Elective Induction of Labor at Term Compared With Expectant Management

Maternal and Neonatal Outcomes

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OBJECTIVE: To test the association of elective induction of labor at term compared with expectant management and maternal and neonatal outcomes.

METHODS: This was a retrospective cohort study of all deliveries without prior cesarean delivery in California in 2006 using linked hospital discharge and vital statistics data. We compared elective induction at each term gestational age (37–40 weeks) as defined by The Joint Commission with expectant management in vertex, nonanomalous, singleton deliveries. We used multivariable logistic regression to test the association of elective induction and cesarean delivery, operative vaginal delivery, maternal third- or fourth-degree lacerations, perinatal death, neonatal intensive care unit admission, respiratory distress, shoulder dystocia, hyperbilirubinemia, and macrosomia (birth weight greater than 4,000 g) at each gestational week, stratified by parity.

RESULTS: The cesarean delivery rate was 16%, perinatal mortality was 0.2%, and neonatal intensive care unit admission was 6.2% (N=362,154). The odds of cesarean delivery were lower among women with elective induction compared with expectant management across all gestational ages and parity (37 weeks [odds ratio (OR) 0.44, 95% confidence interval (CI) 0.34–0.57], 38 weeks [OR 0.43, 95% CI 0.38–0.50], 39 weeks [OR 0.46, 95% CI 0.41–0.52], 40 weeks [OR 0.57, CI 0.50–0.65]). Elective induction was not associated with increased odds of severe lacerations, operative vaginal delivery, perinatal death, neonatal intensive care unit admission, respiratory distress, shoulder dystocia, or macrosomia at any term gestational age. Elective induction was associated with increased odds of hyperbilirubinemia at 37 and 38 weeks of gestation and shoulder dystocia at 39 weeks of gestation.

CONCLUSION: Elective induction of labor is associated with decreased odds of cesarean delivery when compared with expectant management.

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Induction of labor before 42 completed weeks of gestation increased steadily in the United States between 1990 and 2010.[1,2] This increase reflects rises in rates of induction with and without medical indication (also known as elective induction of labor). However, the evidence about nonmedically indicated induction of labor and its effect on a variety of maternal and neonatal outcomes is not clear. Data supporting induction of labor for women at 41 weeks of gestation and beyond exist,[3] but less is known about the effect of induction without medical indication between 37 and

40 completed weeks of gestation.[3] With retrospective evidence indicating that early-term (ie, 37 and 38 weeks of gestation) delivery confers higher risk for subsequent adverse neonatal and childhood outcomes compared with later-term weeks,[4] the American College of Obstetricians and Gynecologists has issued recommendations to reduce nonmedically indicated induction of labor at less than 39 weeks of gestation.[5] Recent evaluations of strategies to reduce induction in the absence of medical indication before 39 weeks of gestation have reported decreases in admissions to the neonatal intensive care unit (NICU),[6,7] conflicting results about stillbirth,[7,8] and little information about cesarean delivery, historically one of the key concerns surrounding induction without medical indication.[9]

The lack of transparent, reproducible methods to classify inductions as medically indicated or not and to define appropriate comparison groups is a key contributor to the evidence gap about the health effects of induction of labor without medical indication. This analysis focuses on induction of labor without medical indication and expectant management at each term gestational week (37–40 weeks). We improve on prior work by using a transparent method to classify inductions as nonmedically indicated and the clinically relevant comparison group, expectant management.[10] We stratify by gestational age and parity and test the association of induction without a medical indication and cesarean delivery, operative vaginal delivery, third- or fourth-degree perineal lacerations, perinatal death, NICU admission, respiratory distress, hyperbilirubinemia, shoulder dystocia, and macrosomia.

MATERIALS AND METHODS

We conducted a retrospective cohort study using 2006 California Department of Health Services linked data (death files, birth certificates, and unmasked hospital discharge data).[11] It contains linked birth and delivery records that contain deidentified information for a mother and neonate pair from neonatal and maternal discharge data and the birth certificate data (N=532,088) and includes all deliveries in a given year.

