Published in final edited form as:
Obstet Gynecol. 2010 November ; 116(5): 1047–1055. doi:10.1097/AOG.0b013e3181f73f97.

Precursors for Late Preterm Birth in Singleton Gestations

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Abstract

Objectives—Previous studies have investigated the consequences of late preterm birth between 34 – 36 weeks gestation, but less is known about the "indicated" reasons and potential differences in neonatal outcomes from various delivery indications. . In singletons, we characterized precursors for late preterm birth and incidences of neonatal morbidities and perinatal mortality by gestational age and precursor.

Methods—Using retrospective observational data, we compared 15,136 gestations born late preterm to 170,593 deliveries between 37 0/7 and 41 6/7 weeks. We defined the following categories of precursors for late preterm delivery: "spontaneous labor", "premature rupture of the membranes (preterm PROM)", "indicated" delivery and "unknown." Incidences of neonatal morbidities were calculated according to category of precursor stratified by gestational age at delivery. Neonatal morbidities and mortality associated with potentially avoidable deliveries (e.g. "soft" precursors or elective) were compared between late preterm births and neonates born at 37 – 40 weeks.

Results—Late preterm birth comprised 7.8% of all births and 65.7% of preterm births. Percentages of precursors were 29.8% spontaneous labor, 32.3% preterm PROM, 31.8% indicated and 6.1% unknown. Different precursors for delivery were associated with varying incidences of neonatal morbidity. One in 15 neonates delivered late preterm for "soft" or elective precursors, and neonatal morbidity and mortality were increased compared to delivery ≥ 37 weeks for these same indications

Conclusion—A significant number of late preterm births were potentially avoidable Elective deliveries should be postponed until 39 weeks' gestation. More prospective data is needed to guide which indications can be managed expectantly.

INTRODUCTION

The overall rate of preterm birth < 37 weeks of gestation for singletons increased from 9.7% in 1990 to 11.0% in 2005, which was entirely due to the increase in preterm births between 34 – 36 weeks gestation, designated as "late preterm" by the 2005 National Institute of Child Health and Human Development of the National Institute of Health workshop.[1, 2] Goldenberg et al have defined the obstetric "precursors" for preterm birth to be spontaneous preterm labor with intact membranes, preterm premature rupture of membranes (preterm PROM), and delivery for maternal or fetal indications, known as "medically indicated".[3] The reason for the increase in late preterm births among singletons is secondary to an

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This research was accepted as a poster presentation at the Annual Meeting of the Society for Pediatric and Perinatal Epidemiologic Research, Seattle, WA, June 23, 2010.

increase in medically indicated deliveries, rather than spontaneous labor or preterm PROM.4 Prior research on late preterm neonates has focused on their physiologic immaturity with associated higher morbidities and mortality compared to neonates born ≥ 37 weeks gestation.[2, 5–8] Less is known about the medical indications for late preterm delivery with only individual institutions reporting indications for a small number of women.[9] It is important to know which medical indications for delivery have been driving the national increase in late preterm birth, because neonatal outcomes likely differ depending upon the underlying pathophysiology of the pregnancy complication. It has also been shown that the actual indication for delivery is a factor in neonatal mortality.[10]. Additionally, medical and obstetrical indications for delivery are heterogeneous and the evidence to guide the timing of delivery in certain pregnancy conditions is limited. There likely are some indications that can be expectantly managed with delivery ≥ 37 weeks to decrease the risk of neonatal morbidity and mortality without a significant increase in stillbirth..[2, 5–8]

We sought to provide epidemiologic data from the Consortium on Safe Labor which reflects current obstetrical practice in the United States First, we quantified the proportion of different precursors for late preterm birth, with indicated deliveries further characterized by the individual medical and obstetrical complications. We also calculated the incidence of neonatal morbidities and mortality by gestational age for the different precursors of late preterm birth. Finally, we wanted to further explore the morbidities associated with the proportion of deliveries that were potentially preventable.

