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Trends in Cesarean Deliveries in Illinois hospitals, 1994-2007

Illinois Department of Public Health, Office of Patient Safety and Quality

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Introduction

Cesarean Section (C-section) rate for deliveries in Illinois hospitals reached an all-time high of 30.4 percent in 2007, up from 19.3 percent in 1997. This represents a 58 percent increase in the C-section rate, which put Illinois slightly ahead of the national rate which grew by 51 percent during the same time period. The World Health Organization (WHO) recommends optimal C-section rates between 5 percent and 15 percent. Rates outside this range may do more harm than good (Althabe and Belizan, 2006). The National Priorities Partnership is seeking to reduce C-section rates *"while ensuring the delivery of appropriate care"* (National Priorities Partnership, 2008). Although C-section can be a life saving procedure, it must be recognized as major surgery that carries risks for both mothers and babies, risks that are not present in a vaginal birth.

This report presents information about trends in C-section rates in Illinois hospitals from 1994 to 2007. Dissemination of this analysis of practice patterns may serve as the impetus to better understand the risks and benefits of this procedure, to examine attitudes relating to childbirth, and to further evaluate obstetric practices**.**

Methods

(See Appendix 1 for Detailed Description of Methods)

Data from the Illinois Hospital Discharge dataset (IHD) for all delivery hospitalizations occurring from 1994 to 2007 were analyzed. IHD collects administrative inpatient data from all hospitals in Illinois. It includes up to nine International Classification of Diseases, 9th edition (ICD-9) diagnosis codes, up to six ICD-9 procedure codes, and other relevant patient and hospital information for each hospitalization. To identify delivery hospitalizations in IHD, the outcome of delivery code on the maternal discharge record, or the V27 code was used, as well as diagnosis-related group (DRG) codes for delivery and delivery-specific procedure ICD-9 codes, while excluding abortive and abnormal pregnancy outcome hospitalizations.

Potential indicators for C-section were identified using ICD-9 codes. The presence of any of the indications on the hospital discharge record resulted in the classification of the delivery as having "any indicated risk" (AIR). Delivery hospitalization records not containing any of the indication codes were classified as having "no indicated risk" (NIR). C-section among NIR deliveries approximates a "medically elective" procedure.

To facilitate comparisons between types of hospitals, hospitals were assigned to one of four categories based on perinatal center status, teaching status, locale and bed size. Table 1 describes the classification criteria and shows the distribution of deliveries by hospital group.

Table 1. Characteristics of Illinois delivery hospitals

	Perinatal Center or Teaching Hospital	Location	Number of Beds	# deliveries	% Illinois deliveries
Group 1	Yes	Large Urban or Other Urban	>300	662,145	27
Group 2	No	Large Urban or Other Urban	>300	796,086	33
Group 3	No	Large Urban or Other Urban	≤300	772,065	32
Group 4	No	Rural	any	202,940	8

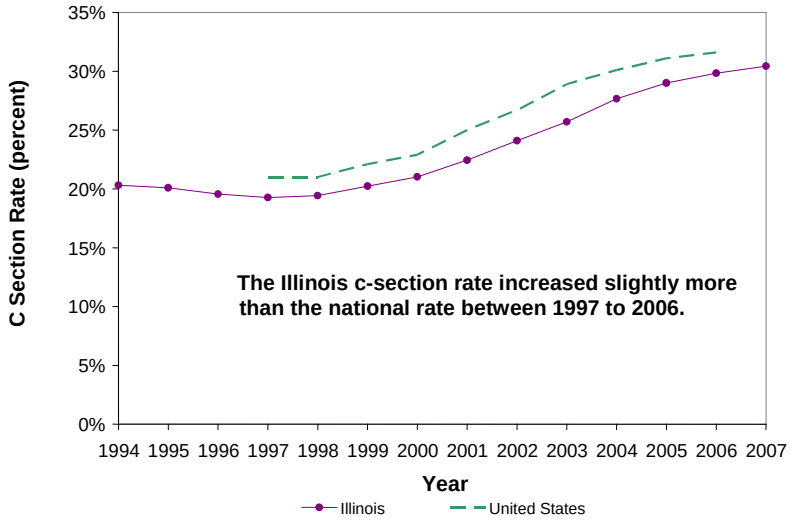
The unit of analysis was a delivery hospitalization, not an individual. SAS v.9.1.3 (SAS Institute, Cary, NC) was used to manage the IHD dataset and calculate C-section rates by dividing the number of C-section deliveries by the total number of deliveries. SAS was also used to tabulate total numbers of deliveries and C-sections by year, maternal age, hospital characteristics, and maternal risk status.

