Recent Trends in Elective Deliveries in New Jersey and California

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In the United States, Caesarian section (C-section) deliveries increased by 44% and inductions of labor increased by 150% between 1990 and 2012. Primary C-sections (those to first-time mothers) increased by 36% during the same two decades (authors' calculations from U.S. Natality Statistics). A look at the longer-term trend is even more revealing: In 1970, 5% of births in the U.S. were delivered by C-section; that rate more than tripled to 17% in 1980, and stands at about 1/3 of all births today (comparable data for inductions are not available) (MacDorman, Menacker and Declercq 2008). Increases in C-sections are most common among mothers who are white, educated, and privately insured, suggesting that an increase in high-risk pregnancies is not responsible (Declercq, Menacker and MacDorman 2008; APHA 2014).

There is no doubt that C-sections have saved lives of mothers and babies. Fetal and infant mortality declined considerably between 1980 and 2000 and C-sections have been shown to be a major contributing factor (Ananth and Vintzileos 2006). However, rates of fetal and infant mortality have remained stable since 2000, while C-sections rose sharply (March of Dimes 2016; Infoplease 2018). C-sections reduced maternal mortality during the 20th century, but not after 1990 (Hoyert 2007). Thus, recent increases in obstetric interventions do not appear to be saving mothers' and infants' lives.

Moreover, these interventions themselves confer risks. C-sections expose mothers to risks accompanying surgery and put their newborns at increased risk for neonatal respiratory disorders (e.g., Tutdibi et al. 2010) and asthma (Black et al. 2015). Going through the birth canal stimulates the infant's lungs, reducing the likelihood of neonatal respiratory conditions (Tutdibi et al. 2010), and may alter the infant's microbiome in ways favorable for their health (Azad et al. 2013). Inductions of labor (initiation of uterine contractions for the purpose of delivery by medical or surgical means), when not post-term, are associated with numerous risks and few benefits. A systematic review revealed support for only 2 medical indications for induction of labor: >41 weeks gestational age and pre-labor rupture of membranes at term (Mozurkewich et al. 2009). Induced contractions increase the use of epidural anesthesia and vacuum- or forceps-assisted deliveries (APHA 2014), and inductions can fail, increasing the likelihood of C-sections. Seyb et al. (1999) estimated that "elective induction" doubles the C-section rate. That said, a recent randomized controlled study found that inductions at 39 weeks improved maternal and child outcomes compared to expectant management women with low risk pregnancies who planned to deliver vaginally (Grobman et al. 2018). Both C-sections and inductions, by definition, reduce gestational age, and earlier gestational age is associated with less favorable developmental outcomes even among children born at term (Reichman et al. 2015; Rose et al. 2013; Dueker et al. 2016; Noble et al.2012).

While trends in C-sections and inductions are widely known, trends in elective (non-medically indicated) C-sections and inductions are less well documented. Furthermore, as far as we know, no existing reports or studies documenting trends in delivery methods have distinguished between inductions resulting in vaginal deliveries and those resulting in C-sections. In this paper, we document trends in elective C-sections that did not follow inductions, elective inductions that did not lead to C-sections, and C-sections that followed elective inductions in two large populous states—New Jersey and California. In 2013, NJ had the highest rate of C-sections in the US (38.4% of all births), while the rate in CA was 33.2%, which is much closer to the US rate of 32.7%, and CA had the lowest rate of inductions in the country (3.8%), while the rate in NJ was 19.1% and the national rate was 23% (US natality statistics; 2013 is the last year induction rates are available by state). For each state, we also provide an analysis of trends in each of these procedures by key demographic attributes of mothers (race/ethnicity, age, education, nativity, health insurance status, and marital status), as well as document corresponding trends in delivery methods by gestational age.