MATERIALS AND METHODS

The Consortium on Safe Labor was a study conducted by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health and has been described in detail elsewhere.[11] In brief, this was a retrospective cohort study involving 228,668 deliveries from 12 clinical centers and 19 hospitals representing 9 American Congress of Obstetrics and Gynecology (ACOG) districts. Women gave birth between 2002 and 2008. Institutional Review Board approval was obtained by all participating institutions. Women could have more than one pregnancy in the cohort, so to avoid intra-person correlation we only included the first pregnancy for a total of 206, 969 women. One site that did not include indications for induction was excluded. There were 16,910 deliveries between 34 0/7 and 36 6/7 weeks gestation. Of the late preterm births, 15,136 were singletons and 1,774 were multiple gestations (1,712 twin, 61 triplet, 1 quadruplet). We compared the 15,136 singleton gestations born late preterm to 170,593 singleton deliveries between 37 0/7 and 41 6/7 weeks gestation.

Demographic data, medical history, labor and delivery information as well as obstetrical, post partum and neonatal outcomes were extracted from patient electronic medical records from each institution. Data from the neonatal intensive care unit was collected and linked to the newborn record. Maternal and newborn discharge ICD-9 codes were also collected for each delivery. Data was transferred in electronic format from each site and was mapped to common categories for each pre-defined variable at the data coordinating center. Investigators at each site completed surveys on hospital and physician characteristics. Data inquiries, cleaning and logic checking were performed. Validation studies were performed for four key outcome diagnoses and the electronic medical records were found to be a highly accurate representation of the medical charts (> 95% for the majority of variables).[11]

We defined the following categories of precursors for late preterm delivery: “spontaneous labor”, “preterm PROM)”, “indicated” delivery and “unknown.” The admission reason and indication for induction or cesarean delivery were used to identify the precursors for delivery. We identified any other maternal, fetal, obstetrical or demographic variables

associated with the outcome of the pregnancy. We classified the precursors for delivery using the following hierarchy. Women who presented in spontaneous labor were included only in the "spontaneous preterm birth" category even if they had other pregnancy complications (e.g. maternal diabetes). Women with premature rupture of the membranes and not in labor were included as "preterm PROM". Thus, if a women presented with both preterm PROM and in spontaneous labor she was counted only once in the "spontaneous labor" category. If a woman did not present in spontaneous labor or with preterm PROM, we then identified all potential maternal, fetal or obstetrical complications of pregnancy, and included these in the "indicated" category. A woman could have more than one pregnancy condition in the "indicated" category. If there was no other reason, then we identified those women who were admitted to labor and delivery for an unspecified "fetal" or "maternal" reason and not in spontaneous labor or preterm PROM. These two categories were the only ones in the "indicated" category that were exclusive, and are specified as "Admission for fetal reason, not otherwise specified", or "Admission for maternal reason, not otherwise specified". The "unknown" category included elective inductions or cesarean sections as identified by the site with no other obstetrical, fetal or maternal conditions, as well as if there was no reason for induction or cesarean section provided and there were no other obstetrical, fetal or maternal conditions of the pregnancy.

We calculated the incidence of neonatal outcomes according to category of precursor of late preterm delivery stratified by the gestational age at delivery. Finally, we identified precursors for preterm delivery that could have been managed to deliver until 37 weeks of gestation and then potentially up to 40 weeks of gestation according to available evidence and expert opinion, and re-categorized these as "soft precursors". Soft precursors included suspected macrosomia without maternal diabetes12; uncomplicated gestational13 and chronic hypertension[14]; and history of fetal, maternal or obstetrical complication in a prior pregnancy (e.g., history of preeclampsia in a previous pregnancy). We also identified "elective" induction or cesarean delivery as indicated by the site, with no other fetal, maternal or obstetrical complication. For late preterm birth, the soft precursors category came from both the original "indicated" and "unknown" categories. We did not include spontaneous labor or preterm PROM because those were likely the indications for the preterm delivery (i.e., soft indications without spontaneous or preterm PROM).

In order to examine how delaying delivery for women with a soft precursor would affect neonatal outcomes, we considered that a woman with a soft indication might either be delivered late preterm or expectantly managed until term. We compared neonatal morbidity and mortality between late preterm births for a soft indication and neonates born at 37 – 40 weeks of gestation with the same array of (soft) precursors. For pregnancies ≥ 37 weeks of gestation, a woman with a soft precursor who was being expectantly managed could have gone into spontaneous labor or had rupture of membranes. Thus, we included all women at term with a soft precursor at that gestational week of delivery for comparison (i.e., soft precursors with or without spontaneous or PROM). Stillbirths at term were also included in the comparison group.