To identify changes in C-section rate over time, software provided by the National Cancer Institute, Statistical Research Applications Branch, was employed to carry out joinpoint analysis (srab.cancer.gov/joinpoint). The purpose of joinpoint analysis is to locate possible points in time when a significant change occurred in the C-section rate. A detailed description of the joinpoint analysis can be found in Appendix 1.

Results

Between 1997 and 2007, the C-section rate in Illinois increased from 19.3percent to 30.4 percent, a relative increase of 58 percent (Figure 1). While the actual C-section rate in Illinois is slightly lower than that reported for the United States, the relative increase, between 1997 and 2006, is greater than the 51 percent observed nationally (Russo).

Figure 1. Cesarean section rate among deliveries in hospitals, Illinois and the United States, 1994-2007.



In Illinois, the rates for both primary C-section (women with no prior C-sections) and repeat C-section (women with a prior C-section) reached a low in 1997 but have increased annually since that time (Figure 2). The primary C-section rate rose from 13.7 percent in 1997 to 20.4 percent in 2007, a relative increase of 49 percent. The repeat C-section rate rose from 60.3 percent in 1997 to 89.0 percent in 2007, a relative increase of 48 percent. The rate of vaginal birth after cesarean (VBAC) is inversely related to the repeat C-section rate such that the VBAC rate decreased from a high of 39.7 percent in 1997 to 11.0 percent in 2007.

Figure 2. Cesarean section rate among deliveries in Illinois hospitals, 1994-2007.

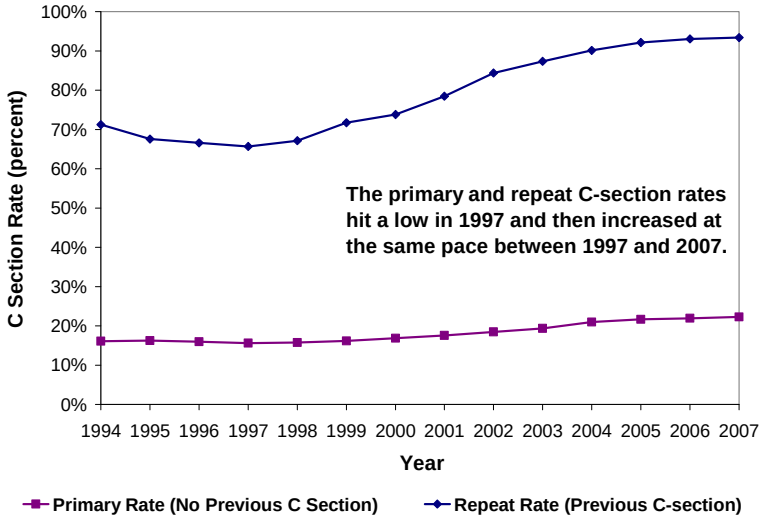


Table 2. Cesarean section rate and average annual percentage change (AAPC) among deliveries in Illinois hospitals, by hospital, maternal, and pregnancy characteristics.

	C-section Rate (percent)			AAPC	
	1994	2000	2007	2000 - 2007	
Overall Number of Deliveries	178,831	176,945	172,712		
Overall C-Section Rate	20.3	21.0	30.4	5.4	
History of Prior C-section					
No *(primary c-section rate)*	14.2	14.8	20.4	4.6	
Yes *(repeat c-section rate)*	65.2	67.0	89.0	4.2	
Hospital Group					
1: Perinatal Centers or Teaching*	18.9	21.4	30.4	5.1	
2: Large Urban	20.3	19.9	30.5	6.2	‡
3: Medium/Small Urban	20.4	20.0	28.5	5.3	
4: Rural	21.0	21.4	28.3	3.8	‡
Maternal Age					
<20 years old*	14.4	14.3	20.7	5.6	
20-34 years old	20.3	20.6	29.6	5.3	
35+ years old	27.4	28.9	41.2	5.1	
Payer for Delivery					
Private Insurance*	21.9	22.4	33.3	5.9	
Public Insurance	18.3	19.1	27.5	5.4	
Uninsured/Unknown	17.9	18.8	27.1	5.4	

Risk Conditions					
Single Gestation*	20.0	20.5	29.7	5.5	
Multiple Gestation	50.8	57.5	78.4	4.2	‡
No Diabetes*	19.8	20.4	29.4	5.4	
Gestation Diabetes	32.1	34.4	43.0	3.5	‡
Chronic Diabetes	45.7	49.2	62.1	3.0	‡
No Hypertension*	19.3	19.9	29.1	5.6	
Gestational Hypertension	37.1	35.1	43.8	3.6	‡
Chronic Hypertension	34.0	39.4	51.8	4.1	

* = reference group for comparison
‡ = difference statistically significant difference: $p < 0.05$

Table 2 shows the Illinois C-section rates in 1994, 2000 and 2007 and the average annual percentage change (AAPC) during 2000-2007, according to various maternal characteristics. Between 2000 and 2007, the AAPC in C-section rate was 4.6 percent for primary C-sections and 4.2 percent for repeat C-sections; the difference between these AAPCs was not statistically significant. This demonstrates that the increase in the rate of C-sections is occurring at the same pace for primary and repeat C-sections.