We arrived at our analytic sample of 362,154 after a series of exclusions (Fig. 1). In the induction without medical indication group, we included women who delivered between 37 and 40 completed weeks of gestation because late-term or postterm pregnancy (greater than 41 or 42 completed weeks of gestation) is a common indication for induction, and good evidence already exists to support induction for such pregnancies.[3,10] We used The Joint Commission list of indications possibly justifying delivery before 39 completed weeks of gestation[12] to classify women with induction without medical indication (see Appendix 1, available online at http://links.lww.com/AOG/A431).

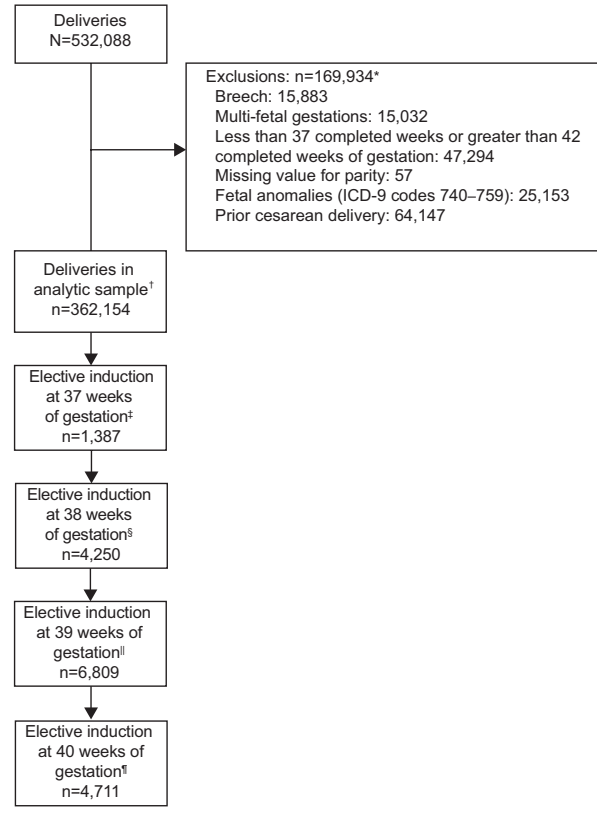

Fig. 1. Sample flow and comparison groups for elective induction of labor compared with expectant management, California deliveries, 2006. Expectant management indicates that the women went on to deliver at some later gestational age regardless of induction or mode of delivery (eg, vaginal or cesarean delivery). *Some women may have more than one exclusion criterion; these numbers do not necessarily represent the total frequency of each exclusion in the dataset. †At each gestational week, spontaneous deliveries that week and women with antenatal indications for delivery are excluded; thus, at 37 weeks of gestation, the induction group plus the expectant group does not equal the sample total. ‡Compared with expectant management and delivery at 38–42 weeks of gestation (n=305,876). §Compared with expectant management and delivery at 39–42 weeks of gestation (n=242,473). ‖Compared with expectant management and delivery at 40–42 weeks of gestation (n=144,898). ¶Compared with expectant management and delivery at 41 or 42 weeks of gestation (n=54,517).

Darney. Elective Labor Induction and Expectant Management. Obstet Gynecol 2013.

A limitation of previous observational studies is choice of comparison group: women undergoing induction have been compared with women who had spontaneous labor in that same week of gestation.[9,13–16] However, the clinical reality is not a choice between induction or spontaneous labor but between induction and continuing pregnancy, ie, expectant management

with the potential for either spontaneous or induced labor and delivery at a later gestational age.[17] To ensure that our findings reflected clinical practice, we compared women with nonmedically indicated inductions at each term week of gestation with expectant management (a group of women who deliver in the next week or beyond, up to 42 completed weeks of gestation) (Fig. 1).

