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Maternal and Neonatal Outcomes With Early Compared With Delayed Pushing Among Nulliparous Women

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Abstract

Objective—To describe factors associated with delayed pushing and evaluate the relationship between delayed pushing and perinatal outcomes in nulliparous women with singleton term gestations.

Methods—This was a secondary analysis of NICHD Assessment of Perinatal Excellence (APEX) cohort of 115,502 women and their neonates born in 25 U.S. hospitals from 2008-2011. Nulliparous women with singleton, cephalic, nonanomalous term births who achieved 10 cm cervical dilation were included. Women in whom pushing was delayed by ≥ 60 minutes (delayed group) were compared with those who initiated pushing within 30 minutes (early group). Multivariable regression analyses were used to assess the independent association of delayed pushing with mode of delivery, length of second stage and other maternal and perinatal outcomes (significance defined as $p < 0.05$).

Results—Of 21,034 women in the primary analysis sample, pushing was delayed in 18.4% ($n=3870$). Women who were older, privately insured, or non-Hispanic white, as well as those who

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had induction or augmentation of labor, diabetes, or epidural analgesia were more likely to have delayed pushing. Delayed pushing was more common when the second stage began during daytime hours or in hospitals with dedicated 24-hour obstetric anesthesia, although differences were small. After adjusting for differences in baseline and labor characteristics including center, women in the delayed group had longer mean durations of the second stage (191 vs. 84 min, $p<0.001$) and of active pushing (86 vs. 76 min, $p<0.001$). Delayed pushing was associated with greater rates of cesarean delivery (11.2% vs 5.1%; adjusted odds ratio [aOR] 1.86, 95% confidence interval [CI] 1.63-2.12), operative vaginal delivery (aOR 1.26, 95% CI 1.14-1.40), postpartum hemorrhage (aOR 1.43, 95% CI 1.05-1.95) and blood transfusion (aOR 1.51, 95% CI 1.04-2.17). Delayed pushing was not associated with increased odds of adverse neonatal outcomes compared with early pushing.

Conclusion—In this large birth cohort, delayed pushing was associated with longer second stage duration, increased odds of cesarean delivery, and increased odds of postpartum hemorrhage, but was not associated with neonatal morbidity.

INTRODUCTION

Delayed pushing, or the practice of resting in the second stage prior to initiating active bearing down, has become an increasingly common labor management practice.¹ Also known as “laboring down” or “passive descent,” this practice has been proposed to reduce maternal exhaustion and prevent maternal morbidity such as cesarean delivery and severe perineal lacerations. While the American College of Obstetricians and Gynecologists has no explicit position statement on delayed pushing, midwifery and some obstetric literature recommend consideration of delayed pushing for one to two hours, or until the woman experiences the urge to push, for appropriate patients.²⁻⁴ Similarly, the International Federation of Gynecology and Obstetrics recommends waiting up to four hours for the nulliparous women to experience the urge to push before initiating active pushing.⁵

While a long second stage^{6,7} and prolonged active pushing in the second stage⁸ have been associated with an increased risk of adverse maternal and neonatal outcomes, data on the maternal and neonatal risks associated with delayed pushing are conflicting. Some data suggest delayed pushing is associated with less active pushing time^{9,10} and increased likelihood of spontaneous vaginal delivery.⁹ In contrast, a meta-analysis of twelve randomized controlled trials reported delayed pushing was not associated with increased spontaneous vaginal delivery when the analysis was limited to high quality studies.¹⁰ Randomized trials also have reported conflicting results, with some reporting decreases in time spent actively pushing,^{11,12} others with no difference in time spent actively pushing or mode of delivery,^{13,14} and another with a decrease in “difficult” deliveries but no difference in “nondifficult” vaginal deliveries.¹⁵ A retrospective analysis by Frey et al reported delayed pushing to be associated with longer active pushing time, no change in or lower spontaneous vaginal delivery rate, and worse perinatal outcomes, including maternal fever and lower cord arterial pH.¹⁶

The objectives of this analysis were two-fold. First, we aimed to assess the relationship between delayed pushing and perinatal outcomes in a large, diverse national cohort of

nulliparous women. Second, we aimed to examine patient and hospital-level factors associated with use of delayed pushing. We hypothesized that delayed pushing would be associated with adverse perinatal outcomes and would vary by hospital and patient characteristics.