When the four groups in the hospital characteristic index were examined, perinatal center/teaching hospitals and large urban hospitals had slightly higher C-section rates (30.5 percent and 30.4 percent, respectively) than medium/small urban hospitals or rural hospitals (28.5 percent and 28.3percent, respectively). However, the AAPC between 2000-2007 varied by hospital type. Compared to perinatal centers/teaching hospitals, large urban hospitals had a higher AAPC and rural hospitals had a lower AAPC. Medium/small hospitals did not have an AAPC statistically different from the perinatal centers/teaching hospitals. This indicates that the C-section rate has increased the fastest among large urban hospitals and the slowest among rural hospitals in recent years.

C-section rates in Illinois are highest in older mothers (35+ years) and lowest in younger mothers (<20 years). In 2007, the C-section rate among older mothers (41.2 percent) was twice that of younger mothers (20.7 percent). From 2000 to 2007, however, the average annual percentage change (AAPC) was the same among all age groups of mothers, showing that the C-section rate has been increasing at approximately the same pace in women of all ages.

Illinois C-section rates are higher for deliveries paid for by private insurance than deliveries paid for by public insurance (Medicaid/Medicare) or no insurance. In 2007, the C-section rate was 33.3 percent among deliveries paid for by private insurance, 27.5 percent among paid for by public insurance, and 27.1 percent among deliveries not paid for by any insurance. From 2000 to 2007, there was no statistical difference in AAPC between deliveries in the three payer groups. Therefore, the C-section rate has been increasing at approximately the same pace in all deliveries, regardless of payer status.

C-section rates in Illinois are higher for multiple gestation deliveries than single gestation deliveries. In 2007, the C-section rate among multiple gestation deliveries (78.4 percent) was about 2.5 times higher than that for singleton deliveries (29.7 percent). From 2000 to 2007, the AAPC among single gestation deliveries was 5.5 percent and the AAPC among multiple gestation deliveries was 4.2 percent. The AAPC difference was statistically significant, indicating that the C-section rate rose faster among singleton deliveries than multiple gestation deliveries during this time period.

C-section rates in Illinois are higher among women who are diagnosed with diabetes than those without a diabetes diagnosis. In 2007, the C-section rate among women with chronic diabetes (62.1 percent) was more than two times higher than the C-section rate among women without diabetes (29.4 percent). In the same year, the C-section rate among women with gestational diabetes (42.0 percent) was about 1.5 times higher than that for women with no diabetes. Despite having the lowest C-section rate, the C-section rate rose at the fastest pace among women without a diabetes diagnosis. In this group of women, the AAPC was 5.5

percent, which was significantly different from the AAPCs for C-section rate among women with either gestational (3.5 percent) or chronic diabetes (3.0 percent).

Illinois C-section rates are higher among women who are diagnosed with hypertension than those without a hypertension diagnosis. In 2007, the C-section rate among women with chronic hypertension (51.8 percent) was more than 1.7 times higher than the C-section rate among women with no hypertension diagnosis (29.1 percent). In the same year, the C-section rate among women with gestational hypertension (43.8 percent) was about 1.5 times higher than that for women with no hypertension. Despite having the lowest C-section rate, the C-section rate rose at the fastest pace among women with no hypertension diagnosis. In this group of women, the AAPC was 5.6 percent, which was significantly different from the C-Section rate AAPCs for women with gestational hypertension (3.6 percent), but not different from the C-section rate AAPC among women with chronic hypertension (4.2 percent).

It is interesting to note that, for plurality, diabetes and hypertension, the C-section rate increased at the fastest pace among women *without* the higher risk conditions. To further explore the hypothesis that the C-section rate is increasing the fastest among deliveries to "low risk" women, annual C-section rates among women with "no indicated risk (NIR)" for C-section (having none of the codes listed in Table 1) were examined. C-section among NIR women approximates a "medically elective" procedure.

