rates and CV* across hospitals.

	Statewide Cesarean rates		Hospital Cesarean rates			
	Primary	Repeat	Primary		Repeat	
Year	mean	mean	mean	CV*	mean	CV*
1999	18.4%	72.8%	18.3%	18.9	73.4%	12.7
2000	19.1%	76.3%	18.7%	18.3	76.8%	10.6
2001	19.9%	81.5%	19.3%	19.3	81.5%	9.0
2002	21.4%	85.4%	20.9%	20.8	85.6%	8.4
2003	23.1%	88.0%	22.7%	19.1	87.8%	7.6
2004	24.0%	90.5%	24.1%	20.9	90.5%	7.5
2005	25.4%	92.0%	25.2%	21.9	92.0%	6.0
2006	26.0%	92.9%	25.8%	26.1	92.7%	6.7

*CV=coefficient of variation, which is the standard deviation of hospital rates to the mean rate multiplied by 100.

Figure 1(a): Inter-quartile range for primary C-section rates among 59 sample hospitals in New Jersey, 1999-2006

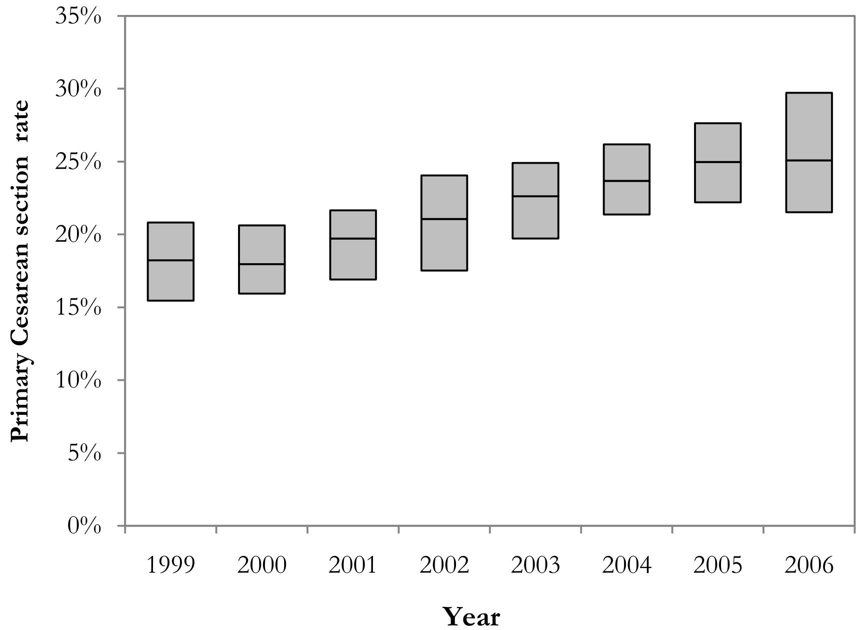


Figure 1(b): Inter-quartile range for repeat C-section rates among 59 sample hospitals in New Jersey, 1999-2006