Background

Researchers have studied supply side factors, particularly physician reimbursement rates and malpractice liability caps. E.g., Gruber, Kim and Mayzlin (1999) found that one half to three quarters of the difference in C-section rates between publicly and privately insured childbearing women could be explained by differential reimbursement rates. The effects of liability caps are not as clear (Currie and MacLeod 2008). Using 2009 data from 593 US hospitals nationwide, Kozhimannil, Law and Virnig (2013) found that cesarean rates varied substantially across hospitals, even for lower-risk pregnancies (defined as term, singleton, vertex (not breech) with no prior maternal C-sections) but that the variation was not explained by hospital bed size, teaching status, or geographic location. Although demand side factors are also thought to play a role in driving up rates of C-sections and inductions, the evidence in this regard is almost exclusively anecdotal. NIH (2006) pointed to a number of maternal factors that may be important, highlighting that few data are available to facilitate an understanding of the role of these factors. These include a desire to be in control of the birth process; fear of labor and delivery; scheduling issues surrounding work and childcare; ensuring that a specific doctor will be present during labor and delivery; concerns about quality of life after childbirth; and a potential "vicious cycle" wherein increasing rates of C-sections may result in C-sections being perceived as the norm. Many of these potential explanations could apply to inductions as well. The panel also suggested that shifts in obstetric practice away from vaginal breech deliveries and vaginal deliveries after C-sections may have further contributed to societal acceptance of C-sections (NIH 2006). Baicker et al. (2006) found that in areas with higher C-section rates, the procedure is performed more often in "medically less appropriate" situations; this finding provides some support for a "vicious cycle" or "contagion" effect

A key challenge in studying the reasons that non-medically indicated obstetric interventions are performed, and even determining the rates of non-medically indicated obstetrical interventions and trends in those interventions in the population, is the difficulty of distinguishing between medically-indicated and non-medically indicated (elective) interventions. Until recently, most studies characterized elective deliveries based upon not having had a trial of labor—an unsatisfactory approach that does not take into consideration medical risks and does not classify elective inductions followed by C-sections as elective deliveries. Signore and Klebanoff (2008) highlighted the difficulty of identifying elective C-sections in research studies because “elective C-section” is rarely noted in hospital records. Tomlinson and Durham (2012) recommended using recent detailed criteria developed by the Joint Commission to measure rates of C-sections and inductions that are not medically indicated. A few recent studies approximated the Joint Commission criteria to identify elective deliveries in studies focusing on different substantive questions and found non-trivial rates of elective deliveries, even among poor or near-poor women (Fowler et al. 2014; Kozhimannil, Macheras and Lorch 2014; Kozhimmanil et al. 2016, 2018; lDahlen et al. 2017).

Data

The NJ Electronic Birth Certificate and Perinatal Database includes records for all births in the state from 1997–2011 (>1.6 million births). We linked these records to the mothers’ and infants’ hospital discharge records from the birth hospitalization. Because the birth and discharge records are from separate systems and collected for different purposes, we used probabilistic matching, with 93% of the birth records matching to maternal discharge records and 92% of the birth records matching to infant discharge records. The birth records include method of delivery, gestational age, maternal medical risk factors, labor and delivery complications, demographic factors, health insurance type, maternal prenatal behaviors, and delivery date. Relevant fields from the maternal discharge records include discharge diagnoses and procedures. From CA, we will also use hospital discharge files that are linked to birth records, allowing us to conduct comparable analyses in both states.

Key measures

Method of delivery. From the birth records, we classify deliveries as C-sections with no trial of labor, C-sections after induction has been attempted (failed inductions), vaginal deliveries after inductions of labor, and vaginal deliveries not following inductions. The first three delivery methods are considered to be elective in our sample of mothers with no documented risk factors for labor/delivery complications.

Gestational age. Following the standard in obstetric practice, we use a clinical measure of completed weeks of gestational age. The clinical assessment in the birth records was based on the “best available information (physical examination of the infant and/or ultrasound visualization)” [p. 83] (New Jersey Department of Health and Senior Services 2005). The vast majority (95%) of mothers in our sample had at least one ultrasound. We assessed the sensitivity of our findings to alternative measures of GA. Concordance across different established measures of GA is highest for term births, the focus of our study (Mustafa and David 2001).

Sample

We limit the sample to low risk pregnancies, which we identified using Joint Commission guidelines for the perinatal core outcomes of “decreasing the C-section rate in nulliparous women with a term, singleton baby in a vertex position” and “decreasing the rate of elective deliveries.” Guidelines for defining the relevant populations for measuring these outcomes, based on characteristics of pregnancies and identified lists of conditions, were compiled by a panel of perinatal experts and implemented in 2014 as part of an effort to monitor perinatal outcomes for hospital accreditation purposes.