We performed logistic regression to calculate the odds ratios for neonatal morbidities (oxygen use, transient tachypnea of the newborn, mechanical ventilation, respiratory distress syndrome, apnea, pneumonia or sepsis, and admission to the NICU) and perinatal mortality with delivery at 37, 38, 39, or 40 weeks gestation compared to delivery at 34–36 weeks of gestation (the referent group) in women with a soft or elective precursor for delivery. We combined 34–36 weeks gestation together as the referent group because our goal was not to show the difference between neonatal outcomes at 34, 35 and 36 weeks gestation, but rather to investigate whether neonatal outcomes improve with each advancing week of delivery beyond preterm. A backwards elimination was performed and variables considered included

maternal race, parity, body mass index, type of insurance, and smoking. All variables were significant with a *P*-value < .05 and therefore were adjusted for in the final model. Chi-square, Cochran-Armitage test for trend, analysis of variance and Kruskal-Wallis tests were also performed where appropriate. Statistical analysis was performed using SAS (SAS Institute Inc., Cary, NC) version 9.1.

RESULTS

The 15, 136 deliveries between 34 0/7 and 36 6/7 weeks gestation comprised 7.8% of all births and 65.7% of preterm births among singleton gestations. The characteristics of the women, their infants and the delivery are presented in Table 1. Women who had a spontaneous preterm birth and preterm PROM had a higher percentage of maternal age < 18 years old, BMI < 25.0 kg/m^2, and single status than women with indicated or unknown precursors or women who delivered at term. The cesarean section rate was twice as high for women with an indicated or unknown reason for late preterm birth (56.1% and 53.4%, respectively) compared to spontaneous preterm birth (22.0%), preterm PROM (23.2%) or women who delivered at term (27.0%). Birth weight < 2500 g was most frequent in indicated births (42.3%), but also more frequent in deliveries due to preterm PROM (36.0%) compared to spontaneous preterm labor (28.5%). When stratified by gestational week at delivery, the mean birth weight was 69, 54 and 59 g higher at 34, 35, and 36 weeks gestation, respectively for spontaneous preterm labor compared to preterm PROM (*P* < .001). There was not a clear association for physician age and precursors for late preterm delivery.

The percentage of precursors for late preterm births was 29.8% for spontaneous labor and 32.3% for preterm PROM. Another 31.8% of the late preterm births had an obstetrical, maternal or fetal condition ("indicated"). There were 6.1% with an "unknown" precursor, of which 175 (19.1%) were elective and 740 (80.9%) had no obstetrical, fetal or maternal conditions. With increasing gestational age at delivery the percentage of spontaneous labor and unknown precursors increased and the percentage of preterm PROM and indicated reasons decreased (Table 2). Hypertensive disease was the most frequent condition for indicated late preterm birth, comprising 47.7% of indicated deliveries and 15.2% of all late preterm births. A maternal condition was the second most frequent complication of indicated late preterm birth (31.5%), followed by a fetal condition (29.7%).

Respiratory morbidity and neonatal sepsis, as well as admission to the neonatal intensive care unit (NICU) and median NICU length of stay all decreased with advancing gestational age, regardless of the reason for late preterm delivery (Table 3). There were very few cases of seizures and intracranial hemorrhage (ICH) at these gestational ages with no obvious gestational age effect. Neonates that were delivered due to complications of preterm PROM had decreased severe respiratory morbidity, including decreased mechanical ventilation and respiratory distress syndrome, compared to neonates that were delivered for the other categories. Indicated deliveries had a higher incidence of newborn sepsis and neonatal death at 35 and 36 weeks compared to the other categories, and a higher incidence of admission to the NICU at every gestational age compared to the other categories.

From the original "indicated" category, there were 869 (18.0%) deliveries for soft precursors and from the "unknown" category there were 175 (19.1%) elective deliveries with no other maternal, fetal or obstetrical complication, and together these 1044 soft or elective precursors comprised 6.9%, or approximately 1 in 15, of all late preterm deliveries (Table 4). The adjusted risk of oxygen use, transient tachypnea of the newborn (TTN), mechanical ventilation, respiratory distress syndrome, pneumonia or newborn sepsis, and admission to

the NICU all were significantly decreased for neonates with soft or elective precursors delivered at 37, 38, 39 and 40 weeks gestation compared to late preterm.