MATERIALS AND METHODS

This is a secondary analysis of a large, multicenter observational study performed at 25 hospitals in the United States. The methodology of the Assessment of Perinatal Excellence (APEX) study has been previously reported.¹⁷ This cohort consisted of 115,502 women and their neonates who delivered at participating hospitals over a 3 year period (2008 – 2011). Institutional Review Board approval was obtained from each site. Clinical data for patients who were at least 23 weeks' gestation and who had arrived at the hospital with a live fetus were collected by trained research personnel at each site. Maternal characteristics, details of the medical and obstetric history, intrapartum and postpartum care, obstetrical outcome, and aspects of the health system were collected.¹⁷ For this analysis, chorioamnionitis was categorized as an intrapartum characteristic rather than an outcome because time of infection diagnosis was not recorded, and thus it was not possible to differentiate if chorioamnionitis occurred before or during the second stage of labor. Recorded data for each patient additionally included the time at which 10 cm dilation was diagnosed, the time that active pushing was initiated, and the time of delivery. Decision time for cesarean deliveries was also collected.

Women eligible for inclusion in this analysis included nulliparous women with singleton, term (≥ 37 weeks), vertex, non-anomalous gestations who reached the second stage of labor (ie, full cervical dilation documented on the labor and delivery unit). The analysis was limited to nulliparous women in order to focus on the most clinically relevant group in which delayed pushing is employed, as multiparous women with a prior vaginal delivery are likely to experience vaginal delivery regardless of second stage characteristics.^{8,16}

The total length of second stage was defined as the amount of time from when the woman was examined and found to have 10 cm dilation until vaginal delivery, or to decision time for cesarean delivery. Women were designated as having delayed or early pushing based on the difference in time between achievement of 10 cm cervical dilation and time of initiation of active pushing. Delayed pushing was defined as delay in initiation of active pushing until 60 minutes after complete dilation was diagnosed. These women were compared to those who initiated pushing within 30 minutes of achieving complete dilation (early pushing). These time intervals were chosen as surrogates for intent regarding management of the second stage; sixty minutes was felt to be an amount of time in which it was likely that the patient or provider intentionally waited to initiate pushing, rather than delayed for logistical or personnel reasons. This definition of delayed pushing is consistent with prior published reports on this topic^{14,16} and with the definition used in a current National Institutes of Health-sponsored multicenter randomized trial of immediate versus delayed pushing.¹⁸ Women who initiated pushing between 31 and 59 minutes after achieving the second stage were excluded from the primary analysis due to lack of information about the reason why pushing was intermediately delayed; this population was included in a sensitivity analysis.

Women with a calculated second stage greater than 12 hours were excluded due to likely erroneous data entry (n=29).

The primary outcome was the mode of delivery (vaginal or cesarean delivery). Secondary outcomes included the total length of second stage, length of time spent actively pushing, and operative vaginal delivery. Additional maternal and neonatal secondary outcomes included episiotomy, major perineal laceration (3rd or 4th degree laceration), postpartum hemorrhage (defined as estimated blood loss >1500mL, blood transfusion, or hysterectomy), blood transfusion, maternal intensive care unit (ICU) admission, shoulder dystocia, 5-minute Apgar score <5, cord umbilical artery pH <7.0, and neonatal intensive care unit (NICU) admission. Hospital- and system-level factors were compared between the delayed pushing and early pushing groups; these factors included presence of an in-house attending obstetrician, anesthesiologist or neonatologist 24 hours/day, presence of obstetrics and gynecology residents on the labor and delivery unit, start of second stage during shift change, and presence of official board sign out at shift change. All variables were recorded by trained study nurses.

