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ORIGINAL ARTICLE

Changes in delivery methods at specialty care hospitals in the United States between 2006 and 2010

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OBJECTIVE: Given the increasing rates of labor induction and cesarean delivery, and efforts to reduce early term births, we examined recent trends in methods and timing of delivery.
STUDY DESIGN: We identified delivery methods and medical indications for delivery from administrative hospital discharge data for 231 691 deliveries in 2006 and 213 710 deliveries in 2010 from 47 specialty care member hospitals of the National Perinatal Information Center/Quality Analytic Services. In a subset of 17 hospitals, we examined trends by gestational age.
RESULT: From 2006 to 2010, there was an 11% increase in labor induction and a 6% increase in cesarean delivery, largely due to repeat cesareans. There was a 4 per 100 reduction in early term births (37 to 38 weeks), mostly due to a decline in non-medically indicated interventional deliveries.
CONCLUSION: We report a shift in deliveries at 38 weeks, which we believe may be attributed to efforts to actively limit non-medically indicated early term deliveries.

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INTRODUCTION

Substantial changes in the use of obstetric interventions for delivery occurred from the early 1990s through 2006.[1] Forceps or vacuum delivery became less common, whereas rates of cesarean delivery and labor induction increased.[2–9] Other identified trends included increases in repeat cesarean delivery, cesarean delivery after labor induction and preterm birth.[5,7,10–12] Increased rates of delivery interventions before spontaneous onset of labor are believed to contribute to the observed shift to lower average gestational age at birth.[13–16] Because of the adverse newborn outcomes related to early birth, it is important to study recent trends in interventional delivery and gestational age at birth.[17]

Research revealing adverse consequences of late preterm and early term birth resulted in recommendations to limit non-medically indicated deliveries before 39 completed weeks of gestation.[16,17] Select hospitals reported successfully reducing deliveries before 39 weeks after implementing comprehensive quality improvement programs.[18–21] However, it is not clear how widely such guidelines are being adopted and whether there has been a broad impact that applies across institutions.

This study examined delivery methods in a sample of hospitals with specialty perinatal care services between 2006 and 2010. Our aims were to examine trends in obstetrical interventions for delivery and differences in interventions by gestational age. We hypothesized that between 2006 and 2010, the frequency of labor inductions and cesarean deliveries would increase, operative vaginal deliveries would decrease and there would be a reduction in early term deliveries. A systematically collected large data resource from the National Perinatal Information Center/Quality Analytic Services (NPIC/QAS) provides us with the opportunity to address these questions and detect current and subtle trends in obstetric care not available through other sources.

METHODS

The NPIC/QAS is a membership organization that includes hospitals throughout the United States offering specialty perinatal care. In 2010, 75 member hospitals were located in 25 states and represented all American Hospital Association geographic census divisions.[22] NPIC/QAS member hospitals provide demographic, clinical and financial discharge data submitted quarterly. A data validation report is created following each submission; the validation report is reviewed by hospital administration, and the clinical leaders for data quality before the hospital's data are added to the database.

First, we analyzed hospital discharge data from delivery hospitalizations in the NPIC/QAS database for 47 hospitals that were participating members in both 2006 and 2010, excluding 28 hospitals that were members in 2010 but not 2006. The 47 hospitals studied were from 23 states and the distribution by American Hospital Association census divisions was as follows: New England, 7; Mid-Atlantic, 6; South Atlantic, 15; East North Central, 5; East South Central, 3; West North Central, 1; West South Central, 3; Mountain, 1; and Pacific, 6. Maternal hospitalizations were linked to the corresponding infant hospitalization using medical record number.

Gestational age at birth by completed week was provided for a subset of deliveries and reviewed as part of the data validation process. First, a distribution of numeric gestational age by category, including missing and unknown values, was provided to the submitting hospital. Second, coded gestational age was examined in relation to coded birth weight and implausible values were flagged for review. Hospitals were asked to submit corrected data when appropriate.

We used hospital discharge International Classification of Diseases, 9th Revision (ICD-9) codes to identify labor inductions (73.01, 73.1 and 73.4), cesarean deliveries (All Patient-Refined Diagnosis-Related Group 540—Cesarean Delivery) and operative vaginal deliveries (72.XX) for discharges during the calendar years of 2006 and 2010. We used the Joint Commission list of 'conditions possibly justifying elective delivery before 39 weeks gestation',[23] and added the ICD-9 code for early spontaneous onset of delivery before 37 completed weeks of gestation (644.21) to define medically indicated deliveries. The 73 conditions included maternal

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hypertensive, cardiovascular or diabetic disorders, placenta problems, multiple gestation, fetal abnormalities, fetal distress, antepartum hemorrhage and premature rupture of membranes. The code for spontaneous onset of delivery before 37 weeks was added so that spontaneous labors requiring intervention to complete delivery were considered to have a reason for the intervention. Deliveries lacking diagnosis codes for any of these conditions were classified as non-medically indicated.