DISCUSSION

Our large scaled study provides detailed information on precursors for late preterm births and associated neonatal outcomes. Spontaneous preterm birth, including spontaneous labor and preterm premature rupture of membranes, accounted for approximately two thirds of all late preterm births, while another third had an indicated precursor. A small percentage had no identifiable precursor. Some of these cases may be due to underreporting of maternal or fetal conditions; however given the large number of different variables collected and our conservative effort to exclude all possible conditions, a certain proportion of these deliveries with an unknown precursor were likely truly elective. When combining pregnancies with a "soft" precursor for delivery or elective as indicated by the site with no other pregnancy complications, at least 1 in 15 of all late preterm births potentially could have been expectantly managed until 39 weeks gestation.

When obstetrical or maternal complications of pregnancy occur, caregivers have to balance the risks and benefits of delivery versus expectant management for the maternal, fetal and neonatal health in order to determine the optimal time for delivery. Our findings suggest that if delivery for women with a soft or elective precursor is delayed until 39 weeks gestation, then neonatal morbidities may be decreased. In addition, current obstetrical practice is to perform an amniocentesis to document fetal lung maturity before elective deliveries less than 39 weeks. We did not have this data available; however, it is important to note that morbidities other than respiratory were still significantly decreased with delivery at gestational ages beyond 37 weeks compared to late preterm in deliveries with elective or soft precursors. Expectant management of these soft precursors was not associated with an increased risk of stillbirth or neonatal mortality in this study, and in fact is likely to be associated with a decreased risk of neonatal mortality.

It is not surprising or new that respiratory morbidity and neonatal sepsis, as well as admission to the neonatal intensive care unit (NICU) and median NICU length of stay all decreased with advancing gestational age.[5–7] However, the incidence of neonatal morbidities varied depending on the precursor for late preterm delivery. The differences in neonatal outcomes by type of precursor suggest that the underlying pathology for precursors is an important determining factor in neonatal morbidity. The precursor may directly affect neonatal risks, such as infection being more common in preterm PROM compared to spontaneous labor, as well as indirectly affect neonatal risks by influencing labor patterns and delivery route. For example, the lower rate of cesarean delivery for preterm PROM compared to indicated or unknown precursors may explain the lowest incidence of respiratory morbidity with this precursor. ., It has also been suggested that the increased NICU admissions in preeclampsia at term are due to a high induction of labor and subsequent high cesarean section rate.15 Prolonged inductions with an unfavorable cervix also could increase the risk of chorioamnionitis and neonatal infections.

Our study is limited because we extrapolated the precursors for medically indicated delivery from indications for induction and cesarean delivery, which were not always provided. Thus, we were conservative and supplemented the precursors with any other medical, obstetrical or fetal conditions, even though those may not have been the actual indication for delivery. In addition, we were unable to determine whether an indication was a soft indication in certain conditions, such as small for gestational age with reassuring antenatal testing (normal nonstress test, biophysical profile score, amniotic fluid, and Doppler). Therefore, the true incidence of soft or elective precursors was likely higher than we have reported. This is

supported by a recent study at a single center where 8.8% of the late preterm births were delivered for a mild stable condition, and an additional 8.2% were elective.[16] Neonatal death was also not completely captured in our dataset, because neonatal deaths after hospital discharge could not be collected. However, this is a rare occurence. Finally, the gestational age at delivery was the best obstetrical estimate as determined by the clinician and transferred by the site. The study did not collect information on the accuracy of dating. However, this study represents current obstetrical practice in the United States, so our findings can be extrapolated to a population where best obstetrical estimating for gestational age is practiced.