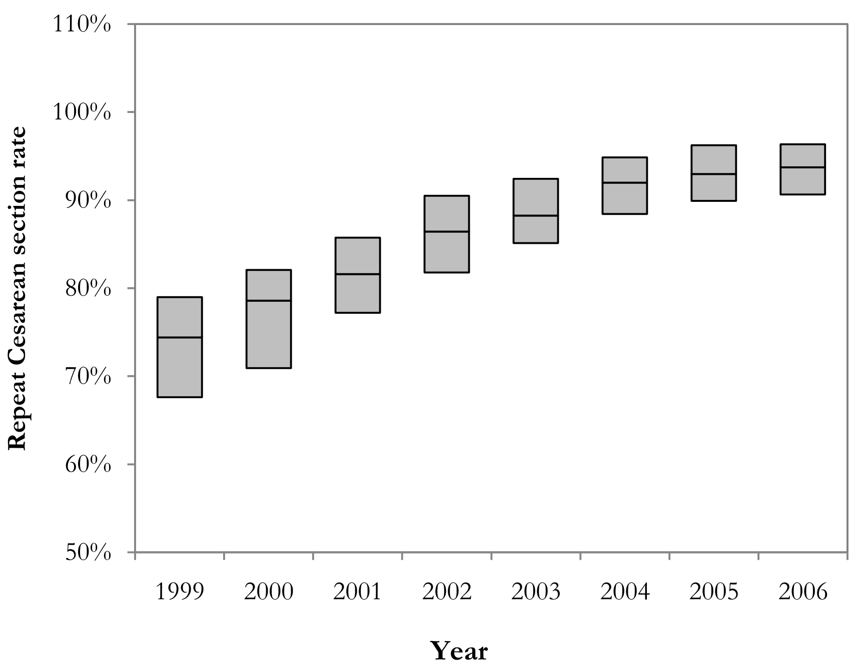


Table 2: Hierarchical linear model results and the correlation of random intercept and random slope

	Primary C-section rate			**Repeat C-section rate**		
	Coefficient	Std. Error	p-value	Coefficient	Std. Error	p-value
Fixed Effects						
Intercept	0.169	(0.029)	<0.001	0.790	(0.053)	<0.001
Rural location	-0.013	(0.012)	0.297	-0.010	(0.021)	0.630
% White	-0.015	(0.026)	0.550	0.018	(0.046)	0.697
% Black	0.016	(0.040)	0.681	-0.073	(0.071)	0.304
% Hispanic	0.041	(0.032)	0.201	0.040	(0.057)	0.478
% Medicaid	-0.089	(0.078)	0.254	-0.036	(0.139)	0.799
% Age above 35	0.071	(0.135)	0.601	-0.093	(0.241)	0.701
% High risk	0.011	(0.055)	0.843	-0.184	(0.098)	0.059
Birth volume (per 1000)	0.006	(0.003)	0.097	0.003	(0.006)	0.637
$Time^1$	0.006	(0.011)	0.622	0.012	(0.017)	0.490
$Time^2$	-0.005	(0.012)	0.684	0.033	(0.018)	0.071
$Time^3$	0.004	(0.005)	0.439	-0.012	(0.007)	0.078
$Time^4$	-0.001	(0.001)	0.376	0.002	(0.001)	0.107
$Time^5$	0.000	(0.000)	0.375	0.000	(0.000)	0.130
	Variance component	Std. Error	p-value	Variance component	Std. Error	p-value
Random Effects						
Intercept	0.026	(0.003)	<0.001	0.072	(0.008)	<0.001
Time	0.007	(0.001)	<0.001	0.011	(0.001)	<0.001
	Correlation coefficient		p-value	Correlation coefficient		p-value
Corr (Intercept, Time)	0.08		0.069	-0.72		<0.001

Figure 2(a): Trend in hospital primary C-section rates stratified by proportion of high risk patients

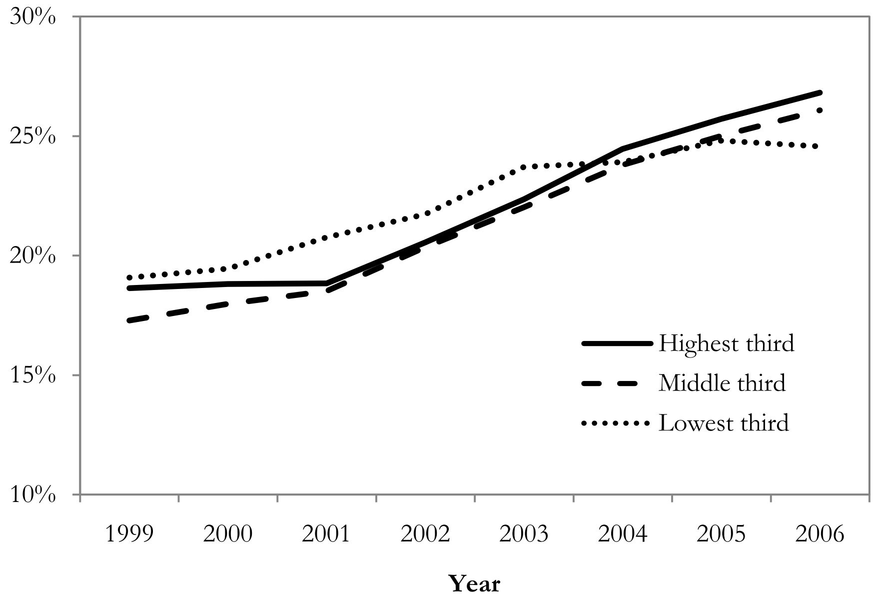


Figure 2(b): Trend in hospital repeat C-section rates stratified by proportion of high risk patients