We further divided the sample by gestational age such that all women with nonmedically indicated inductions at 37 completed weeks of gestation were compared with women who delivered at 38–42 completed weeks of gestation, excluding women at each week with deliveries who had antepartum indications (Fig. 1). At each week of induction without a medical indication, the comparison group shifts to include only those women delivered after the week of induction. Because this method assumes that expectant management continues into the next week, we also performed a sensitivity analysis comparing induction without a medical indication at each week with women at that week or above.[18,19]

We used hospital discharge International Classification of Diseases, 9th Revision, Clinical Modification diagnosis and procedure codes to identify cesarean delivery (669.7, 669.70, 669.71, 763.4, 74, 74.0, 74.1, 74.2, 74.4, 74.9, 74.99), third-or fourth-degree perineal lacerations (664.2, 664.20, 664.21, 664.24), operative vaginal delivery (669.5, 669.50, 669.51, 72.8, 72.9), respiratory distress (769, 770, 770.89, 770.84, 770.9), hyperbilirubinemia (277.5, 773.4, 774, 774.0, 774.1, 774.2, 774.3, 774.30, 774.31, 774.39, 774.5, 774.6, 774.7, 782.4), and shoulder dystocia (660.4, 660.40, 660.41, 660.43). Neonatal intensive care unit admission was a composite of NICU admission or transfer documented on the birth certificate and neonatal length of stay greater than maternal length of stay documented in the discharge record. Perinatal death was a composite of fetal, neonatal, and infant death obtained from vital statistics files. Macrosomia (birth weight greater than 4,000 g) was recorded on the birth certificate. Covariates extracted from hospital discharge or birth certificate data included advanced

Table 1. Sample Characteristics by Term (37–40 Weeks) Gestational Week of Induction Without Medical Indication and Expectant Management Comparison Group, California, 2006

Characteristic	Total Sample	37 0/7–37 6/7 Weeks of Gestation		38 0/7–38 6/7 Weeks of Gestation		39 0/7–39 6/7 Weeks of Gestation		40 0/7–40 6/7 Weeks of Gestation	
		Induction	Expectant	Induction	Expectant	Induction	Expectant	Induction	Expectant
n	362,154	1,387	305,876	4,250	242,473	6,809	144,898	4,718	54,517
Maternal age 35 y and older	15.1	18.6	13.9	19.9	13.4*	19.8	12.7*	15.9	12.0*
Race									
White	34.2	41.2	34.9*	48.0	35.5*	48.5	36.3*	44.1	37.6*
African American	4.9	4.7	4.8	3.3	4.7	3.6	4.7	3.6	4.7
Hispanic or Latina	46.1	41.3	46.1	35.6	46.0	35.0	46.0	39.4	45.1
Asian	11.8	9.7	11.1	9.9	10.8	9.9	10.0	9.7	9.3
Other or mixed	2.8	3.0	2.9	3.3	2.8	3.0	2.9	3.3	3.1
Completed high school	46.6	48.1	46.6	57.5	46.7*	58.6	46.3*	52.5	45.8*
Initiated prenatal care in the first trimester	86.4	88.0	86.3*	90.9	86.1*	90.9	85.4*	88.3	83.6*
Insurance									
None	3.3	1.6	3.4*	1.7	3.5*	1.9	3.6*	2.0	3.4*
Public	47.9	45.1	48.2	37.7	48.1	35.8	48.4	41.5	49.4
Private	48.6	52.3	48.2	60.6	48.2	62.3	47.7	56.5	46.9
Delivered at a teaching hospital	14.6	8.8	14.1*	7.4	14.5*	7.9	15.2*	8.0	16.2*
Nulliparous (vs prior vaginal delivery)	46.47	30.4	47.3*	28.6	48.6*	32.1	51.2*	40.7	53.1*

Data are % unless otherwise specified.

Induction, induction of labor without medical indication as defined by The Joint Commission (see Appendix 1, available online at http://links.lww.com/AOG/A431).

Expectant management includes all women who do not undergo induction that week, do not have antenatal indications for early delivery, and deliver in a subsequent week, up to 42 completed wk of gestation.

* $P<.001$ (χ^2) for difference between induction and expectant groups.