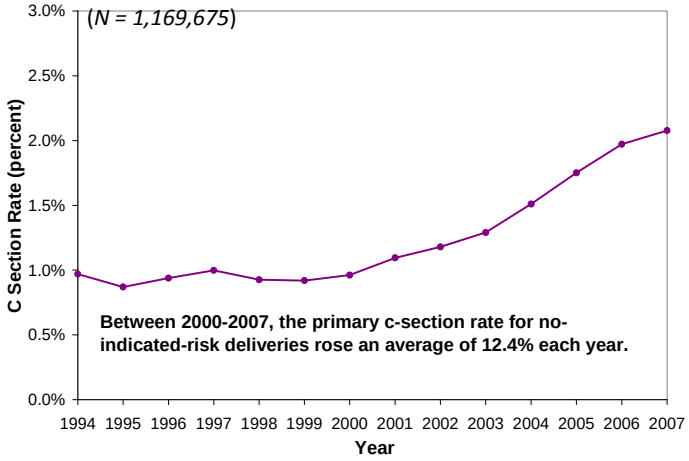
During 1994-2007, there were 2,094,047 singleton deliveries to women with no history of C-section. Of these deliveries, 1,169,675 (55.1 percent) were classified as NIR, though the proportion of singleton deliveries that were NIR decreased over time, from 61.7 percent in 1994 to 49.9 percent in 2007.

Figure 4a illustrates the annual C-section rate for NIR deliveries between 1994 and 2007. The C-section rate remained relatively stable between 1994 and 2000 at approximately 1.0 percent, whereupon it began increasing steadily to a rate of 2.1 percent in 2007. The average annual increase between 2000 and 2007 was 12.4 percent.

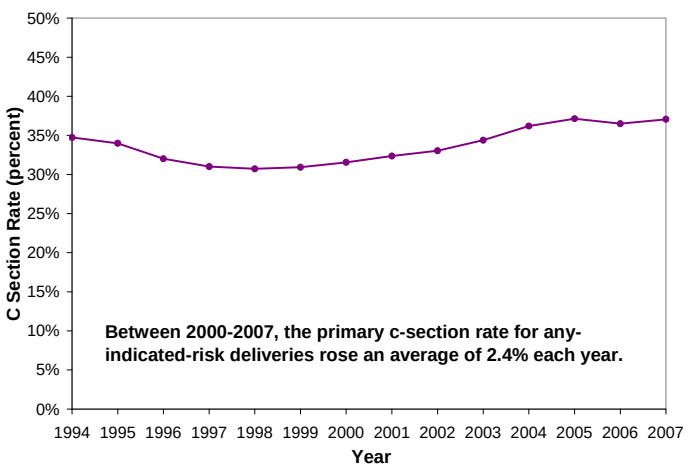
Figure 4b shows the annual C-section rate for AIR deliveries between 1994 and 2007. The C-section rate decreased between 1994 and 1997 and then remained level until 2000, when it began a gradual increase until 2005. In 2007, 37.1 percent of AIR deliveries were C-section. The C-section rate increased an average of 2.4 percent between 2000-2007. While the AAPC for AIR deliveries is statistically lower than that of NIR deliveries, it should be noted that the absolute C-section rate among AIR deliveries is much higher, resulting in lower relative increases despite higher absolute increases.

Figure 4. Primary C-section delivery rate among singleton deliveries in Illinois hospitals, by presence of any indications for C-section, 1994-2007.

a) Among no-indicated-risk deliveries



b) Among any-indicated-risk deliveries



The primary C-section rate for AIR deliveries was higher than that of NIR deliveries for any given sub-group. However, the AAPC for AIR deliveries was lower than that of NIR deliveries for every sub-group. As mentioned before, this should be interpreted with caution because the higher absolute C-section rates among AIR deliveries results in a lower relative increase despite sometimes higher absolute increases. The primary C-section rate increased among all sub-groups of deliveries examined, with the exception of those with any-indicated-risk in rural hospitals. The AAPC for this group of deliveries was -0.6 percent, a statistically significant decrease between 2000-2007.

When comparing different hospital groups, a change occurred over time in the types of hospitals with the highest primary C-section rate for NIR deliveries. In 1994, rural hospitals had the highest NIR c-section rate at 1.4 percent (compared to 0.9 percent, 1.0 percent, and 0.8 percent among perinatal centers/teaching, large urban, and medium/small urban hospitals, respectively). But, by 2007, this had shifted so that perinatal center/teaching hospitals had the highest primary C-section rate for NIR deliveries. Since 2000, the primary C-section rate for NIR deliveries annually increased an average of 7.5 percent in rural hospitals, 11.8 percent in small/medium urban hospitals, 13.6 percent in large urban hospitals, and 8.7 percent in perinatal centers/teaching hospitals. The AAPC differences between these groups were not statistically significant, though that of medium/small urban hospitals neared a statistical difference from perinatal center/teaching hospitals (p= 0.07). This suggests that the primary C-section rate for NIR deliveries in medium/small urban hospitals may be rising faster than in perinatal centers/teaching hospitals, but that rural and large urban hospitals have had a rate of increase similar to that of the perinatal center/teaching hospitals.