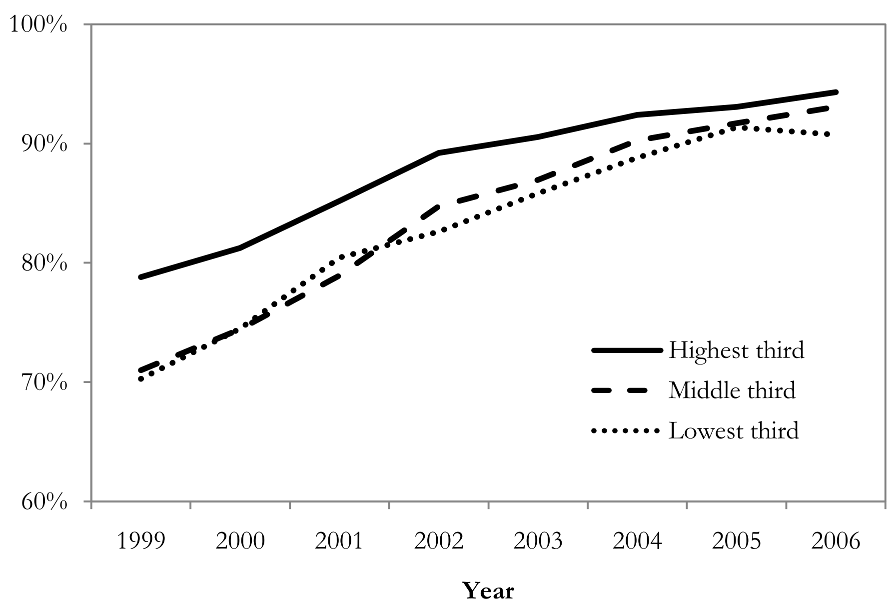


Figure 3(a): Trend in hospital primary C-section rates stratified by proportion of Medicaid patients

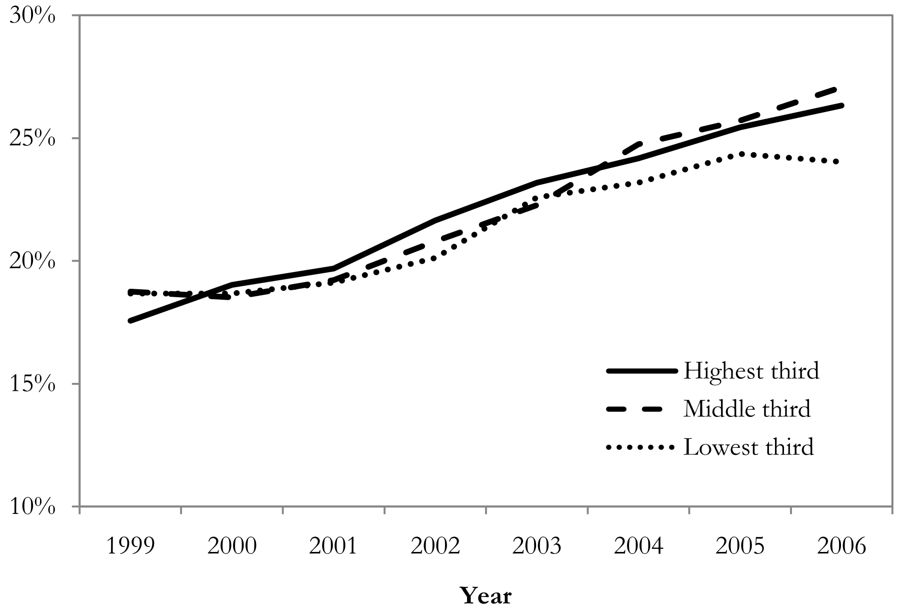


Figure 3(b): Trend in hospital repeat C-section rates stratified by proportion of Medicaid patients