Table 2. Outcomes by Elective Induction of Labor Compared With Expectant Management Group at Each Term Gestational Age and by Parity, California, 2006

Gestational Age Group	Induction or Expectant Management Group	n	Cesarean Delivery	Operative Vaginal Delivery	3rd- and 4th-Degree Lacerations
All deliveries	Total	362,154	16.2	8.8	2.9
37 wk	Induction	1,387	7.6*	6.8†	2.0‡
	Expectant	305,876	15.4	9.0	3.0
38 wk	Induction	4,250	8.0*	7.2*	2.0*
	Expectant	242,473	15.9	9.2	3.1
39 wk	Induction	6,809	9.3*	7.8*	2.2*
	Expectant	144,898	17.3	9.6	3.2
40 wk	Induction	4,711	12.4*	7.7*	2.7
	Expectant	54,517	19.0	9.4	3.2
Nulliparous	Total	168,305	26.5	13.1	5.2
37 wk	Induction	422	18.3*	12.1	5.9
	Expectant	144,581	25.5	13.3	5.3
38 wk	Induction	1,214	21.4*	13.8	4.9
	Expectant	177,896	26.1	13.4	5.4
39 wk	Induction	2,186	22.8*	14.5	5.3
	Expectant	74,115	27.7	13.6	5.4
40 wk	Induction	1,920	25.2*	12.9	5.7
	Expectant	29,104	29.7	13.3	5.2
Prior vaginal	Total	193,849	7.3	5.1	0.9
37 wk	Induction	965	3.0*	4.5	0.3‡
	Expectant	161,295	6.4	5.2	0.9
38 wk	Induction	3,036	2.7*	4.6	0.8
	Expectant	124,577	6.3	5.3	0.9
39 wk	Induction	4,632	3.0*	4.7	0.8
	Expectant	70,783	6.5	5.4	0.9
40 wk	Induction	2,791	3.5*	4.1‡	0.6
	Expectant	25,413	6.7	5.0	0.8

NICU, neonatal intensive care unit; Macosomia, birth weight of 4,000 g or greater; Induction, induction without medical indication.
Data are % unless otherwise specified.
Shoulder dystocia excludes women with a cesarean delivery; therefore, group totals are smaller.
* $P<.001$, † $P<.01$, and ‡ $P<.05$ for difference between elective induction and expectant group within each gestational week; tests are two-sided test of proportions.

maternal age (35 years or older) at the time of delivery, initiation of prenatal care in the first trimester, insurance status (none, public, private), maternal education (completed high school or not), maternal race, and delivery at a teaching hospital. We did not control for birth weight because increasing birth weight is an inherent risk of expectant management and is also on the causal pathway from expectant management to several neonatal outcomes including macrosomia. Some covariates are available in both the birth certificate and in the hospital discharge data. We privileged the hospital discharge data over the birth certificate information when possible, congruent with data validation studies.[20–22]

We compared proportions of each binary outcome between induction without a medical indication and expectant groups stratified by parity (nulliparous women or previous vaginal delivery) using a two-sample test of proportions. We used multivariable logistic regression models to estimate adjusted associations between induction without a medical indication and our predetermined outcomes. We used robust standard errors to account for data clustering at the hospital level.[23] We included common individual and institutional-level confounders (listed previously) in our models. We included only women with vaginal deliveries in our model for shoulder dystocia. We anticipated that cesarean delivery would be a common outcome and therefore that odds ratios (ORs) would overstate associations if interpreted as relative risks, so we also estimated relative risks[24] but estimates were similar so we present only the OR estimates.

Our elective induction classification scheme assumes that all documented indications were known before the decision to induce. Our data do not permit us to assess temporality, but it is plausible that some conditions could develop after an induction without medical indication. For example, fetal distress (656.31) could occur before the decision to induce, in which case it is an indication for induction, or after the