Table 3. Primary Cesarean section rate and average annual percentage change (AAPC) rate among singleton deliveries in Illinois hospitals, by risk status and delivery characteristics.

	No Indicated Risk (NIR)					Any Indicated Risk (AIR)				
	Primary C-section Rate (%)			AAPC 2000 - 2007		Primary C-section Rate (%)			AAPC 2000 - 2007	
	1994	2000	2007			1994	2000	2007		
Overall	1.0	1.0	2.1	12.4		34.7	31.6	37.1	2.4	
Hospital Characteristics										
1: Perinatal Centers or Teaching*	0.9	1.2	2.3	8.7		29.2	30.0	36.1	2.9	
2: Large Urban	1.0	0.8	2.1	13.6		36.1	30.3	37.9	3.2	
3: Medium/Small Urban	0.8	0.9	1.9	11.8	†	37.6	32.6	36.6	1.6	†
4: Rural	1.4	1.2	2.0	7.5		43.2	40.0	39.1	-0.6	‡
Maternal Age										
<20 years old*	0.9	0.8	1.3	8.4		33.9	30.4	35.4	2.3	
20-34 years old	0.9	0.9	2.0	12.0	†	34.6	31.3	36.3	2.0	
35+ years old	1.3	1.4	3.3	13.9	‡	36.5	33.6	42.0	3.1	
Payer for Delivery										
Private Insurance*	1.1	1.1	2.6	13.4		35.6	32.0	39.4	3.1	
Public Insurance	0.9	0.8	1.6	10.4	†	33.4	30.7	34.5	1.7	
Uninsured/Unknown	0.8	0.8	1.9	14.5		34.1	31.4	33.0	2.2	

* = reference group for comparison
‡ = difference statistically significant: p < 0.05
† = difference neared significance: p <0.10

Among AIR deliveries, the trend in primary C-section rate varied by hospital characteristics (Table 3). Primary C-sections for AIR deliveries increased over time for perinatal centers/teaching hospitals, exhibited a "U-shaped" curve for both the large and medium/small urban hospitals, and decreased steadily in rural hospitals. Since 2000, the C-section rate annually decreased an average of 0.6 percent in rural hospitals, while annually increasing an average of 1.6 percent in small/medium urban hospitals, 3.2 percent in large urban hospitals, and 2.9 percent in perinatal centers or teaching hospitals. The AAPC of rural hospitals was statistically different from perinatal center/teaching hospitals, and the difference in AAPCs between small/medium urban hospitals and perinatal center/teaching hospitals neared significance. There was not an AAPC difference between perinatal center/teaching hospitals and large urban hospitals. This indicates that the C-section rate for AIR women is rising the fastest within perinatal centers/teaching hospitals and large urban hospitals.

Among NIR deliveries, the primary C-section rate AAPC varied by maternal age (Table 4). Between 2000 and 2007, the AAPC for women younger than 20 years old was 8.4 percent, compared to 12.0 percent among women ages 20-34 ($p<0.10$) and 13.9 percent among women 35 or older ($p<0.05$). This indicates that the primary C-section rate among NIR deliveries is going up the fastest for older mothers and the slowest for younger mothers. The AAPC in C-section rate did not vary by maternal age among AIR deliveries.

Among NIR deliveries, the primary C-section rate AAPC varied by payer for delivery (Table 4). The AAPC for deliveries paid for by private insurance was 13.4 percent, compared to 10.4 percent for deliveries paid for by public insurance (Medicaid or Medicare). While this difference was not statistically significant ($p = 0.10$), it does seem to hint at differences in how C-section is provided based on insurance status. The rise in primary C-section rate may be higher among deliveries to privately insured women than publicly insured women. The rate of change in C-section among women who were uninsured or of unknown insurance status did not differ from that of privately insured women. The AAPC in C-section rate among AIR deliveries, however, did not vary by payer for delivery.

Discussion

Overall, C-section rates in Illinois have been rising since the late 1990s. Between 1997 and 2007, the C-section rate increased from 19.3 percent to 30.4 percent. The increase has occurred for both primary and repeat C-sections. This trend in increased C-section rates has been reported nationally (Macdorman et al, 2008; Russo et al, 2009) and regionally (Denk et al, 2006). As the repeat C-section rate steadily increased between 1997 and 2007, the rate for vaginal births after C-section (VBAC) decreased, which also mirrors national and regional findings.

C-section rates were compared according to hospital and to maternal and pregnancy characteristics, such as maternal age, plurality, history of prior C-section, payer, and maternal medical conditions. In each sub-category of these indicators, the C-section rates increased over time. Joinpoint analysis revealed that C-section rates for low-risk groups have increased faster than for high-risk groups. This trend has been reported by others (Declercq et al, 2005; Denke et al, 2006; MacDorman et al, 2008; Burke et al, 2006).