Univariable analyses using Wilcoxon test for continuous variables and chi-square tests for categorical variables were performed comparing baseline and labor characteristics and neonatal and maternal outcomes between delayed versus early pushing groups. Possible confounders were chosen on the basis of a p-value <0.05 in analyses of maternal demographic or labor characteristics, and included maternal age, gestational age, body mass index at delivery, race and ethnicity, insurance status, diabetes, labor augmentation or induction, neuraxial analgesia or anesthesia, birth weight, and treatment for chorioamnionitis. To assess the independent association of delayed pushing with maternal and perinatal outcomes, multivariable linear regression analyses were used for continuous outcomes and multivariable logistic regression analyses were used for categorical outcomes. These regression models accounted for center as a fixed effect. Additionally, Firth's adjustment was used for logistic regression models that did not converge due to separation of values. A sensitivity analysis was performed in which women who initiated pushing from 31 to 59 minutes after complete dilation were included in the delayed pushing group. SAS software (SAS Institute, Cary, NC) was used for the analyses. All tests were two-tailed and a p-value of <0.05 was used to define statistical significance. Imputation for missing data was not performed.

RESULTS

Of the 115,502 women in the APEX cohort, 23,732 met inclusion for overall analysis and 21,034 women were included in the primary analysis (Figure 1). A sub-group of 2,698 women with a delay of 31-59 minutes was included in a sensitivity analysis. Women who were older, privately insured, or non-Hispanic white, or who had diabetes were more likely to have delayed pushing (Table 1). With regard to labor characteristics, women who experienced induction or augmentation of labor and women who utilized neuraxial (epidural or combined spinal-epidural) analgesia were more likely to experience delayed pushing (Table 2). There were no differences in use of delayed pushing based on day of the week in which the delivery occurred. However, delayed pushing was more likely to take place when

the second stage of labor began during daytime hours. Average birth weight was greater among women who experienced delayed pushing (3400g vs 3311g, $p<0.001$).

In unadjusted analyses, women who experienced delayed pushing had a significantly greater frequency of cesarean delivery compared to women who experienced early pushing (11.2% vs 5.1%; OR 2.33 [95% CI 2.07-2.63], $p<0.001$) (Table 3). When adjusting for center and potential confounding factors, this finding remained statistically significant, with women who experienced delayed pushing having nearly two-fold greater odds of cesarean delivery (aOR 1.86, 95% CI 1.63-2.12). In addition, unadjusted rates of operative vaginal delivery, episiotomy, and major perineal laceration were all significantly greater for women who experienced delayed pushing, while there were no differences in unadjusted rates of postpartum hemorrhage or maternal ICU admission. After adjusting for potential confounders and center, delayed pushing was associated with an increased odds of operative vaginal delivery (aOR 1.26, 95% CI 1.14-1.40) and postpartum hemorrhage (aOR 1.43, 95% CI 1.05-1.95). Additionally, delayed pushing was associated with a higher odds of blood transfusion (aOR 1.51, 95% CI 1.04-2.17). Regarding indication for operative deliveries, the indications for cesarean differed by pushing status ($p<0.001$), where women who had a cesarean with delayed pushing being less likely to have the indication be non-reassuring fetal status (9.3% vs 20.9%) but more likely to be for dystocia (83.5% vs 72.9%). Similarly, indications for operative vaginal delivery differed between groups ($p<0.001$). Among those who had an operative vaginal delivery, women with delayed pushing were less likely to have the indication be non-reassuring fetal status (29.0% vs 42.6%) but more likely to be for failure to descend (17.0% vs 11.2%) or maternal exhaustion (37.5% vs 29.1%).

With regard to neonatal outcomes, the unadjusted rate of admission to the neonatal intensive care unit was greater for neonates born to mothers who delayed pushing (8.8% vs 6.8%; OR 1.31 [95% CI 1.16-1.49] $p<0.001$). However, after adjusting for potential confounders and center, there were no significant differences between pushing status in NICU admission, low 5-minute Apgar scores, acidotic umbilical artery pH, or shoulder dystocia for neonates (Table 3). The adjusted odds ratio for NICU admission was 1.10 (95% CI 0.96-1.26).