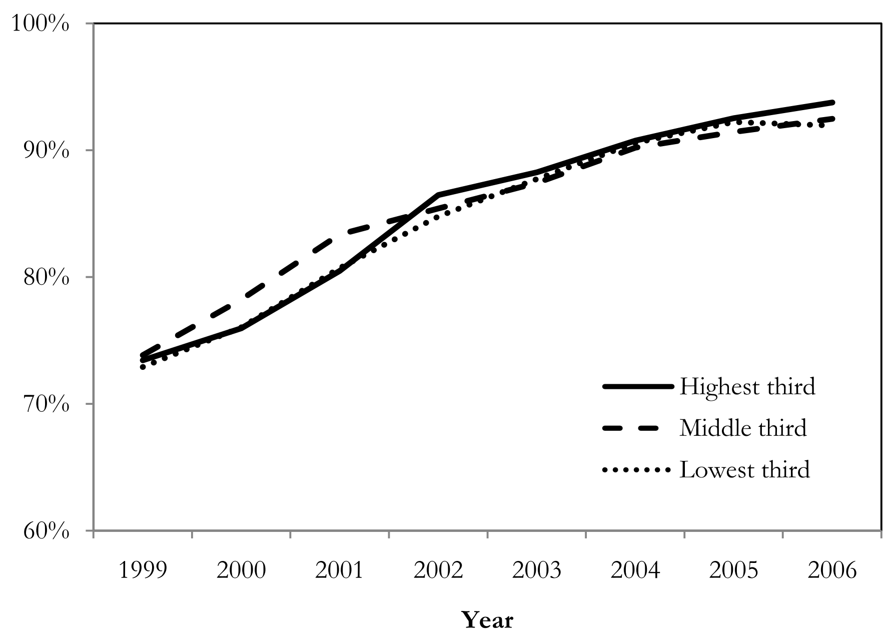


Figure 4(a): Trend in hospital primary C-section rates stratified by birth volume