Perinatal Mortality	NICU Admission, Transfer, or Neonatal Length of Stay Greater Than Mother's	Respiratory Distress	Hyperbilirubinemia	Shoulder Dystocia	Macrosomia
0.2	6.2	1.4	12.8	1.6	9.3
0.1	4.7	1.4	13.6	1.6	5.6*
1.2	5.8	1.3	12.2	1.6	9.6
0.0‡	4.3*	1.0	13.1‡	1.4	7.9*
0.1	5.8	1.3	12.0	1.7	10.8
0.0‡	3.7*	0.8*	11.5	2.3‡	10.9*
0.1	5.9	1.4	12.1	1.8	12.5
0.1	4.0*	0.7*	12.5	2.1	13.9
0.2	6.0	1.5	12.1	2.0	14.0
0.2	6.6	1.7	15.9	1.3	7.7
0.0	5.0	1.7	17.1	1.5	4.0†
0.2	6.3	1.6	15.2	1.3	8.0
0.1	5.0	1.0	18.3*	1.5	5.2*
0.2	6.2	1.6	14.9	1.4	9.0
0.0‡	4.2*	1.0†	15.2	2.1	8.1*
0.2	6.3	1.7	14.7	1.5	10.6
0.1	4.4*	0.9†	15.9	1.8	11.3
1.2	6.4	1.9	14.6	1.8	12.4
0.2	5.8	1.1	10.1	1.8	10.7
0.1	4.6	1.4	12.1†	1.7	6.3*
0.1	5.4	1.0	9.5	1.7	11.1
0.0	4.0*	1.0	11.1†	1.4	9.0*
0.1	5.4	0.9	9.4	1.9	12.5
0.0	3.5*	0.7	9.8	2.3	12.3*
0.1	5.5	1.0	9.2	2.1	14.5
0.1	3.7*	0.5†	10.1	2.2	15.7
0.1	5.6	1.1	9.2	2.2	15.7

induction, in which case it is part of the risk of an elective induction. We therefore changed our assumptions in a sensitivity analysis where we retained intrapartum conditions that could plausibly follow elective induction in the elective induction group (see Appendix 1, http://links.lww.com/AOG/A431). All analyses were conducted using STATA 12. This study was approved by the California Office of Statewide Health Planning and Development, Oregon Health & Science University institutional review board, and the University of California, San Francisco Committee on Human Research.

RESULTS

The analytic sample included 362,154 term vertex singleton deliveries (46.5% nulliparas). Overall, 5.4% of all deliveries were identified as induced without a documented indication (elective), whereas 11.4% of included deliveries were identified as induced with a documented indication. At each term week of gestation, a greater proportion of women who were induced without medical indication were white, had private insurance, had completed high school, and had initiated prenatal care in the first trimester compared with expectant management (Table 1). A smaller proportion of women who were induced without medical indication delivered at a teaching hospital or were nulliparous compared with expectant management. Overall, the cesarean delivery rate was 16% (n=58,667) (26.5% among nulliparous women, 7.3% among multiparous women); perinatal mortality was 0.2% (n=706); and NICU admission, transfer, or a neonatal hospital stay greater than that of the mother was 6.2% (n=22,409). In bivariate analyses (Table 2), the proportion of cesarean deliveries was significantly larger at each gestational age in the expectant management groups (37 weeks of gestation 15.4% compared with 7.6%; 38 weeks of gestation 15.9% compared with 8.0%; 39 weeks of gestation 17.3% compared with 9.3%; 40 weeks of gestation 19.0% compared with 12.4%). The proportion of hyperbilirubinemia and shoulder dystocia in the elective induction groups was higher than in the expectant groups at 37 and 38 weeks and at 39 weeks of gestation, respectively. There was either no difference or a lower proportion of all other outcomes in the induction without medical indication groups than in the expectant management groups in bivariate analyses (Table 2).

Table 3. Maternal Outcomes: Association of Induction of Labor Without Medical Indication Compared With Expectant Management with Cesarean Delivery, Operative Vaginal Delivery, and Lacerations, California, 2006