The average lengths of time (in minutes) of the second stage and in active pushing were compared between women who delayed pushing and those experiencing early pushing (Table 4). Mean duration of the second stage was longer for those experiencing delayed pushing (unadjusted mean $\pm$ standard error: 187.3 ± 1.32 delayed vs 70.2 ± 0.44 early, $p<0.001$). Additionally, median and interquartile range for duration of the second stage was longer in women who delayed pushing (median, 25th-75th percentile: 170, 126-232) compared to those experiencing early pushing (median, 25th-75th percentile: 53, 30-94). The mean amount of time spent actively pushing was also greater for women experiencing delayed pushing (unadjusted mean $\pm$ standard error: 80.4 ± 0.98 delayed vs 61.7 ± 0.43 early, $p<0.001$). When adjusting for potential confounders including center and maternal factors described previously, both average length of total second stage and average time spent actively pushing remained significantly longer for women who experienced delayed pushing. Specifically, women who delayed pushing had an average total second stage that was longer shown by an adjusted mean difference of 107.2 minutes (95% CI 105.1-109.3)

and an average total time actively pushing that was longer shown by an adjusted mean difference of 10.4 minutes (95% CI 8.5-12.3).

For sensitivity analysis, women who initiated pushing from 31 to 59 minutes after complete dilation (n=2,698) were also included in the delayed pushing group. Results generally remained the same. In addition to the consistent findings of increased odds of cesarean delivery (aOR 1.56, 95% CI 1.39-1.76) and operative vaginal delivery (aOR 1.19, 95% CI 1.09-1.30) with delayed pushing, this sensitivity analysis demonstrated a marginally significant association of delayed pushing with major perineal laceration (aOR 1.13, 95% CI 1.01-1.26). Odds of postpartum hemorrhage (aOR 1.37, 95% CI 1.05-1.78) and blood transfusion (aOR 1.40, 95% CI 1.03-1.91) were also consistent with the primary results. In this sensitivity analysis, there were no differences in neonatal outcomes, including 5-minute Apgar score <5 (aOR 0.93, 95% CI 0.52-1.66), cord umbilical artery pH 7.0 (aOR 1.16, 95% CI 0.66-2.04), shoulder dystocia (aOR 0.87, 95% CI 0.72-1.06), or NICU admission (aOR 1.11, 95% CI 0.99-1.24). This supplemental analysis demonstrated that women with delayed pushing still had significantly longer mean total second stage duration (adjusted mean difference of 78.1 minutes, 95% CI 76.4-79.9) and mean time spent actively pushing (adjusted mean difference of 6.9 minutes, 95% CI 5.4-8.5) than women with early pushing.

Regarding the second objective, although absolute differences between groups were very small, the association of hospital-level characteristics with delayed pushing demonstrated that delayed pushing was less common in women who delivered in hospitals with an in-house obstetric attending (86.1% delayed vs 88.5% early, $p<0.001$) or an in-house neonatology attending (81.8% vs 86.3%, $p<0.001$) (Table 5). However, delayed pushing was more common in hospitals when anesthesia dedicated to obstetrics was available (89.8% delayed vs. 86.0% early, $p<0.001$). There were no differences in use of delayed pushing based on whether obstetrics and gynecology residents were present on the labor unit or whether the start of second stage occurred during a resident or attending shift change.

DISCUSSION

In this analysis, we investigated the relationship between delayed pushing and obstetric outcomes among nulliparous women who reached the second stage of labor. Women who delayed pushing greater than 60 minutes experienced a longer duration of active pushing, nearly two-fold greater odds of cesarean, and increased odds of postpartum hemorrhage. Women who delayed pushing did not experience an increase in adjusted odds of major perineal lacerations, episiotomy, or maternal intensive care unit admission, although the number of admissions to maternal intensive care unit was relatively small. After adjusting for potential confounders including center, delayed pushing was also not associated with increased risk of neonatal morbidity, although the analysis was not powered to detect differences in rare adverse neonatal outcomes. Sensitivity analyses in which delayed pushing was defined as starting greater than thirty minutes from documentation of complete dilation did not greatly alter these findings. It is notable that in this large cohort, no maternal or neonatal outcomes were improved in association with delayed pushing. While delayed pushing has previously been proposed as a labor technique that may decrease risk of cesarean or decrease the amount of active pushing, these data do not support that contention.