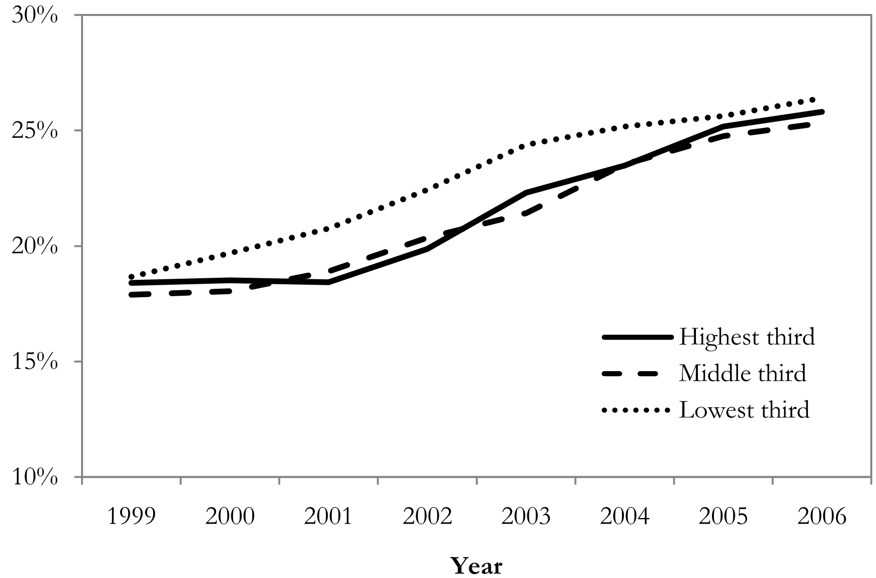


Figure 4(b): Trend in hospital repeat C-section rates stratified by birth volume

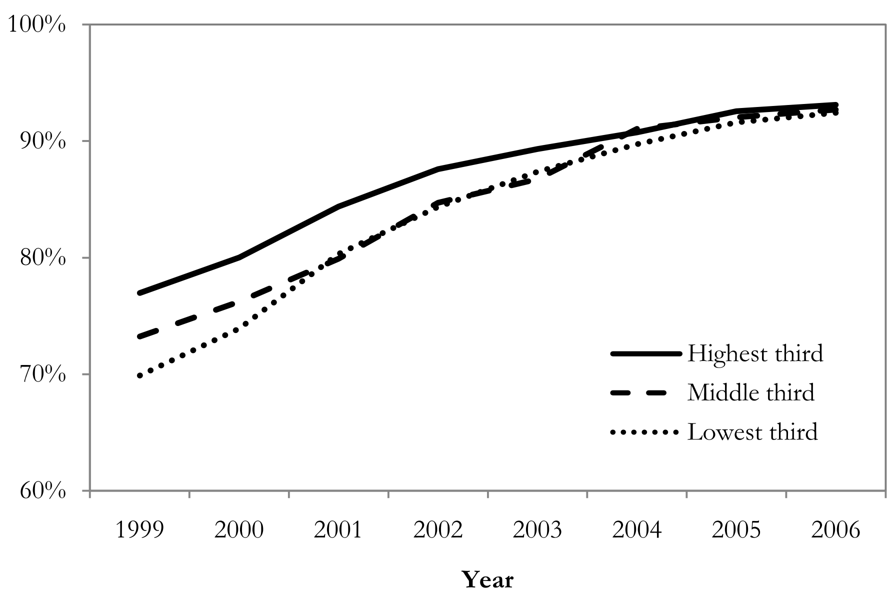


Figure 5(a): Trend in hospital primary C-section rates stratified by urban and rural location

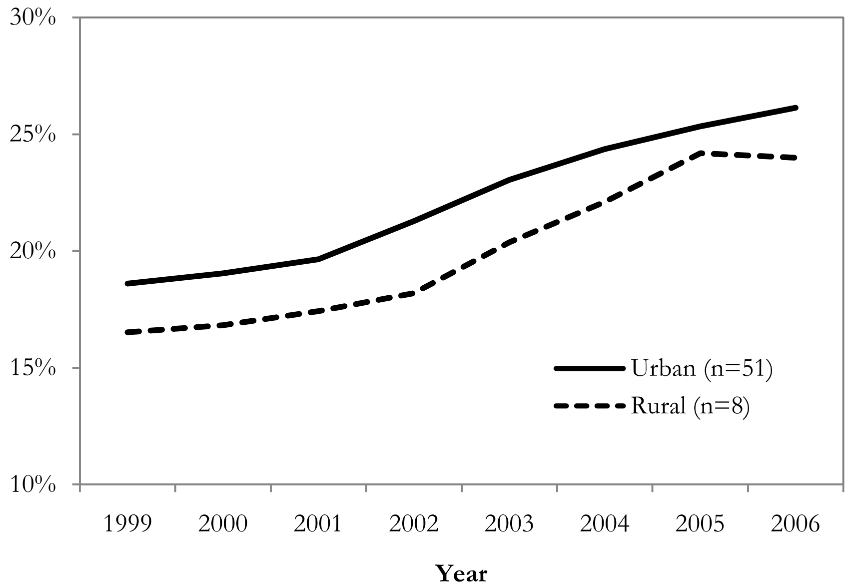


Figure 5(b): Trend in hospital repeat C-section rates stratified by urban and rural location