Our results regarding risk of neonatal morbidities for soft or elective precursors should be interpreted with caution, because we are applying cross-sectional data to a longitudinal outcome. In a prospective study, women with a soft precursor for delivery would be identified at late preterm and randomized to delivery versus expectant management. We did not know the timing of diagnosis for hypertensive disease, and therefore excluded women between 34 – 36 weeks with a soft precursor who had preterm labor or rupture of membranes, and we also included women at term that may have developed gestational hypertension after 36 weeks gestation. However, we performed a sensitivity analysis for the most common soft precursor, hypertensive disease, and assumed the, “worst case scenario”, that all women who developed severe disease had developed gestational hypertension between 34–36 weeks and were expectantly managed. While the incidence of neonatal morbidities were slightly higher in this group, the odds ratios from logistic regression were similar, thus supporting our findings that if delivery for women with a soft or elective precursor was delayed until term then neonatal morbidities may be decreased. In the absence of a randomized controlled trial, these are the best data we have from an observational study, and our findings support previous demonstration of decreased neonatal morbidities with delivery at later gestational ages.[5–7]

Our large, nationally representative cohort study provides epidemiologic data on the precursors for late preterm birth in current obstetrical practice in the United States that can be used to target future prevention strategies for preterm delivery. Different reasons for delivery in the late preterm period were associated with differing rates of neonatal morbidity which affects counseling regarding the risks and benefits of late preterm delivery. There were a significant number of women with a soft or elective precursor for delivery, and both neonatal morbidity and perinatal mortality may be decreased in those neonates delivered ≥ 37 weeks gestation compared to late preterm. We conclude that elective deliveries should be postponed until 39 weeks gestation. More prospective data is needed and guidelines should be developed to help providers and women decide which soft precursors can be managed expectantly.

Précis

Spontaneous labor, preterm premature rupture of membranes and indicated deliveries each account for about 30% of late preterm births; the remaining 6% are potentially avoidable.

Acknowledgments

The data included in this paper were obtained from the Consortium on Safe Labor, which was supported by the Intramural Research Program of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health, through Contract No. HHSN267200603425C. Institutions involved in the Consortium include, in alphabetical order: Baystate Medical Center, Springfield, MA; Cedars-Sinai Medical Center Burnes Allen Research Center, Los Angeles, CA; Christiana Care Health System, Newark, DE; Georgetown University Hospital, MedStar Health, Washington, DC; Indiana University Clarian Health, Indianapolis, IN;

Intermountain Healthcare and the University of Utah, Salt Lake City, Utah; Maimonides Medical Center, Brooklyn, NY; MetroHealth Medical Center, Cleveland, OH.; Summa Health System, Akron City Hospital, Akron, OH; The EMMES Corporation, Rockville MD (Data Coordinating Center); University of Illinois at Chicago, Chicago, IL; University of Miami, Miami, FL; and University of Texas Health Science Center at Houston, Houston, Texas.

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Table 1

Characteristics of the women, their infants, and delivery according to precursors of delivery.

	Term Birth n = 170,593	Late Preterm Birth* n = 15,136			
Characteristic		**Spontaneous n = 4,508 %**	**PPROM n = 4,895 %**	**Indicated n = 4,818 %**	**Unknown n = 915 %**
Maternal age – year					
<18	3.2	5.2	4.1	2.9	1.7
18–34	81.6	82.6	78.5	76.8	78.7
≥ 35	15.0	12.1	17.3	20.2	19.3
Missing	0.2	0.1	0.1	0.1	0.2
Body mass index at delivery - kg/m^2					
< 25.0	11.1	22.6	14.8	9.4	10.2
25.0 – 29.9	30.7	31.5	28.9	21.0	21.1
≥ 30.0	37.2	32.1	36.1	47.2	24.7
Missing	21.0	13.8	20.2	22.4	44.0
Race or ethnic group					
White/non-Hispanic	50.3	44.2	43.5	43.6	50.3
Black/non-Hispanic	20.7	27.6	28.5	30.0	25.1
Hispanic	17.5	19.3	17.2	17.2	16.0
Asian/Pacific-Islander	4.4	3.3	3.6	3.2	3.6
Other/ Unknown	7.0	5.6	7.1	6.0	5.0
Marital status					
Married	60.6	51.9	50.2	54.7	56.2
Divorced/widowed	1.5	2.2	2.3	2.4	2.6
Single	34.7	43.5	43.6	39.7	36.7
Unknown	3.1	2.4	3.9	3.2	4.5
Insurance type					
Private	58.0	44.7	52.7	53.6	54.6
Public	29.9	41.3	34.1	37.6	35.1
Self pay	1.2	1.7	1.4	1.2	1.3
Other	11.0	12.3	11.8	7.6	9.0
Parity					