To further investigate the trends in C-section delivery among low-risk groups, a classification of "no indicated risk cesarean delivery", developed by Kahn et al (2009) was utilized. The primary C-section rate among NIR deliveries in Illinois ranged from 0.9-2.1 percent, and the rates for 1994 to 2001 were similar to the rate reported by Kahn et al (2009). The AAPC in C-section rate for NIR deliveries varied by maternal age, such that the annual rate increased at a significantly greater pace in older women ($\geq$35 years) compared to their younger counterparts. The AAPC in C-section deliveries was not significantly different when compared by either hospital characteristics or payer status, indicating that this trend was driven by other factors.

The rise in C-section rate in recent years in Illinois should be of concern for public health and clinical practitioners. A C-section is a surgical procedure, that carries inherent risks of complications; these risks need to be weighed against the potential benefit to the mother and infant. The Illinois Department of Public Health recently attended a meeting with Chicago-based obstetricians and delivery room nurses to review the Illinois C-section trends and to discuss factors potentially related to the trend. Several interconnected factors were put forth that may explain the rising rates:

- Side effects of common labor interventions, such as electronic fetal monitoring
- Changes in medical education and the training of residents
- Changes in nursing practice (e.g., increased patient load and dependence on technology)
- Physician and patient attitudes about acceptable levels of risk
- Defensive medicine due to providers' fear of malpractice lawsuits

A review of the literature agreed with the sentiments raised by the health care providers. A wide spectrum of obstetric and non-obstetric issues influencing C-section trends have been extensively enumerated and discussed in the medical and sociological literature (National Institutes of Health state-of-the-science conference statement: cesarean delivery on maternal request March 27-29, 2006. (2006); Gamble et al, 2007; Kahn et al, 2009; Kuklina et al, 2009; Deneux-Tharaux et al, 2006; Lu et al, 2005; Wax, 2006; Klein et al, 2005; Murthy et al, 2007) One factor shown in the literature not mentioned by the physician and nurse group is more prevalent maternal morbidity.

Other factors that may be driving the trend are listed below. These factors have not been discussed in the literature, but may be areas for further exploration with providers and patients.

- Low priority of enhancing women's own abilities to give birth
- Casual attitudes about surgery, and particularly C-sections
- Limited awareness of harms that are more likely with C-sections
- Incentives to practice in a manner that is efficient for providers

Methodological Issues

This study relied on hospital discharge data, which is not without its limitations. While birth records have been more commonly used to monitor population-based trends in delivery methods and indications (Denk et al, 2006; Macdorman et al, 2008; Russo et al, 2009), the use of discharge data has gained favor because of more extensive documentation of medical risk factors and complications of labor and delivery (Roohan et al, 2003; DiGuiseppe et al, 2002; Kahn et al, 2009). Ideally, studies capable of linking data from both sources would greatly enhance our ability to elucidate reasons for the increase in primary cesarean delivery, particularly those categorized as "no indicated risk." Adding a field to the birth certificate that indicates whether the C-section was planned in advance has been suggested as a way to improve interpretation of these rates (Denk et al, 2006).

An enhanced delivery identification method, based on additional indications of delivery in hospital discharge records as described by Kuklina et al(2008), was used. This enhanced method was employed to improve the accuracy of identifying deliveries, especially those with more severe complications. Kuklina et al (2008) identified 3.4 percent more deliveries using the enhanced method than the standard V27 method for birth years 1998-2004. The enhanced method increased the number of identified deliveries by 4.0 percent during the same years in the Illinois dataset. However, the enhanced method was especially important during 1994 to 1997 because more than 17 percent of deliveries during this time period would have been missed by relying on V27 codes alone. Over the entire time period, 186,950 (7.7 percent) of the 2,433,236 deliveries would have been missed if the enhanced method had not been used.

The classification of deliveries into "no indicated risk" and "any indicated risk" using discharge diagnoses codes may be subject to shifts in coding practices, reflecting what Leitch and Walker (1998) refer to as "a lowering in the overall threshold concerning the decision to carry out a caesarean section." We reported that the proportion of singleton deliveries classified as NIR decreased over time, from 61.7 percent in 1994 to

49.9 percent in 2007. Whether there was a true increase in the prevalence of clinical indicators that would, in turn, result in the reclassification of a delivery into the "any indicated risk" group or this was the result of modifications in charting and/or assigning discharge codes is unclear. Linkage of discharge data with birth records might enable more thorough examination of these issues as would routine validation of delivery hospitalization records.

A unique feature of the current analysis is the use of joinpoint analysis. The advantage of using this analysis is that it can examine non-linear trends, such changes in trend direction or the slope of trends.