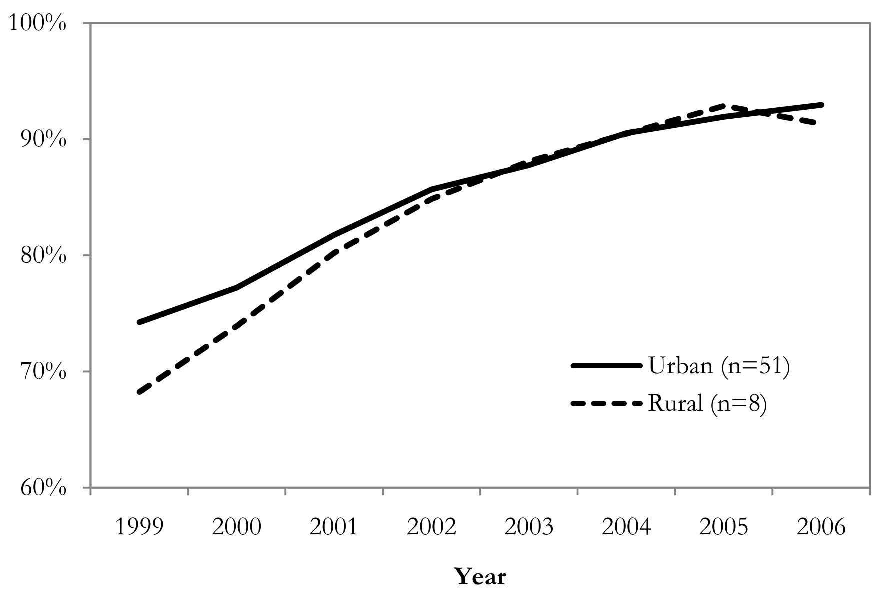


Figure 6(a): Trend in hospital primary Cesarean section rates stratified by proportion of patients age over 35

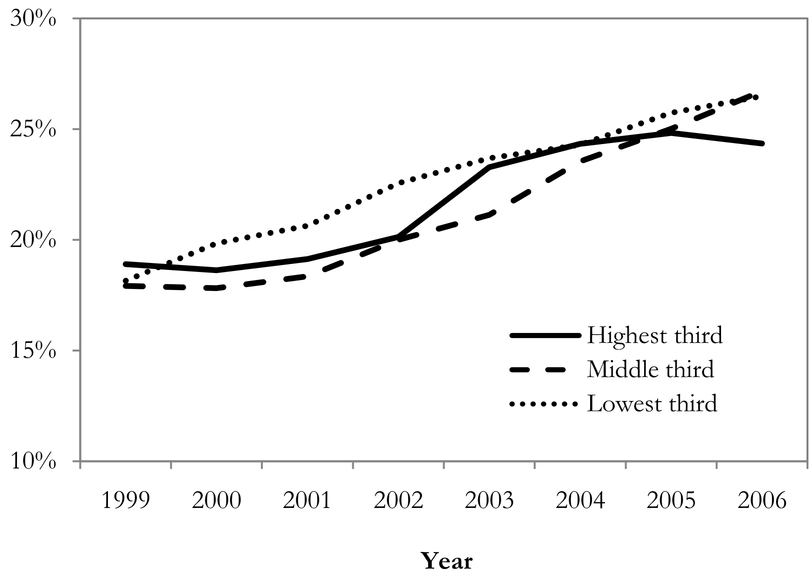


Figure 6(b): Trend in hospital repeat Cesarean section rates stratified by proportion of patients age over 35

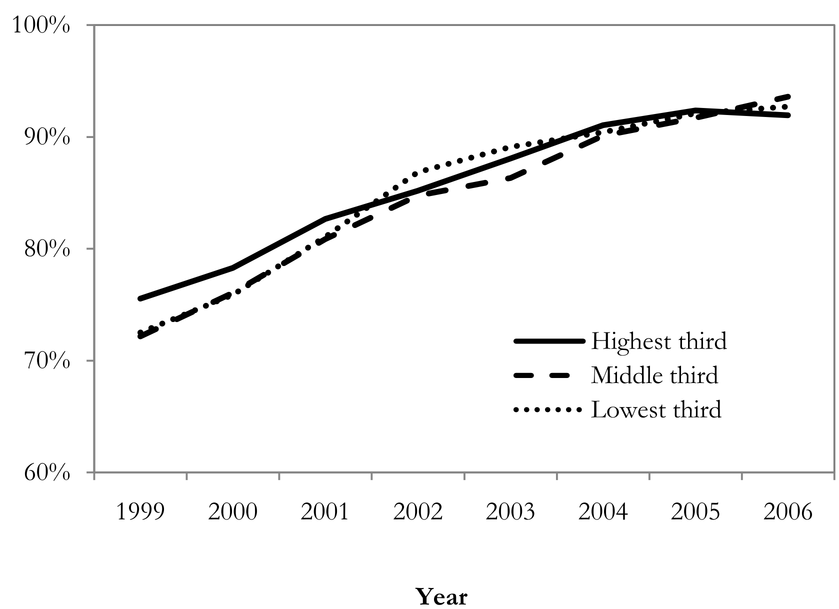


Figure 7(a): Trend in hospital primary Cesarean section rates stratified by proportion of white patients