We use the Joint Commission criteria to define the population of uncomplicated full-term pregnancies, for which most C-sections and inductions should be medically unnecessary. We combine the sample restrictions for the 2 core Joint Commission perinatal outcomes, defining the low risk population for elective deliveries as women having singleton first births, not having any of the ICD-9 codes listed on the Joint Commission list for "Conditions Possibly Justifying Elective Delivery Prior to 39 Weeks Gestation" [Table 1] or "Contraindications to Vaginal Delivery" [Table 2], not having had premature rupture of the membranes, not having had prior uterine surgery, not having had a trial of labor before a C-section (except when labor was induced prior to the C-section), and giving birth at 37+ weeks gestation. The Joint Commission restricts the relevant population for elective deliveries (C-section or induced) to births taking place at 37 or 38 weeks and that for C-section deliveries to births taking place at 37+ weeks. We excluded births with 41 weeks gestational age because many of those would be close to 42 weeks (e.g., 41 weeks plus 6 days), and thus on the margin for medically indicated inductions (Mozurkewich et al. 2009), and no method of assessing of GA is accurate to the day (Mustafa and David 2001).

Statistical analysis

First, we provide validating evidence that the designation of "elective" deliveries is reliable. We then document trends in delivery methods for NJ and CA compared to the U.S. Next, we document trends in delivery methods for low-risk pregnancies in NJ and CA, identified using the Joint Commission specifications, overall and by maternal characteristics. Finally, we document corresponding trends by week of gestation age among low-risk pregnancies.

Preliminary results

Rates of C-sections were 3–5% higher in NJ than in the U.S. but the trends in delivery methods in NJ between 1997 and 2011 were similar to those at the national level, with large increases in C-section rates and smaller but steady increases in rates of inductions (Figure 1).

The more stringent low-risk sample consisted of 150,032 births in NJ. The rate of elective deliveries in this sample more than doubled between 1997 and 2007, from 17% to 40%, and then stabilized (Figure 2). Most of the increase is accounted for by increases in C-sections with no labor trial (650%) and C-sections after inductions (275%). Overall, 31% of births in this sample involved C-section or induction. More than half of the deliveries that were induced (20,000 of 38,000) ended up as C-sections, and the ratio of "successful" inductions decreased from 58% in 1997 to 41% in 2011.

In NJ: Non-Hispanic whites were more likely than other mothers in to have induced vaginal deliveries, particularly compared to non-Hispanic blacks. Mothers <20 years old were less likely to have interventions and mothers age 35+ were much more likely to have interventions, than mothers ages 20–34. Interventions were also higher among highly-educated mothers, married mothers, and mothers whose deliveries were not covered by Medicaid (Table 3).

Overall, these preliminary results from NJ demonstrate that elective deliveries increased three-fold over a recent 15-year period. Notably, one third of induced deliveries were delivered by C-section in

1997, while the rate climbed to double that—at two thirds—in 2011. Additional preliminary findings indicate that the increases occurred among all demographic groups but were larger for higher socioeconomic status groups than lower socioeconomic status groups.

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Table 1. Conditions Possibly Justifying Elective Delivery Prior to 39 Weeks Gestation, from Table Number 11.07 in The Joint Commission's *Specifications Manual for Joint Commission National Quality Core Measures* (v2014A1)