To study delivery methods by gestational age, we limited the initial sample to mothers linked to live births between 20 and 44 completed weeks of gestation for deliveries occurring at a subset of 17 hospitals that consistently reported gestational age in both 2006 and 2010 (Figure 1). Using this subset reduced the likelihood that changes in the reporting frequency of gestational age would influence the results. The 17 hospitals were from 13 states and represented seven of the nine census divisions. In 2010, valid numeric gestational age data were available for 59.2% of deliveries at all hospitals, but 96.2% of deliveries in the subset of 17 hospitals. Stillbirths were excluded because they were often lacking gestational age data—gestational age was only reported on the newborn record and a medical record is not required for stillbirths. We included deliveries resulting in multiple births provided that at least one newborn was live born. For multiple births, gestational age was extracted from the first newborn record linked to the mother's record.

Analysis

For overall changes in methods of delivery at all 47 hospitals, we calculated the differences in proportions with 95% confidence intervals between 2006 and 2010 for each delivery method. We used a 'fetuses-at-risk' approach[24,25] to examine methods of delivery according to gestational age for the subset of deliveries with reported gestational age, considering all pregnancies that continued to a given week of gestation in the denominator. For a given week of gestation, we determined the number of spontaneous deliveries, labor inductions, primary and repeat cesarean deliveries, and pregnancies that completed the week without delivery.

We calculated the gestational week-specific incidence for each delivery outcome, which is the probability of delivering during a given gestational week among those who did not yet deliver by the beginning of that week. Overall delivery method incidence during a given week was then calculated taking into account competing risks for the other delivery methods.[26] For example, the incidence of spontaneous delivery in week 38 was calculated by multiplying (1) the probability of experiencing a spontaneous delivery in week 38 among pregnancies that reached week 38 undelivered by (2) the probability of not delivering via any method in all prior weeks. We also focused on iatrogenic (labor induction or cesarean) deliveries in early term gestation (37 to 38 weeks) and examined the differences in non-medically indicated iatrogenic birth rates in 2006 compared with 2010.

Analyses were performed using IBM SPSS Statistics Version 20 (IBM Corporation, Chicago, IL, USA). This study was approved by the Women and Infants Hospital of Rhode Island Institutional Review Board Subcommittee for Expedited Review.

RESULTS

In 2008, the number of deliveries in 74 NPIC/QAS member hospitals ranged from 589 to 16 545, with a mean of 4435 deliveries per hospital. In comparison, the number of births in 3265 US hospitals offering obstetric services in 2008 ranged from 0 to 17 203, with a mean of 1302 births.[27] Almost 8% of births in the United States in 2008 occurred at NPIC/QAS member hospitals. In 2008, cesarean delivery and low birth weight incidences were slightly higher at NPIC/QAS hospitals (34.7% and 10.4%, respectively) compared with all US hospitals (32.3% and 8.2%, respectively).[28] Despite the size and uniqueness of the studied data set, the NPIC/QAS member hospitals are fairly comparable to all US hospitals on these two important metrics.

The mean (standard deviation) number of deliveries per hospital was 4930 (3869) in 2006 and 4547 (3500) in 2010. Hospitals experienced a 7.8% decrease in deliveries from 231 691 in 2006 to 2 13 710 in 2010 (Table 1). This is slightly more than the United States decrease of 6.2% during the same time period.[29]

Among all deliveries at the 47 studied hospitals, operative vaginal deliveries decreased 24% from 5.5 per 100 deliveries in 2006 to 4.2 per 100 deliveries in 2010 (Table 1). The proportions of deliveries involving cesarean delivery or labor induction increased during the study period. In 2010, 22 per 100 deliveries involved labor induction (11% increase) and 36 per 100 deliveries occurred via cesarean delivery (6% increase). Primary cesarean deliveries were more common than repeat cesarean deliveries; however, the proportion of deliveries via primary cesarean remained constant over time, whereas the proportion of deliveries via repeat cesarean increased. Sixteen per 100 deliveries were repeat cesareans in 2010 compared with 14 per 100 in 2006, a 14% increase. Nearly 24 of every 100 labor inductions culminated in a cesarean delivery in 2010, a 9% increase over 2006 (Table 1).