Impact of No Indicated Risk C-sections

The year 2000 was the beginning of the significant increase in primary C-section rate among deliveries with no indicated risk. From 2001-2007, 8,277 primary NIR C-sections were completed in Illinois hospitals. If the primary C-section rate had remained at the 2000 level, 3,094 (37.4 percent) of the C-sections during those seven years would have been prevented. During that time period, primary C-section NIR deliveries averaged a hospital length of stay 1.61 days longer than vaginal NIR deliveries. As well, the primary C-section NIR deliveries averaged about $7,000 more in hospital charges than NIR deliveries during 2001-2007. If the "preventable" 3,094 primary NIR C-sections during 2001-2007 had been delivered vaginally, approximately $21 million would have been saved in hospital fees over that time period.

Conclusion

Further study is needed to determine how we can begin to lower C-section rates down to the CDC Healthy People 2010 rate of 15 percent for low risk pregnant woman giving birth for the first time (U.S. Department of Health and Human Services, 2000). Cesarean is a major surgery that carries risks for both mothers and babies, risks that are not present in a vaginal birth. It is critical, that health care providers carefully examine the clinical validity of performing C-sections for all pregnant women.

While medical risk of Caesarean sections is well documented, further research is needed on the economic implications of the rising C-section rate for hospitals, providers, insurers and patients. In the interest of patient safety and quality and coming health care reform, the Illinois Department of Public Health is calling for more research to reduce Caesarean sections.

Appendix 1: Detailed Description of Methodology

Data Source

The Illinois Department of Public Health collects inpatient data from all hospitals in the state. These data then are entered in the Illinois Hospital Discharge (IHD) dataset. For this analysis, data pertaining to all delivery hospitalizations occurring between 1994 and 2007 were examined. These included up to nine International Classification of Diseases, 9th edition (ICD-9) diagnosis codes, up to six ICD-9 procedure codes, and other relevant patient and hospital information for each hospitalization. During this study period race/ethnicity information was not collected so the variation in C-section rate by race could not be assessed. IHD began to collect race/ethnicity information, as well as up to 25 ICD-9 diagnosis and procedure codes, in 2008.

Identification of Delivery Hospitalizations and Cesarean Section Deliveries

To identify delivery hospitalizations in IHD, an enhanced methodology developed by Kuklina, et al (2008) was used. The traditional method of identifying deliveries in hospital discharge datasets uses the outcome of delivery code on the maternal discharge record, or the V27 code. The enhanced method supplements this code with diagnosis-related group (DRG) codes for delivery and delivery-specific procedure ICD-9 codes, while excluding abortive and abnormal pregnancy outcome hospitalizations. The enhanced method has been shown to improve the identification of delivery hospitalizations, particularly for women who experienced severe morbidity (Kuklina et al, 2008). Using this method, 2,433,236 hospitalizations were identified as delivery hospitalizations during 1994-2007.

C-section deliveries were identified through the use of a combination of DRG and ICD-9 procedure codes. Because there were changes to the DRG coding system that went into effect on October 1, 2007, different DRG codes were used for C-section before and after that time. Original DRG codes for C-section were 370 and 371, but they changed to 765 and 766 on October 1, 2007. The procedure codes for C-section (74.0, 74.1, 74.2, 74.4, 74.99) did not change during the time period. Deliveries were considered to be C-section if either type of code was present. During 1994-2007, 571,401 (23.5 percent) deliveries were via C-section.

Indications for C-section

A list of potential indications for C-section and their corresponding ICD-9 codes was developed by Kahn, et al in 2009. "Risk definition 2" from that paper was used to identify delivery hospitalizations with any recorded indication for C-section. Table A1 shows the conditions and ICD-9 codes used to identify potential indications for C-section. The presence of any of the indications on the hospital discharge record resulted in the classification of the delivery as having "any indicated risk" (AIR). Delivery hospitalization records not containing any of the indication codes were classified as having "no indicated risk" (NIR). C-section among NIR deliveries approximates a "medically elective" procedure.

This part of the analysis focused on the prevalence of primary C-section among singleton deliveries. Because multiple gestation deliveries are generally considered "higher risk" and therefore an indication for C-section, this analysis did not examine the risk factors among multiple gestation deliveries. As well, the analysis of indicators for C-section excluded women with a history of the procedure because the factors that influence a decision for a repeat C-section may be different from those that influence a decision for a primary C-section.