042 HUMAN IMMUNO VIRUS DIS; **576.8** DIS BILIARY TRACT; **641.01** PLACENTA PREVIA; **641.11** PLACENTA PREV HEM; **641.21** PREM SEPAR PLACEN; **641.31** COAG DEF HEMORR; **641.81** ANTE-PARTUM HEM NEC; **641.91** ANTEPARTUM HEM NOS; **642.01** ESSEN HYPERTEN; **642.02** ESSEN HYPERTEN-DEL W P/P; **642.11** RENAL HYPERTEN PG; **642.12** RENAL HYPERTEN- P/P; **642.21** OLD HYPERTEN NEC; **642.22** OLD HYPERTEN- P/P; **642.31** TRANS HYPERTEN; **642.32** TRANS HYPERTEN- P/P; **642.41** MILD/NOS PREECLAMP; **642.42** MILD PREECLAMP- P/P; **642.51** SEVERE PREECLAMP; **642.52** SEV PREECLAMP- P/P; **642.61** ECLAMPSIA; **642.62** ECLAMPSIA- P/P; **642.71** TOX W OLD HYPERTEN; **642.72** TOX W OLD HYP- P/P; **642.91** HYPERTENS NOS-; **642.92** HYPERTENS NOS- P/P; **645.11** POST TERM PREG; **646.21** RENAL DIS NOS; **646.22** RENAL DIS NOS- P/P; **646.71** LIVER/BIL TRCT DISR; **648.01** DIABETES; **648.51** CONGEN CV DIS; **648.52** CONGEN CV DIS- P/P; **648.61** CV DIS NEC PREG; **648.62** CV DIS NEC- P/P; **648.81** ABN GLUCOSE TOLER; **648.82** ABN GLUCOSE- P/P; **649.31** COAGULATION DEF; **649.32** CO-AGULATN DEF- P/P; **651.01** TWIN PREG; **651.11** TRIPLET PREG; **651.21** QUADRUPLET PREG; **651.31** TWINS W FETAL LOSS; **651.41** TRIPLETS W FET LOSS; **651.51** QUADS W FETAL LOSS; **651.61** MULT GES W FET LOSS; **651.71** MULT GEST-FET REDUCT; **651.81** MULTI GESTAT NEC; **651.91** MULT GEST NOS; **652.01** UNSTABLE LIE; **652.61** MULT GEST MALPRES; **655.01** FETAL CNS MALFORM; **655.11** FETAL CHROMOSO ABN; **655.31** FET DAMG D/T VIRUS; **655.41** FET DAMG D/T DIS; **655.51** FET DAMAG D/T DRUG; **655.61** RADIAT FETAL DAMAG; **655.81** FETAL ABNORM NEC-UNSPEC; **656.01** FETAL-MATERNAL HEM; **656.11** RH ISOIMMUNIZAT; **656.21** ABO ISOIMMUNIZAT; **656.31** FETAL DISTRESS; **656.41** INTRAUTER DEATH; **656.51** POOR FETAL GROWTH; **657.01** POLYHY-DRAMNIOS; **658.01** OLIGOHYDRAM; **658.11** PREM RUPT MEMBR; **658.21** PROLONG RUPT MEMB; **658.41** AMNIOTIC INFECT; **659.71** ABN FTL HRT RATE/RHY; **663.01** CORD PROLAPSE-DEL; **665.01** PRELABOR RUPT UTERUS-DEL; **663.51** VASA PREVIA; **V08** ASYMP HIV INFECT STATUS; **V23.5** PREG W POOR REPRO HX; **V27.1** DELIV-SINGLE STILLBORN **Note: Data in Tables 1 & 2 are ICD9 Codes and "Condensed Descriptions" of those codes used by the Joint Commission.**

Table 2. Contraindications to Vaginal Delivery, from Table Number 11.09 in The Joint Commission's *Specifications Manual for Joint Commission National Quality Core Measures* (v2014A1)