Characteristic	Term Birth n = 170,593	Late Preterm Birth* n = 15,136			
		Spontaneous n = 4,508 %	PPROM n = 4,895 %	Indicated n = 4,818 %	Unknown n = 915 %
Nulliparous	44.0	33.2	51.8	43.6	32.8
1	29.0	29.8	23.2	26.0	30.9
2+	27.0	37.0	25.0	30.4	36.3
History of preterm birth					
Yes	5.3	20.6	13.6	16.5	22.3
No/ Unknown	94.7	79.4	86.4	83.5	77.7
History of cesarean delivery					
Yes	12.5	15.1	9.2	19.7	33.7
No/ Unknown	87.5	84.9	90.8	80.3	66.3
Smoker					
Yes	5.8	9.2	9.6	7.6	11.3
No/ Unknown	94.2	90.8	90.4	92.4	88.7
Cesarean delivery	27.0	22.0	23.2	56.1	53.4
Birth weight – grams					
< 2500	2.3	28.5	36.0	42.3	30.4
2500 to < 4000	88.7	69.7	61.9	54.1	68.3
≥ 4000	8.0	0.5	0.6	1.7	0.2
Unknown	1.0	1.3	1.5	1.9	1.1
Birth attendant					
Attending	81.8	85.2	80.7	88.1	88.2
Midwife	5.3	2.8	4.4	0.8	0.2
Attending and midwife	11.3	10.3	13.6	8.8	3.7
Unknown	1.6	1.7	1.3	2.3	7.9
Physician age – years					
< 40	23.1	28.4	25.5	24.6	17.3
40 – 49	31.4	30.1	32.2	35.8	38.1
50 – 59	20.9	19.6	18.8	17.1	15.4
≥ 60	11.3	11.1	10.6	11.1	10.7
Unknown	13.3	10.8	12.9	11.4	18.5
Hospital type					

Obstet Gynecol. Author manuscript; available in PMC 2011 January 3.

Characteristic	Term Birth n = 170,593	Late Preterm Birth* n = 15,136			
		Spontaneous n = 4,508 %	PPROM n = 4,895 %	Indicated n = 4,818 %	Unknown n = 915 %
University	39.2	51.4	46.3	48.0	36.3
Community teaching	52.3	40.3	47.3	48.0	61.5
Community non-teaching	8.4	8.4	6.4	4.0	2.2
Region					
West	33.5	32.8	28.7	20.7	18.1
Midwest	11.4	13.6	19.2	12.3	11.0
South	30.5	40.2	32.9	44.6	28.9
Northeast	24.8	13.4	19.3	22.4	42.0

PPROM, preterm premature rupture of the membranes.

All data are presented as percents. Late preterm birth includes singleton gestations born between 34 0/7 and 36 6/7 weeks gestation. Term birth includes singleton gestations born between 37 0/7 and 41 6/7 weeks gestation.

*P-value is < .001 by Chi-square for all comparisons of characteristics between the four precursor categories of late preterm birth.

Table 2

Precursors for late preterm birth according to completed week of gestation at delivery.

Precursor for delivery	Total n = 15,136 %	34 weeks n = 2,592 %	35 weeks n= 4,115 %	36 weeks n = 8,429 %	*P* for trend
Spontaneous labor	29.8	22.9	29.5	32.0	< .001
PPROM	32.3	37.6	34.2	29.8	< .001
Indicated *	31.8	34.3	31.3	31.3	.01
Chorioamnionitis	0.8	0.9	0.7	0.9	.9
Decidual hemorrhage / abruption	6.8	8.8	8.5	5.2	< .001
Placenta previa	5.4	7.4	5.1	4.8	.006
Hypertensive disease	47.7	51.6	51.2	44.8	< .001
Gestational Hypertension	9.8	8.7	9.1	10.5	.07
Preeclampsia	18.8	21.7	21.9	16.3	< .001
Superimposed preeclampsia	8.4	11.0	9.3	7.1	< .001
Eclampsia	0.6	0.2	0.7	0.7	.2
Chronic hypertension	3.7	3.5	3.6	3.9	.6
Unspecified	6.4	6.5	6.6	6.3	.7
Maternal condition†	31.5	26.0	31.4	33.4	< .001
Diabetes	5.9	2.9	5.2	10.4	.1
Fetal anomaly	16.8	20.5	17.5	15.1	< .001
Antepartum stillbirth	1.7	3.3	1.9	1.0	< .001
Suspected fetal macrosomia	1.4	0.6	1.3	1.7	.02
Fetal condition‡	29.7	27.3	30.1	30.3	.1
Maternal fever on admission	1.0	0.8	0.9	1.1	.4
Admission for fetal reason, not otherwise specified¶	0.7	0.5	0.6	0.8	.2
Admission for maternal reason, not otherwise specified¶	1.2	1.9	1.0	1.1	.09
History of maternal/obstetrical Condition§	0.2	0.2	0.2	0.2	.9
History of fetal condition§	4.2	3.6	4.3	4.3	.4
Unknown	6.1	5.2	5.0	6.9	< .001