Table A1. Classification of potential indications for Cesarean section

Condition or complication	ICD-9 Codes
Abnormalities of organs and soft tissues of pelvis	654-654.19, 654.4-654.79
Anesthesia complications	668-668.93
Cephalopelvic disproportion	653-653.63, 660.1-660.13
Cord prolapse	663.0-663.03
Diabetes (chronic)	250-250.9, 648.00-648.03
Diabetes (gestational)	648.80-648.83
Dysfunctional labor	661-661.23
Eclampsia	642.6-642.69
Fetal abnormality (known or suspected) affecting management of the mother	655.X
Fetal distress	656.3-656.33, 659.7-659.73
Genital herpes	054.1-054.19, 647.6-647.69
Heart problems	393-398.99, 410-414.99, 420-429.99, 648.5-648.63
Hemoglobinopathies	282.4-282.79
Hydramnios/oligohydramnios	657.0-658.13
Hypertension (chronic)	401-405.9, 642-642.24
Hypertension (gestational or pregnancy-associated)	642.3-642.59, 642.7-642.79, 642.9-642.93
Incompetent cervix	654.5-654.53
Infection of amniotic cavity	658.4X
Intrauterine growth restriction	656.5X
Lung disease	460-519.99
Macrosomia	656.61
Malpresentation	652-652.09, 652.2-652.49, 652.6-652.99
Meconium	656.8-656.83
Placental abruption	641.2-641.23
Placenta previa	641.0-641.13
Premature rupture of membranes	658.1-658.13
Prolonged labor	662.2-662.23
Prolonged rupture of membranes	658.2-658.33
Renal disease	580-586.99, 646.2-646.29, 592-592.99
Rh sensitization	656.1-656.13
Uterine Bleeding	641.3-641.33, 641.8-641.83, 641.9-641.93
Uterine scar (excluding scar from prior C-section)	654.9X

Hospital Characteristic Groups

To facilitate comparisons between types of hospitals, hospitals were classified into four categories based on perinatal center status, teaching status, locale, and bed size. If a hospital was a perinatal center or a teaching hospital, it was grouped into Group 1: "Perinatal Center or Teaching Hospital," regardless of other characteristics. Non-perinatal centers and non-teaching hospitals were separated as follows: Group 2: "Large Urban Hospitals," urban hospitals with a bed size of more than 300; Group 3: "Small/Medium Urban Hospitals," urban hospitals with a bed size of 300 or less; and Group 4: "Rural Hospitals," all rural hospitals regardless of bed size. Initially, we large rural and small/medium rural hospitals were separated, but, because their C-section rates were similar, the two categories were combined to increase sample size.

Statistical Analysis

The unit of analysis was a delivery hospitalization, not an individual. SAS v.9.1.3 (SAS Institute, Cary, NC) was used to manage the IHD dataset and to calculate C-section rates by dividing the number of C-section deliveries by the total number of deliveries. SAS also was used to tabulate total numbers of deliveries and C-sections by year, maternal age, hospital characteristics, and maternal risk status for use in the joinpoint analysis.

To identify changes in C-section rate over time, software provided by the National Cancer Institute, Statistical Research Applications Branch, was used to carry out joinpoint analysis (srab.cancer.gov/joinpoint). The purpose of joinpoint analysis is to locate possible points in time when a significant change occurred in the linear slope of the trend (on a log scale). "Joinpoints" are the best fitting points where the slope changed significantly. Joinpoint analysis begins with the simplest model (i.e., zero joinpoints, which is a straight line) and tests for improved model fit with the addition of up to three joinpoints via permutation tests. In the final model, each joinpoint represents a point in time when the linear trend significantly changed. The software then estimates the annual percentage change (APC) and 95 percent confidence intervals for each line segment by fitting a regression line to the natural logarithm of the rates using year as a regressor variable. For this study stratified joinpoint analysis were done to examine the effect of maternal and hospital characteristics on trend.

Joinpoint software also was used to estimate the average annual percentage change (AAPC) and 95 percent confidence interval for each final joinpoint model. The AAPC is a weighted average of all segment APCs over the entire time period. It takes into consideration both the duration of each segment and the magnitude of its slope. C-section AAPCs from 2000 to 2007 were examined in the final joinpoint models. This time period was selected because it represents recent changes in clinical practice, making it the most relevant for hospitals and providers.

In the most recent version of the joinpoint software (version 3.3), there is not a way to statistically test the difference between the AAPCs of two models, nor was there a way to directly output the standard error for AAPCs. Therefore, IHD analysts tested for a statistical difference in AAPCs by first back-calculating the standard error of each AAPC from the 95 percent confidence intervals using formula 1 and then hand-calculating z values by using formula 2 to determine whether there was a statistically significant difference.

Formula 1 $SE = (AAPC_{\text{Upper 95\% CI limit}} - AAPC) / 1.96$

Formula 2 $z = (AAPC_1 - AAPC_2) / \sqrt{[(SE_1)^2 + (SE_2)^2]}$

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