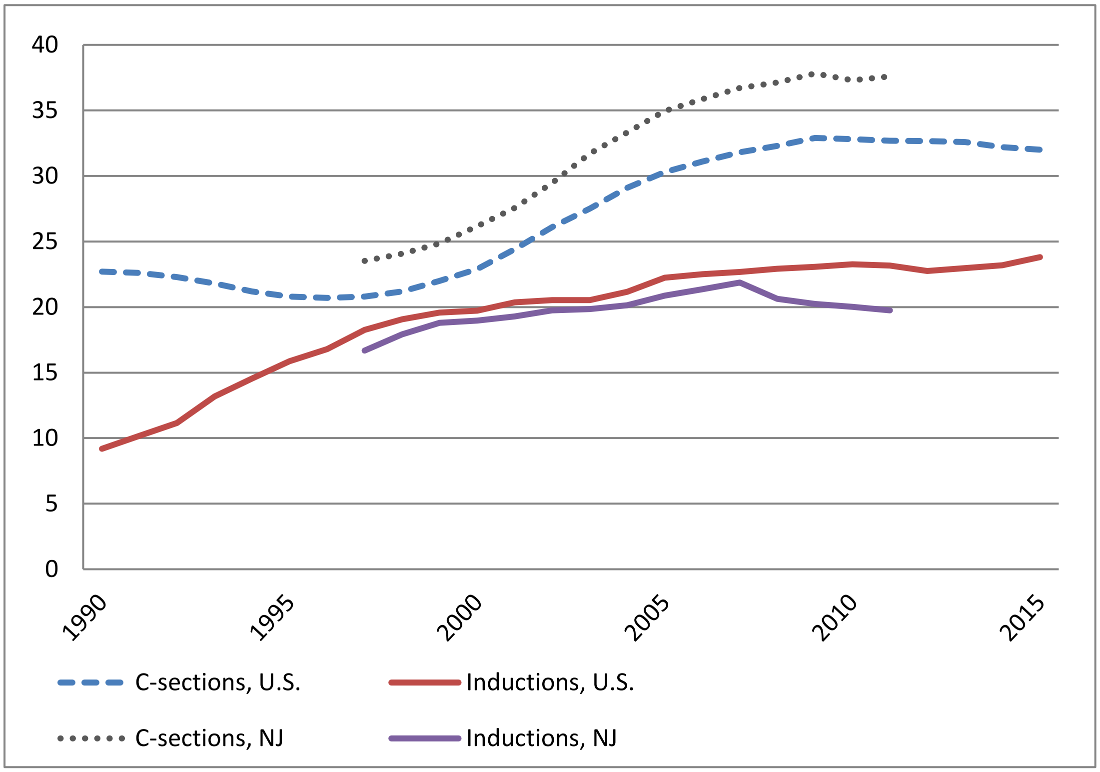
644.21 EARLY ONSET DEL; **651.01** TWIN; **651.11** TRIPLET; **651.21** QUAD ; **651.31** TWINS W FET LOSS; **651.41** TRIPLETS W FET LOSS; **651.51** QUADS W FET LOSS; **651.61** MULT GEST W FET LOSS; **651.81** MULTI GEST NEC; **651.91** MULT GEST NOS; **652.21** BREECH PRESENT; **652.31** TRANSVER/OBLIQ LIE; **652.41** FACE/BROW PRESENT; **652.61** MULT GEST MALPRE; **652.81** MALPOS NEC; **654.21** PREV C-SECT NOS; **656.41** INTRAUTER DEATH; **660.51** LOCKED TWINS; **662.31** DELAY 2ND TWIN; **669.61** BREECH EXTR NOS; **761.5** MULT PREG AFF NB; **V27.1** SINGLE SB; **V27.2** TWINS, BOTH LIVE; **V27.3** DEL-TWINS, 1 NB, 1 SB; **V27.4** DEL-TWINS, BOTH SB; **V27.5** DEL-MULT BIRTH, ALL LIVE; **V27.6** DEL-MULT BRTH, SOME LIVE; **V27.7** DEL-MULT BIRTH, ALL SB

Table 3. Sample Characteristics by Delivery Method, New Jersey, 1997–2011

	Delivery Method				Sig.
	Vaginal		C-section		
	Not Induced	Induced	Not Induced	Induced	
Mother's race/ethnicity					
White, non-Hispanic	48.92	53.34	57.84	50.33	***
Black, non-Hispanic	13.09	11.81	10.05	12.63	***
Hispanic	25.27	20.89	20.69	21.59	***
Other	12.72	13.96	11.42	15.45	***
Mother's age					
< 20 years	16.69	13.01	5.52	7.28	***
20–34	76.55	78.87	73.04	78.61	***
35+	6.76	8.12	21.44	14.11	***
Mother U.S.-born	63.79	66.42	68.06	64.84	***
Mother's education					
< High school graduate	14.99	10.74	6.40	7.91	***
High school graduate or equivalent	27.17	25.83	23.12	24.41	***
Some college	20.71	21.70	20.76	22.46	***
College graduate	37.13	41.73	49.72	45.21	***
Mother married	60.60	65.58	73.12	68.93	***
Medicaid birth	25.54	20.77	14.00	17.56	***
N	103,545	18,075	8,276	20,136	