PPROM, preterm premature rupture of the membranes.

*Categories for the “indicated” precursors can add up to > 100 % because women could have more than one pregnancy condition.

[†] Maternal conditions included maternal medical problems such as diabetes (percent of women with diabetes who had an indicated precursor is listed), cardiac disease, etc.

[‡] Fetal conditions included conditions such as intrauterine growth restriction, abnormal antenatal testing.

[§] History of maternal/obstetrical or fetal conditions included pregnancy complications in a prior pregnancy (e.g. “traumatic first delivery” or “history of fetal demise”, respectively).

[¶] Admission for fetal or maternal/obstetrical reasons were included only if there was no other pregnancy condition. These are the only two indicated categories that are exclusive of other indications.

Obstet Gynecol. Author manuscript; available in PMC 2011 January 3.

Table 3

Incidence of neonatal outcomes by precursor of late preterm delivery stratified by gestational age at delivery.

Outcomes	Spontaneous labor %	PPROM %	Indicated %	Unknown %
Neonatal death				
34 weeks	1.7	0.6	1.6	0.0
35 weeks	0.2	0.0	1.0	0.0
36 weeks	0.3	0.4	0.6	0.2
P	<.001	.6	.004	.5
Oxygen use				
34 weeks	41.1	31.0	35.8	35.1
35 weeks	39.0	24.7	32.9	26.0
36 weeks	28.7	22.8	31.1	23.2
P	<.001	<.001	.01	.007
Transient tachypnea of the newborn				
34 weeks	15.7	16.1	17.2	17.9
35 weeks	10.8	10.2	14.7	13.7
36 weeks	6.6	6.2	9.1	11.8
P	< .001	< .001	< .001	.06
Mechanical ventilation				
34 weeks	12.1	9.4	12.7	16.4
35 weeks	7.7	4.8	9.1	5.9
36 weeks	3.9	2.5	5.4	4.2
P	<.001	<.001	<.001	<.001
Respiratory distress syndrome				
34 weeks	17.2	16.2	19.9	23.1
35 weeks	11.2	7.9	12.8	15.2
36 weeks	5.1	3.0	6.7	5.7
P	<.001	<.001	<.001	<.001
Apnea				
34 weeks	9.9	12.2	14.8	15.7
35 weeks	3.2	4.3	6.8	5.9
36 weeks	1.6	1.6	2.8	2.1
P	<.001	<.001	<.001	<.001
Pneumonia				
34 weeks	1.5	2.3	1.2	1.5
35 weeks	2.5	2.2	1.7	2.5
36 weeks	1.2	1.1	1.1	1.2
P	.09	.004	.5	.5