Although previous data have suggested that a longer duration of active pushing⁸ or total length of second stage^{6,19} are associated with adverse perinatal outcomes, few contemporary reports have specifically demonstrated increased risks associated with delayed pushing. Notably, work by Grobman et al in a different APEX cohort of parous and nulliparous women reported that longer duration of pushing was associated with increased odds of cesarean delivery and neonatal complications.⁸ Our data differ from this report in its focus on delayed pushing in a cohort limited to nulliparous women. Our data are in contrast to a meta-analysis by Tuuli et al (including 3115 women), which suggested delayed pushing was associated with few clinical differences but decreased amount of active pushing.¹⁰ Our data are also in contrast to work by Frey et al, who demonstrated while delayed pushing was associated with a decreased rate of spontaneous vaginal delivery in the total population (N = 5290), in the subgroup analysis of nulliparous women, there was no difference in cesarean delivery based on immediate versus delayed pushing.¹⁶ Our secondary analysis represents a large investigation of delayed pushing and is notable in the finding of a statistically significant increased risk of adverse maternal outcomes. While our data are retrospective in nature, the larger sample increases the power to detect differences and the diverse cohort enhances reliability of these findings. Our findings may differ from prior work due to these strengths, as well as some limitations discussed below.

Further work is required to understand the mechanism behind the identified associations. For example, the association with postpartum hemorrhage could be due to multiple etiologies, such as uterine atony due to prolonged labor or hemorrhage after operative delivery. Moreover, while the prolonged second stage duration is logical given the second stage duration includes the delay itself, it remains unclear why delayed pushing is associated with a greater duration of active pushing. This may be due to intrinsic differences about the woman that may be associated both with a longer duration of active pushing and with use of delayed pushing. For example, women whose fetuses are occiput posterior, asynclitic, or higher station may be more likely to delay pushing, as an effort to reduce maternal exhaustion or allow for spontaneous fetal rotation, as well as inherently more likely to require a greater duration of active pushing.

It was notable that women who were older, privately insured, and non-Hispanic white were more likely to experience delayed pushing. This finding is consistent with Frey et al's finding that black race was associated with decreased use of delayed pushing.²⁰ In addition, while the absolute differences in rates were small, our data showed statistically significant differences in delayed pushing based on hospital characteristics. Delayed pushing was employed more when the second stage began during daytime hours or when there was dedicated obstetrical anesthesiology presence, as well as less employed when there were in-house obstetricians or neonatologists. These results suggest the possibility that the reasons for delayed pushing may extend beyond strictly medical indication, for instance outpatient office obligations. Further work is warranted to understand the role non-medical physician factors in the management of labor.

Strengths of this analysis include the large cohort with detailed information about the components of the second stage, patient characteristics, and labor events. The use of a second stage interval that ends at either vaginal delivery or time at which a cesarean delivery

is decided is also important, as it excludes from the duration of the second stage the time in which patients may be awaiting performance of a cesarean delivery. Another strength is that this study utilized the time at which a patient was found to be completely dilated as the beginning of the second stage; while this time represents the time at which she was examined rather than the exact time of achieving 10 cm of cervical dilation, this designation is felt to be most clinically relevant. In addition, these data were collected by trained research personnel at geographically and demographically diverse hospitals, which enhances generalizability. Collection of data from multiple types of hospitals also allowed investigation of hospital-level characteristics associated with delayed pushing, which has not previously been investigated.

However, this investigation is not without limitations. Importantly, information about fetal station and position at initiation of the second stage were unavailable; it is possible that an initially high fetal station confounded the primary outcome. However, as noted before, it appears that factors that dictated delayed pushing may extend beyond those that were solely medical. Similarly, we were unable to fully account for intentional versus unintentional delay; it is possible the exclusion of those who delayed pushing from 31 to 59 minutes may have underestimated the proportion of women experiencing intentional delayed pushing. However, our sensitivity analysis demonstrated that inclusion of women in this intermediate time period did not substantively alter the findings. Furthermore, we were unable to account for the role of provider type, as the APEX study collected the provider as the delivering attending; thus, midwives or family medicine physicians who transfer patients to obstetrician–gynecologists for operative deliveries may not be reported as the provider of record, thus misattributing the operative vaginal or cesarean deliveries to the obstetrician–gynecologists. Additionally, these data are observational and cannot demonstrate causation, and it is not possible to account for all sources of bias with statistical models. Finally, this secondary analysis was not specifically powered to detect differences in rare adverse outcomes.