The largest changes in gestational age-specific deliveries between 2006 and 2010 were in weeks 38 and 39 (Figure 2). More than 35% of all deliveries in 2010 occurred at week 39 compared with about 31% in 2006. Incidences decreased for labor induction in week 38 (4.2 per 100 deliveries in 2006 to 3.1 per 100 deliveries in 2010), primary cesarean delivery in week 38 (2.9 per

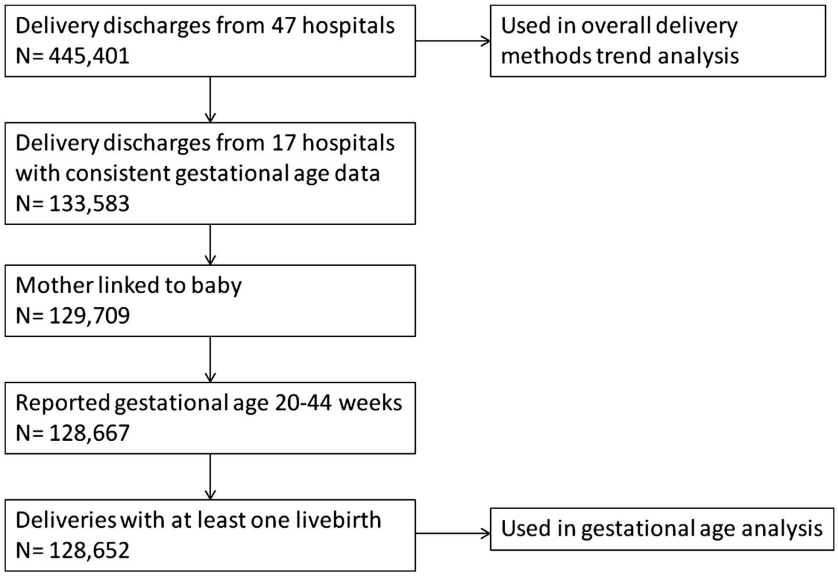

Figure 1. Flowchart of study population. Sample sizes used in overall delivery methods trend analysis and gestational age analysis.

Table 1. Changes in methods of delivery among deliveries at 47 hospitals, 2006 to 2010

	2006	*2010*	*Percent change (95% CI)*
Total deliveries	231 691	213 710	−7.8 (−7.7, −7.9)
Operative vaginal deliveries	12 795	9001	
Proportion of total deliveries	0.055	0.042	−23.7 (−21.5, −26.0)
Cesarean deliveries	79 286	77 486	
Proportion of total deliveries	0.342	0.363	+6.0 (+5.1, +6.8)
Primary cesarean	47 380	43 933	
Proportion of total deliveries	0.204	0.206	+0.5 (−0.6, +1.7)
Repeat cesarean	31 906	33 553	
Proportion of total deliveries	0.138	0.157	+14.0 (+12.5, +15.5)
Induction of labor	46 354	47 522	
Proportion of total deliveries	0.200	0.222	+11.1 (+9.9, +12.3)
Resulting in cesarean	10 035	11 258	
Proportion of labor inductions	0.216	0.237	+9.4 (+7.0, +11.9)
Primary cesarean	9772 (97.4%)	10 970 (97.4%)	
Repeat cesarean	263 (2.6%)	288 (2.6%)	

Abbreviation: CI, confidence interval.

100 to 2.2 per 100) and repeat cesarean delivery in week 38 (4.4 per 100 to 3.0 per 100) (Table 2). In week 39, incidence of labor induction increased (7.5 per 100 deliveries in 2006 to 8.8 per 100 deliveries in 2010), incidence of primary cesarean delivery increased slightly (3.9 per 100 to 4.3 per 100) and incidence of repeat cesarean delivery increased (5.2 per 100 to 8.2 per 100), suggesting postponement of iatrogenic deliveries from the previous week of pregnancy. Spontaneous deliveries remained relatively constant over time at weeks 38 and 39. The cumulative incidences of deliveries by 39 weeks reflected increases in repeat cesarean delivery, but little difference in other delivery methods between 2006 and 2010. Reductions in early term births were largely limited to week 38, as there were few changes in delivery incidence and methods over time at week 37.