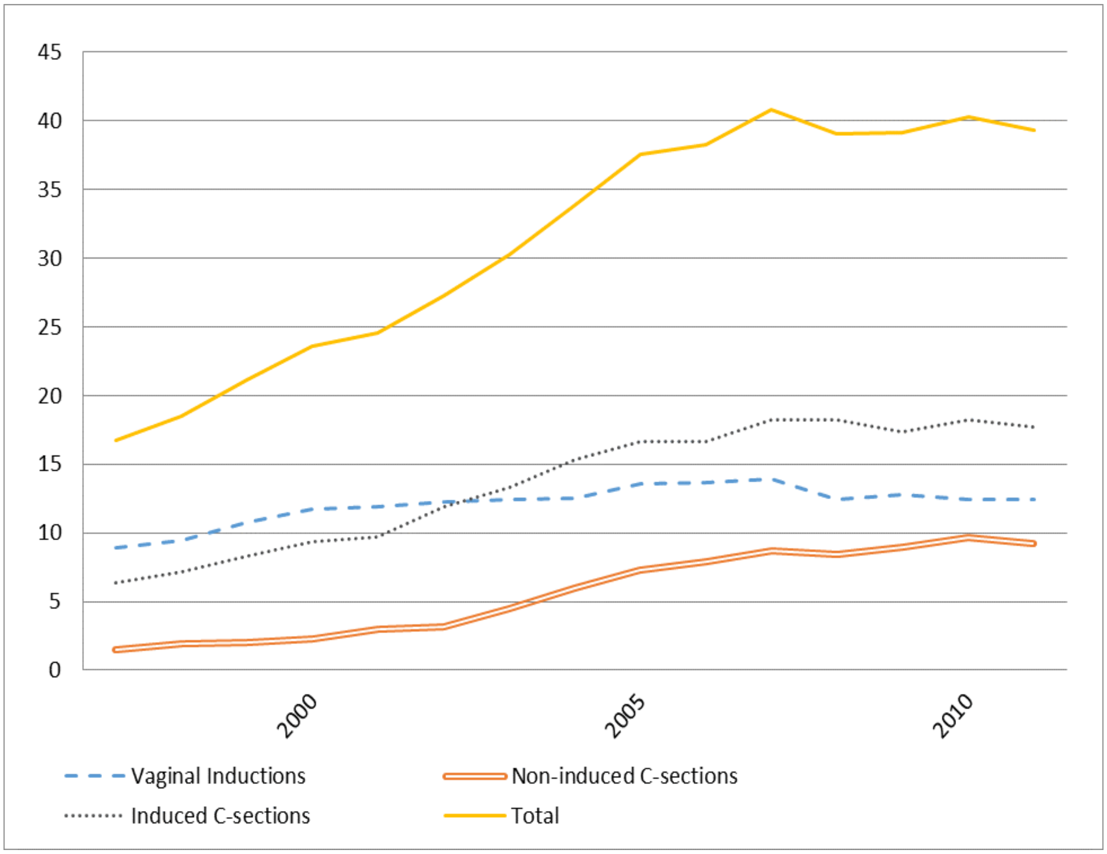
Data source: New Jersey Electronic Birth Certificate & Perinatal Database, 1997–2011.
Notes: All figures are column percentages unless indicated otherwise. Sample includes singleton first births, 37–40 weeks gestational age, no labor trial (for C-sections, except those that followed inductions), no medical risk factors or labor/delivery complications recorded in birth record (exception for inductions that result in C-sections, for which mothers can have labor/delivery complications). Asterisks correspond to P-values from chi-square tests by delivery method: ***p < 0.001.

Figure 1. Percentages of births delivered by C-section and induction, U.S. and New Jersey, 1990–2015



Data sources: U.S. Centers for Disease Control and Prevention online vital statistics 1990–2015 birth data files and New Jersey Electronic Birth Certificate & Perinatal Database for 1997–2011.
Notes: Figure displays percentages of all births in the U.S. and N.J. in the time periods specified. Percentages delivered by C-section and induction are not mutually exclusive.

Figure 2. Percentages of Low-Risk Births Delivered by C-section and Induction, New Jersey, 1997–2011



Data source: New Jersey Electronic Birth Certificate & Perinatal Database, 1997–2011.
Notes: Sample includes singleton first births, 37–40 weeks gestational age, no labor trial (for C-sections, except those that followed inductions), no medical risk factors or labor/delivery complications recorded in birth record (exception for inductions that result in C-sections, for which mothers can have labor/delivery complications).