In summary, while a number of strategies have been proposed to reduce the risk of primary cesarean deliveries, including delayed pushing, these data from a large, contemporary, diverse cohort call attention to the potential risks associated with delayed pushing in the nullipara. While the risks and benefits of delayed pushing must take into consideration specific patient factors, such as predicted fetal weight, maternal exhaustion, and clinical examination, our findings suggest that before delayed pushing is routinely employed, its benefit should be demonstrated in a large randomized controlled trial. A large, multicenter randomized controlled trial of immediate versus delayed pushing in nulliparous women with neuraxial analgesia is currently underway and will shed light on the potential benefits of delayed pushing.¹⁸

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Study Cohort

Table 1

Maternal and pregnancy characteristics

	Delayed pushing (n=3870)	Early pushing (n=17164)	p-value
Maternal age (years)	27.0 ± 0.10	25.4 ± 0.05	<0.001
Gestational age (weeks)	39.3 ± 0.02	39.2 ± 0.01	<0.001
Body mass index at delivery (kg/m ²)	30.4 ± 0.09	30.0 ± 0.04	<0.001
Race and ethnicity			<0.001
Non-Hispanic white	2272 (58.7)	8211 (47.8)	
Non-Hispanic black	419 (10.8)	3344 (19.5)	
Non-Hispanic Asian	341 (8.8)	1101 (6.4)	
Hispanic	539 (13.9)	3492 (20.3)	
Other or not documented	299 (7.7)	1016 (5.9)	
Insurance status [*]			<0.001
Uninsured or self-pay	190 (5.0)	1636 (9.6)	
Government-assisted	1060 (27.7)	6214 (36.5)	
Private	2576 (67.3)	9184 (53.9)	
Gestational or pregestational diabetes mellitus	200 (5.2)	737 (4.3)	0.02
Preeclampsia or gestational hypertension	358 (9.3)	1659 (9.7)	0.43
Chronic hypertension	57 (1.5)	244 (1.4)	0.81

Data are presented as mean ± standard error or n (%).

^{*} Number of missing values: 173

Table 2

Labor characteristics associated with use of delayed pushing

	Delayed pushing (n=3870)	Early pushing (n=17164)	p-value
Labor type			<0.001
Spontaneous	937 (24.2)	4980 (29.0)	
Augmented	1612 (41.7)	6530 (38.0)	
Induced	1321 (34.1)	5654 (32.9)	
Date of delivery			0.27
Weekday (Monday-Friday)	2873 (74.2)	12594 (73.4)	
Weekend (Saturday-Sunday)	997 (25.8)	4570 (26.6)	
Time of day that second stage of labor began			<0.001
Day (7AM-7PM)	2195 (56.7)	9233 (53.8)	
Night (7PM-7AM)	1675 (43.3)	7931 (46.2)	
Length of first stage (hours)	11.4 ± 0.14	11.0 ± 0.06	0.05
Neuraxial analgesia or anesthesia	3466 (89.6)	13571 (79.1)	<0.001
Meconium	873 (22.6)	3346 (19.5)	<0.001
Birth weight (grams)	3400 ± 6.95	3311 ± 3.23	<0.001
Treated for chorioamnionitis	346 (8.9)	1081 (6.3)	<0.001

Data are presented as mean ± standard error or n (%).