Gestational Age Group (wk)	Model	Cesarean Delivery	Operative Vaginal Delivery	3rd- and 4th-Degree Lacerations
All deliveries				
37	305,099	0.44 (0.34–0.57)	0.72 (0.53–0.97)	0.66 (0.47–0.93)
38	245,006	0.43 (0.38–0.50	0.73 (0.55–0.97)	0.61 (0.50–0.75)
39	150,730	0.46 (0.41–0.52)	0.77 (0.63–0.95)	0.65 (0.55–0.78)
40	58,845	0.57 (0.50–0.65)	0.77 (0.66–0.89)	0.82 (0.68–10.0)
Nulliparous				
37	143,982	0.66 (0.49–0.89)	0.87 (0.64–1.19)	1.15 (0.81–1.63)
38	118,283	0.74 (0.63–0.87)	1.00 (0.81–1.27)	0.90 (0.71–1.15)
39	75,828	0.75 (0.67–0.83)	1.05 (0.86–1.27)	0.97 (0.81–1.16)
40	30,837	0.77 (0.67–0.88)	0.94 (0.79–1.11)	1.09 (0.90–1.32)
Prior vaginal only				
37	161,117	0.44 (0.30–0.63)	0.83 (0.23–1.31)	0.23 (0.06–0.91)
38	126,723	0.41 (0.33–0.52)	0.83 (0.55–1.24)	0.78 (0.53–1.16)
39	74,902	0.44 (0.37–0.53)	0.84 (0.65–1.10)	0.75 (0.52–1.09)
40	28,008	0.51 (0.40–0.65)	0.78 (0.60–0.99)	0.75 (0.47–1.20)

Data are n or odds ratio (95% confidence interval).

All models include the following covariates: maternal age (older than or younger than 35 y old), maternal education (high school completed or not), teaching hospital (yes or no), maternal race (five categories), prenatal care initiated in first trimester (yes or no), health insurance (none, public, private). Each week compares induction without medical indication that week with expectant management (delivery the next week or beyond, up to 42 completed wk of gestation).

Table 4. Neonatal Outcomes: Association of Induction of Labor Without Medical Indication Compared With Expectant Management with Perinatal Death, Neonatal Intensive Care Unit Admission, Respiratory Distress, Hyperbilirubinemia, Shoulder Dystocia, and Macrosomia, California, 2006

Gestational Age Group (wk)	Model	Perinatal Death	NICU Admission, Transfer, or Neonatal Length of Stay Longer Than Mother's	Respiratory Distress
All deliveries				
37	305,099	0.49 (0.07–3.50)	0.82 (0.61–1.10)	1.16 (0.71–1.90)
38	245,006	0.19 (0.03–1.30)	0.78 (0.67–0.92)	0.77 (0.54–1.08)
39	150,730	0.24 (0.06–0.94)	0.68 (0.59–0.78)	0.59 (0.46–0.76)
40	58,845	0.46 (0.15–1.43)	0.70 (0.59–0.83)	0.47 (0.34–0.65)
Nulliparous				
37	143,982		0.76 (0.48–1.22)	1.06 (0.51–2.19)
38	118,283		0.83 (0.63–1.09)	0.61 (0.34–1.08)
39	75,828		0.68 (0.55–0.86)	0.58 (0.36–0.91)
40	30,837		0.72 (0.55–0.93)	0.52 (0.33–0.82)
Prior vaginal only				
37	161,117		0.89 (0.64–1.23)	1.43 (0.82–2.49)
38	126,723		0.81 (0.68–0.97)	1.07 (0.73–1.57)
39	74,902		0.71 (0.60–0.84)	0.75 (0.54–1.02)
40	28,008		0.70 (0.57–0.87)	0.49 (0.29–0.83)

NICU, neonatal intensive care unit.

Data are n or odds ratio (95% confidence interval).

All models include the following covariates: maternal age (older than or younger than 35 y old), maternal education (high school completed or not), teaching hospital (yes or no), maternal race (five categories), prenatal care initiated in first trimester (yes or no), health insurance (none, public, private). Perinatal death model includes parity; small numbers precluded stratification.

Each week compares induction without medical indication that week with expectant management (delivery the next week or beyond, up to 42 completed weeks of gestation).

* The shoulder dystocia outcome includes only women with vaginal deliveries, because cesarean deliveries are not at risk for shoulder dystocia; model n is therefore smaller for this outcome.