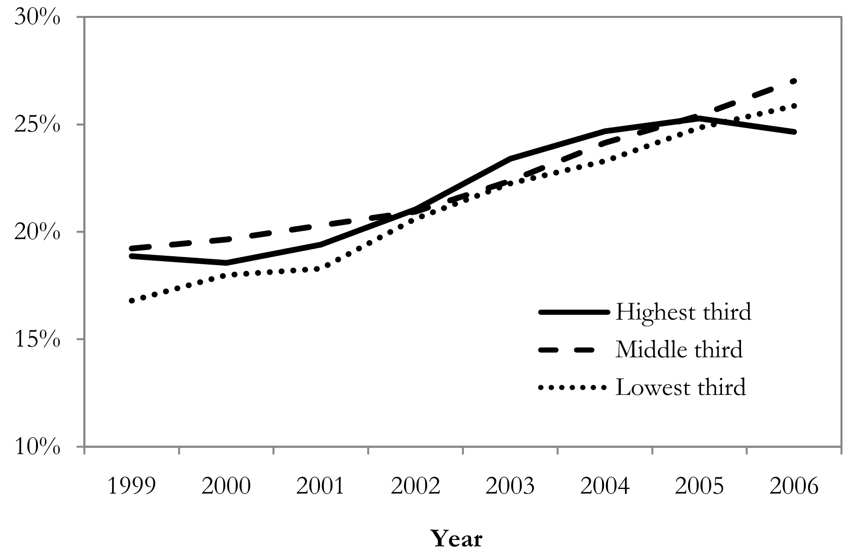
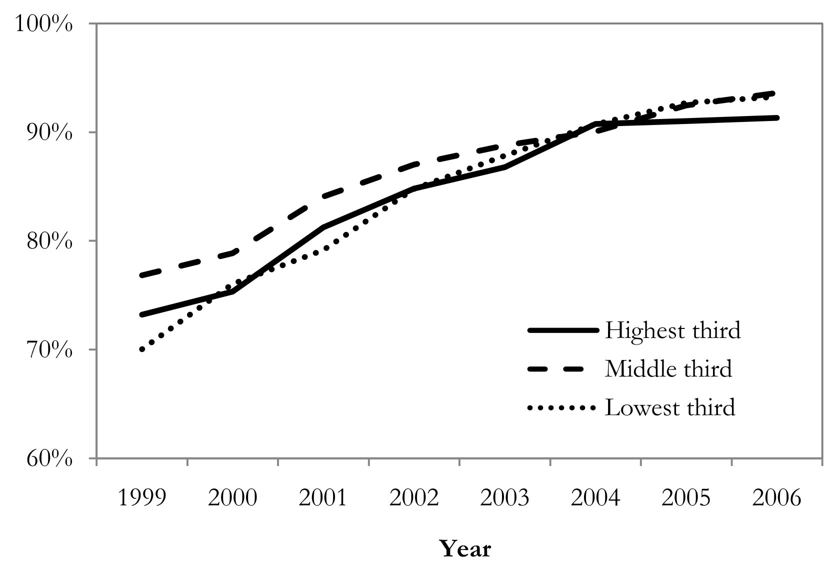


Figure 7(b): Trend in hospital repeat Cesarean section rates stratified by proportion of white patients



Appendix 1: High-risk clinical conditions and associated ICD-9 codes

Condition	**ICD-9-CM codes**
Unengaged head at term	652.5
Soft tissue disorder	654.0 654.1 654.4/654.7
Malpresentation	652.0 652.2/652.4 652.6/652.9
Oligohydramnios	658.0
Severe hypertension	642.5 642.6
Other hypertension	642.0/642.4 642.7/642.9
Antepartum bleeding	641
Liver disorders	646.7
Substance use	648.3
Mental illness	648.4
Polyhydramnios	657
Herpes	054 647.6
Kidney disorder	646.2
Thyroid disorder	644.81
Asthma	493
Heart disease	648.5 648.6
Isoimmune disease	656.1 656.2
Diabetes (includes gestational)	648.0 648.8
Macrosomia	656.6
Intrauterine growth restriction	656.5
Chromosome abnormality	655.0 655.1
Cerebral hemorrhage	431 432 433 434

Source: Gregory, et al. Vaginal birth after Cesarean: clinical risk factors associated with adverse outcome. Am J Obstet Gynecol 2008.