Table 3

Delivery outcomes associated with delayed pushing

Outcome	Delayed pushing (n=3870)	Early pushing (n=17164)	Unadjusted OR (95% CI)	p-value	aOR (95% CI) *	p-value *
Cesarean delivery	432 (11.2)	878 (5.1)	2.33 (2.07-2.63)	<0.001	1.86 (1.63-2.12)	<0.001
Operative vaginal delivery	627 (16.2)	1923 (11.2)	1.53 (1.39-1.69)	<0.001	1.26 (1.14-1.40)	<0.001
Episiotomy	763 (19.7)	2867 (16.7)	1.22 (1.12-1.34)	<0.001	1.01 (0.92-1.11)	0.87
3 rd or 4 th degree perineal laceration	340 (8.8)	1198 (7.0)	1.28 (1.13-1.46)	<0.001	1.11 (0.97-1.27)	0.13
Postpartum hemorrhage	62 (1.6)	220 (1.3)	1.25 (0.94-1.67)	0.12	1.43 (1.05-1.95)	0.02
Blood transfusion	44 (1.1)	163 (0.9)	1.20 (0.86-1.68)	0.29	1.51 (1.04-2.17)	0.03
Maternal ICU admission **	11 (0.3)	64 (0.4)	0.79 (0.42-1.48)	0.46	1.21 (0.65-2.23)	0.55
5-minute Apgar score <5	14 (0.4)	45 (0.3)	1.38 (0.76-2.52)	0.29	1.28 (0.68-2.40)	0.44
Cord umbilical artery pH 7.0 **	10 (0.3)	39 (0.2)	1.18 (0.60-2.33)	0.64	1.33 (0.70-2.52)	0.39
Shoulder dystocia	107 (2.8)	429 (2.5)	1.11 (0.89-1.37)	0.34	0.85 (0.67-1.06)	0.15
NICU admission	340 (8.8)	1172 (6.8)	1.31 (1.16-1.49)	<0.001	1.10 (0.96-1.26)	0.15

OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval; NICU, neonatal intensive care unit

Data are represented as n (%)

Number of missing values: episiotomy (9), 3rd or 4th degree laceration (10), postpartum hemorrhage (680), 5-minute Apgar score (7), cord gases (1), shoulder dystocia (1)

* Adjusted for center, maternal age, gestational age, body mass index, race and ethnicity, insurance, gestational diabetes, labor augmentation or induction, neuraxial analgesia or anesthesia, birth weight, and treatment for chorioamnionitis

** Firth's adjustment used due to separation of values.

Table 4

Difference in length of second stage associated with delayed pushing

Outcome	Delayed pushing (n=3870)			Early pushing (n=17164)			Difference between adjusted means (95% CI) [*]	p-value [*]
	Median (Q1, Q3)	Unadjusted Mean $\pm$ SE	Adjusted mean $\pm$ SE	Median (Q1, Q3)	Unadjusted Mean $\pm$ SE	Adjusted mean $\pm$ SE		
Duration of second stage (minutes)	170.0 (126.0, 232.0)	187.3 $\pm$ 1.32	191.2 $\pm$ 1.63	53.0 (30.0, 94.0)	70.2 $\pm$ 0.44	84.0 $\pm$ 1.39	107.2 (105.1-109.3)	<0.001
Duration of active pushing (minutes)	65.0 (34.0, 114.0)	80.4 $\pm$ 0.98	86.0 $\pm$ 1.49	44.0 (21.0, 85.0)	61.7 $\pm$ 0.43	75.6 $\pm$ 1.27	10.4 (8.5-12.3)	<0.001

CI, confidence interval; SE, standard error; Q1, 25th percentile; Q3, 75th percentile

^{*} Adjusted for center, maternal age, gestational age, body mass index, race and ethnicity, insurance, gestational diabetes, labor augmentation or induction, neuraxial analgesia or anesthesia, birth weight, and treatment for chorioamnionitis

Table 5

Hospital characteristics associated with use of delayed pushing

	Delayed pushing (n=3870)	Early pushing (n=17164)	p-value
In-house attending obstetrician	3332 (86.1)	15197 (88.5)	<0.001
Dedicated obstetrical anesthesiology 24-hours/day	3474 (89.8)	14761 (86.0)	<0.001
In-house attending neonatologist	3165 (81.8)	14815 (86.3)	<0.001
Obstetrics and gynecology residents present	3505 (90.6)	15511 (90.4)	0.70
Start of second stage during resident shift change	273 (7.1)	1152 (6.7)	0.44
Start of second stage during attending shift change	213 (5.5)	909 (5.3)	0.60

Data are presented as n (%).