The odds of cesarean delivery were significantly lower among women in the induction without medical indication group at 37 completed weeks of gestation (OR 0.44, 95% confidence interval [CI] 0.34–0.57), 38 weeks of gestation (OR 0.43, CI 0.38–0.50), 39 weeks of gestation (OR 0.46, CI 0.41–0.52), and 40 weeks of gestation (OR 0.57, CI 0.50–0.65) (Table 3). Although this relationship was especially strong among multiparous women, it held among nulliparous women at each week. We found reduced odds of operative vaginal deliveries among women induced without medical indication in the full sample but no differences between induction without a medical indication and expectant management in the odds of operative vaginal deliveries in analyses stratified by parity except at 40 weeks of gestation among multiparous women (OR 0.78, CI 0.60–0.99). We show similar results for third- or fourth-degree perineal lacerations.

Elective induction of labor was not associated with significantly higher odds of perinatal death, NICU admission, or respiratory distress at any gestational age or parity (we were unable to stratify by parity for perinatal death). However, we cannot rule out increased odds of NICU admission or respiratory distress at 37 and 38 weeks of gestation and shoulder dystocia at 37, 38, 39, and 40 weeks of gestation given wide CIs on these outcomes (Table 4). Elective induction was associated with increased odds of hyperbilirubinemia at 37 (OR 1.29, CI 1.05–1.59) and 38 (OR 1.17, CI 1.00–1.37) weeks of gestation among multiparous women and at 38 (OR 1.27, CI 1.06–1.53) weeks of gestation among nulliparous women and we cannot rule out increased risk at every gestation age (Table 4). Women undergoing induction without a medical indication had reduced odds of delivering a neonate with macrosomia up to 40 weeks of gestation, when there was no difference by group.

In sensitivity analyses, changing our classification scheme to include deliveries "at or above"[18] the week of induction did not alter our results (data not shown). Changing assumptions about the temporality of intrapartum indications did alter results for cesarean delivery, respiratory distress, and hyperbilirubinemia outcomes. Under this scenario, the elective induction group either moved toward the null (for cesarean delivery, respiratory distress) or showed increased risk (hyperbilirubinemia) (Appendix 2, available online at http://links.lww.com/AOG/A431).

DISCUSSION

In our analysis of women with term, singleton, vertex pregnancies in California, we found that induction of labor without medical indication was associated with reduced odds of cesarean delivery among both nulliparous and multiparous women at each term

Hyperbilirubinemia	Shoulder Dystocia*	Macrosomia
1.13 (0.94–1.35)	1.02 (0.68–1.54)	0.54 (0.42–0.69)
1.07 (0.94–1.22)	0.81 (0.60–1.09)	0.66 (0.57–0.75)
0.92 (0.83–1.01)	1.17 (0.96–1.43)	0.79 (0.72–0.87)
1.03 (0.91–1.16)	1.02 (0.80–1.31)	0.96 (0.87–1.06)
1.15 (0.86–1.53)	1.12 (0.47–2.66)	0.48 (0.30–0.80)
1.27 (1.06–1.53)	1.01 (0.60–1.72)	0.53 (0.41–0.70)
1.02 (0.89–1.16)	1.31 (0.86–1.98)	0.72 (0.60–0.85)
1.10 (0.94–1.29)	1.02 (0.65–1.60)	0.88 (0.76–1.03)
1.29 (1.05–1.59)	0.97 (0.60–1.57)	0.53 (0.40–0.69)
1.17 (1.00–1.37)	0.73 (0.53–1.01)	0.64 (0.55–0.73)
1.04 (0.90–1.19)	1.09 (0.86–1.38)	0.75 (0.67–0.83)
1.11 (0.95–1.29)	0.99 (0.76–1.32)	0.95 (0.84–1.08)

gestational age (37–40 weeks). We conducted sensitivity analyses, which included women in the elective induction group who had plausible intrapartum complications, rendering the induction group higher risk, and found that induction without medical indication was not associated with increased odds of cesarean delivery at any term gestational age and was still reduced, although attenuated, among multiparous women. In addition, we found that elective induction was not associated with increased perinatal mortality or NICU admission at any term gestational age (37–40 weeks) compared with expectant management.