In 2006, 66.9% of pregnancies that completed 37 weeks continued to the 39th completed week or beyond, and this increased to 70.9% in 2010 (Table 3). In 2006, 8.0% of pregnancies that reached 37 completed weeks of gestation experienced a non-indicated iatrogenic early term delivery at 37 to 38 weeks compared with 4.8% in 2010. Early term indicated iatrogenic deliveries remained relatively unchanged during this time period.

DISCUSSION

Our analysis of NPIC/QAS member hospitals identified continuing trends for decreasing rates of operative vaginal deliveries and increasing rates of cesarean delivery and labor induction. In addition, between 2006 and 2010 we detected a shift of deliveries from 38 to 39 weeks. This study provides some of the most current analyses of delivery method data, and it is one of the first studies to examine delivery methods by gestational age after the implementation of guidelines to reduce unnecessary early term deliveries.

Our findings that non-medically indicated iatrogenic deliveries decreased between 2006 and 2010, whereas medically indicated iatrogenic deliveries remained relatively constant, suggest successful efforts to limit unnecessary early term births at specialty perinatal care hospitals, beyond individual hospital initiatives that have been noted in the literature.[18–21] The observed incidences of non-medically indicated early term delivery (8.0% in 2006 and 4.8% in 2010) are similar to estimates found at other hospitals. In a study of 27 hospitals, Clark *et al.*[20] found an early term elective delivery rate of 9.6% in 2007 and 4.3% in 2009 after strategies were implemented to reduce such births. We did not see evidence of increased coding of indications to justify iatrogenic delivery as the percent of eligible deliveries that had an indicated early term delivery was similar in 2006 and 2010 (10.2% vs 9.9%).

Based on our findings, the incidence of iatrogenic delivery continues to increase. Labor inductions increased by >11% in 4 years. The incidence of primary cesarean delivery remained relatively constant between 2006 and 2010, but increases in repeat cesarean delivery drove the overall increase in cesarean incidence. Our observed trends are similar in direction and absolute magnitude to documented increases in the incidences of cesarean delivery (primary and repeat), labor induction and cesarean delivery after labor induction from US Nationwide Inpatient Sample data between 2006 and 2009.[9] Labor inductions appear to increase the risk for cesarean delivery compared with spontaneous labor.[12,30,31] More concerning, we show a significant increase in the proportion of labor inductions that ended in cesarean delivery in 2010 compared with 2006.

We restricted the analysis to hospitals that were NPIC/QAS members in both 2006 and 2010 with the aim of isolating clinical practice changes over time among the same hospitals. However, we acknowledge the potential for changes in the patient base that may influence the results. Maternal diabetic and hypertensive disorders are two of the most common complications of pregnancy, and rates of these disorders may be increasing over time because of increases in maternal age and obesity.[32] Therefore, we performed a sensitivity analysis to account for trends in maternal diabetic and hypertensive disorders between 2006 and 2010. Despite a small increase in gestational diabetes and hypertensive disorders, standardization of week-specific delivery incidences to adjust for the presence of a diabetic or hypertensive disorder resulted in risk ratios for delivery in 2010 compared with 2006 that were equal to or slightly further from the null than the unadjusted risk ratios. This confirmed that the observed differences in delivery incidence by gestational age between 2006 and 2010 could not be accounted for by a change in diabetic or hypertensive disorder prevalence.

Strengths of this study include use of a large sample of deliveries from geographically diverse hospitals, operated independently from each other, at two time points. The availability of week-specific gestational age data enabled the analysis of early term births, which would not have been possible using only hospital discharge records. There are also a few limitations that merit discussion. NPIC/QAS member hospitals have more births per year and offer more advanced levels of care than the average US hospital, and so our results are more appropriately generalized to specialty care hospitals than to all US delivery hospitals. The subset of deliveries used in the gestational age analysis included less than one-third of the observations used in the full sample. ICD-9 codes are less accurate and detailed than medical record abstraction and the assignment of ICD-9 codes to hospital