Outcomes	Spontaneous labor %	PPROM %	Indicated %	Unknown %
Newborn sepsis				
34 weeks	8.6	12.0	10.5	13.4
35 weeks	6.0	6.2	7.1	4.4
36 weeks	3.1	3.5	4.2	2.4
P	<.001	<.001	<.001	<.001
Seizure				
34 weeks	0.7	0.2	0.6	1.5
35 weeks	0.2	0.2	0.8	0.0
36 weeks	0.2	0.4	0.4	0.0
P	.1	.3	.3	.004
Intracranial hemorrhage				
34 weeks	0.5	0.6	0.6	0.7
35 weeks	0.2	0.1	0.2	0.0
36 weeks	0.1	0.4	0.5	0.3
P	.06	.5	.9	.7
Admission to the NICU				
34 weeks	59.5	63.1	72.3	70.1
35 weeks	34.9	35.4	48.9	46.6
36 weeks	18.3	17.5	29.4	25.3
P	<.001	<.001	<.001	<.001
NICU length of stay – days, Median (range)				
34 weeks	11.0 (0–124)	10.0 (0–166)	12.0 (0–172)	12.9 (0–84)
35 weeks	8.3 (0–272)	7.0 (0–138)	7.8 (0–97)	8.0 (0–32)
36 weeks	6.0 (0–193)	5.0 (0–134)	6.0 (0–217)	5.0 (0–91)
P	<.001	<.001	<.001	<.001

PPROM, preterm premature rupture of membranes; NICU, neonatal intensive care unit. Fetal anomalies were excluded. *P*-value is for trend by Cochran-Armitage test except for NICU length of stay where *P*-value is by Kruskal-Wallis test.

Table 4

Risk of neonatal outcomes for soft or elective precursors for delivery by gestational age at delivery.

	Referent group 34–36 weeks	37 weeks		38 weeks		39 weeks		40 weeks	
	n (%) 1044	n (%) 989	Adjusted OR (95% CI)	n (%) 1755	Adjusted OR (95% CI)	n (%) 2228	Adjusted OR (95% CI)	n (%) 1118	Adjusted OR (95% CI)
Stillbirth or neonatal death	5 (0.5)	3 (0.3)	0.61 (0.14– 2.62)	4 (0.2)	0.49 (0.13– 1.87)	1 (0.0)	0.09 (0.01– 0.79)	3 (0.3)	0.50 (0.11– 2.17)
Oxygen use	395 (37.8)	335 (33.9)	0.73 (0.61– 0.89)	568 (32.4)	0.67 (0.57– 0.79)	686 (30.8)	0.64 (0.54– 0.75)	321 (28.7)	0.63 (0.52– 0.76)
Transient tachypnea of the newborn	95 (9.1)	47 (4.8)	0.52 (0.36– 0.74)	43 (2.5)	0.26 (0.18– 0.38)	50 (2.2)	0.24 (0.17– 0.34)	27 (2.4)	0.27 (0.17– 0.42)
Mechanical ventilation	61 (5.8)	14 (1.4)	0.20 (0.11– 0.37)	6 (0.3)	0.05 (0.02– 0.11)	9 (0.4)	0.05 (0.03– 0.11)	3 (0.3)	0.04 (0.01– 0.13)
Respiratory distress syndrome	83 (8.0)	16 (1.6)	0.17 (0.10– 0.30)	5 (0.3)	0.03 (0.01– 0.07)	14 (0.6)	0.06 (0.04– 0.11)	6 (0.5)	0.06 (0.03– 0.14)
Apnea	45 (4.3)	6 (0.6)	0.15 (0.06– 0.35)	7 (0.4)	0.09 (0.04– 0.21)	7 (0.3)	0.08 (0.03– 0.17)	7 (0.6)	0.15 (0.07– 0.34)
Pneumonia or newborn sepsis	48 (4.6)	15 (1.5)	0.32 (0.18– 0.58)	16 (0.9)	0.19 (0.11– 0.33)	19 (0.9)	0.17 (0.10– 0.30)	11 (1.0)	0.20 (0.10– 0.39)
Admission to the NICU	300 (28.7)	93 (9.4)	0.27 (0.21– 0.35)	98 (5.6)	0.16 (0.12– 0.20)	130 (5.8)	0.16 (0.13– 0.21)	62 (5.5)	0.15 (0.12– 0.21)
NICU length of stay – Days, median (range)	7.7 (0–166)	5.0 (0–8)		3.0 (0–38)		3.7 (0–33)		3.0 (0–13)	

Soft precursors included suspected macrosomia without maternal diabetes; uncomplicated gestational or chronic hypertension; history of fetal, maternal or obstetrical complication in a prior pregnancy; and “elective” induction or cesarean section as indicated by the site with no other fetal, maternal or obstetrical complication. Fetal anomalies were excluded. Odds ratios were adjusted for maternal race, parity, body mass index, type of insurance, and smoking.