This analysis extends previous observational studies of elective induction by including all term gestational weeks (37–40 weeks), stratifying by parity, and using a transparent method to classify elective induction and expectant management groups. Labor induction without a medical indication is complicated to study in observational data, and our methods improve on previous approaches. Evidence is mounting that elective induction does not increase risks of cesarean delivery and may actually reduce risks of certain outcomes; however, results depend on the analytical method used. Our findings generally support earlier studies that used expectant management comparison groups[19,25] despite differences in classifying induction cases, data sources, and exclusion criteria. Recently, there have been numerous attempts to reduce induction of labor without medical indication before 39 weeks of gestation and in some cases to reduce induction without an indication overall. Unfortunately, these efforts are based on a relatively limited literature and like many medical decisions, there are likely tradeoffs in the use of induction of labor without medical indication.[26] For example, Ehrenthal and colleagues[7] reported that although NICU rates declined after an institutional policy change to restrict elective deliveries at less than 39 completed weeks of gestation, rates of macrosomia and stillbirth increased.

Our sensitivity analyses, which varied assumptions about the timing of indications and thus about the relative risks inherent in expectant management and induction without prior indication, demonstrate the importance of temporality assumptions in retrospective analyses. Our main analysis is conceptually sound, assuming that intrapartum conditions are an inherent risk of expectant management. Our data, however, do not provide temporality of complications that would most commonly occur intrapartum (eg, chorioamnionitis, fetal heart rate abnormalities). Furthermore, the need for a consensus set of medical indications and associated International Classification of Diseases, 9th Revision, Clinical Modification codes for induction will become more pressing as research continues to focus on nonmedically indicated deliveries as a quality metric.[27,28] Prospective data collected for research purposes are necessary to arrive at a conclusive answer, but this analysis points to potential reasons that prior prospective and retrospective work has been so divergent.

This analysis is subject to the limitations of all observational studies. We rely on vital statistics and hospital discharge data sources, which were not designed to answer our study question and likely lead to some misclassification. Gestational age dating using last menstrual period is subject to error but has shown high concordance with clinical estimate dating at term (37–41 weeks of gestation).[29] International Classification of Diseases, 9th Revision, Clinical Modification codes, although better than vital statistics alone to study obstetric management,[20] have varying validity for both induction and medical indications. We have likely missed some inductions (if the procedure was not recorded in the hospital discharge data) and also misclassified some inductions as nonmedically indicated (if medical indications were not recorded) or as medically indicated (if indications were recorded in error). This could bias our results to favor elective induction (if more women are misclassified from elective induction to indicated induction than from indicated to elective). We have controlled for measured variables in our multivariable analyses, but we recognize that there could be additional unmeasured confounders (eg, patient preferences and other health behaviors) and that the distribution of characteristics we were able to measure suggests possible "healthy user" bias (eg, induced women have higher education and earlier prenatal care, which may go along with other health-seeking behaviors). We used The Joint Commission list of indications and codes; although this definition may misclassify some women it is a standard for reporting, and we need to understand how it shapes classification and estimation of outcomes. Although we have a large data set, we report wide uncertainty estimates for rare outcomes such as perinatal mortality and may require a larger sample to compute a more precise estimate. We account for data clustering at the hospital level but do not have information about usual care at each hospital, which could inform observed induction or cesarean delivery rates. We have no data on cervical status, which has been found to be important in the relationship of induction without medical indication and cesarean delivery, although it has very limited ability to predict whether induction will result in a vaginal delivery.[30] Finally, we were unable to identify planned and unplanned repeat cesarean delivery and thus could not include this group in our analysis.

In conclusion, we present evidence that induction without medical indication at term (37–40 weeks of gestation) is associated with reduced odds of cesarean delivery among both nulliparous and multiparous women with a previous vaginal delivery. This holds for multiparous women at 38 and 39 completed weeks of gestation even when we vary assumptions about the timing of intrapartum indications. With the exception of hyperbilirubinemia at early-term gestational ages, we find no evidence of any other increased adverse maternal or neonatal outcomes with elective induction. Focus on induction of labor as a quality metric in obstetrics must be evidence-based. The use of a standard method to classify induction without medical indication and use of the appropriate comparison groups by researchers would permit comparison across studies and improve our ability to draw conclusions about the effect of elective induction on maternal and neonatal health.

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