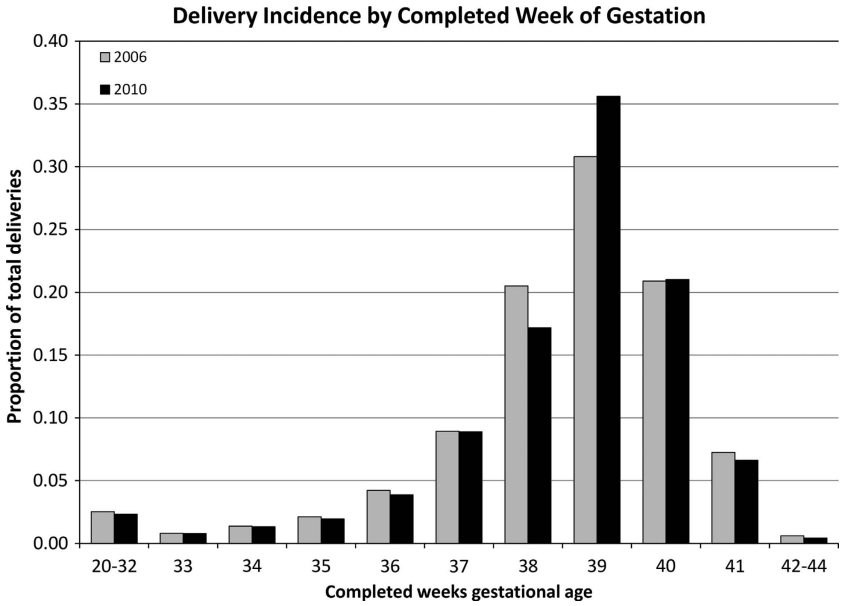

Figure 2. Delivery incidence by completed week gestation. All 2006 incidences and all 2010 incidences sum to 1.00.

Table 2. Incidence of delivery methods by completed gestational week at 17 hospitals (per 100 deliveries)

Gestational age (weeks)	*2006*				*2010*			
	Spontaneous delivery	*Labor induction*	*Primary C-section*	*Repeat C-section*	*Spontaneous delivery*	*Labor induction*	*Primary C-section*	*Repeat C-section*
20–32	0.94	0.17	1.16	0.26	0.78	0.16	1.09	0.31
33	0.25	0.09	0.35	0.11	0.26	0.11	0.31	0.11
34	0.50	0.24	0.46	0.16	0.48	0.20	0.43	0.22
35	0.91	0.32	0.57	0.32	0.83	0.29	0.49	0.33
36	1.80	0.78	0.96	0.68	1.69	0.68	0.84	0.66
37	4.19	1.80	1.55	1.37	4.02	1.95	1.50	1.43
38	9.07	4.23	2.86	4.36	8.83	3.14	2.15	3.04
39	14.14	7.51	3.92	5.22	14.26	8.84	4.34	8.16
40	11.08	5.93	2.95	0.93	11.19	6.17	2.73	0.93
41	2.68	3.34	1.05	0.17	2.26	3.41	0.78	0.17
42–44	0.19	0.28	0.11	0.02	0.09	0.24	0.07	0.02

Table 3. Early term deliveries at 17 hospitals by indication status, 2006 and 2010

	2006		*2010*	
	N	*Percent of those who reached 37 weeks*	*N*	*Percent of those who reached 37 weeks*
Pregnancies that reached 37 weeks	58 857		56 070	
Spontaneous delivery 37–38 weeks	8771	14.9	8032	14.3
Indicated iatrogenic delivery 37–38 weeks	5997	10.2	5541	9.9
Non-indicated iatrogenic delivery 37–38 weeks	4693	8.0	2716	4.8
Continued to week 39	39 396	66.9	39 781	70.9

discharge records is subject to coding error. Non-indicated deliveries only reflect the absence of an approved ICD-9 diagnosis code for early delivery and therefore cannot be verified to be purely elective. Notably, it is not possible to discern whether non-medically indicated iatrogenic deliveries at 37 weeks or later were initiated by spontaneous onset of labor or rupture of membranes, so the incidence may be overstated. Similarly, without medical record review, we cannot determine whether the presence of an indication for an early delivery actually influenced the decision for an early or iatrogenic delivery. Because we restricted the subset to deliveries resulting in live births, the calculated incidences do not reflect the possibility for stillbirth. However, the incidence of stillbirth is approximately 3 per 1000 deliveries after 28 weeks gestation and is sufficiently low that its exclusion is not expected

to affect the calculated incidences of delivery methods by week of gestation.[33] There is also the potential for misclassification of gestational age, which could bias the results if early delivery was related to the accuracy of gestational age data.

In conclusion, the incidence of labor induction, repeat cesarean delivery and labor induction resulting in cesarean delivery in a sample of US hospitals increased between 2006 and 2010. A decline in deliveries at 38 weeks coupled with an increase in deliveries at 39 weeks may be attributed to recent efforts to limit non-medically indicated deliveries before 39 completed weeks of gestation. It will be important for future studies to address the impact of these changes on maternal and neonatal outcomes, and whether efforts to limit deliveries before 39 weeks have successfully extended to smaller, community hospitals.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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