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Vaginal Birth After Cesarean: Neonatal Outcomes and United States Birth Setting

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Abstract

Background—Women seeking VBAC may find limited in-hospital options. Increasing numbers of US women are delivering by VBAC out-of-hospital. Little is known about neonatal outcomes among those delivering by VBAC in vs. out-of-hospital.

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Condensation:

VBAC out-of-hospital is increasing and is associated with worse neonatal outcomes, signaling potential benefit from increasing in-hospital VBAC options and decreasing primary cesareans.

Objective(s)—To compare neonatal outcomes between women delivering via VBAC in hospital vs. out-of-hospital (home and freestanding birth center).

Study Design—Retrospective cohort study using 2007-2010 linked US birth and death records to compare singleton, term, vertex, non-anomalous, live born neonates who delivered by VBAC in or out-of-hospital. Descriptive statistics and multivariate regression analyses were conducted to estimate unadjusted, absolute, and relative birth setting risk differences. Stratification by parity and history of vaginal birth examined association between birth setting and each outcome. Sensitivity analyses involving three transfer status scenarios were conducted.

Results—A small proportion of the total number of US women with a history of cesarean ($n = 1,138,813$) delivered by VBAC ($n = 109,970$, 9.65%) with a large majority of these delivering in-hospital ($n = 106,823$, 97.14%). The proportion of home VBAC births increased from 1.78% to 2.45%. A pattern of increased neonatal morbidity was noted in unadjusted analysis (neonatal seizures, Apgar score <7 or <4 , neonatal seizures), with higher morbidity noted in the out-of-hospital setting (neonatal seizures: 23 (0.02%) vs. 6 (0.19%), $p < 0.001$; Apgar score <7 : 2859 (2.68%) vs. 139 (4.42%), $p < 0.001$; Apgar score <4 : 431 (0.4%) vs. 23 (0.73), $p = 0.01$). A similar, but non-significant, pattern of increased risk was observed for neonatal death and ventilator support among those born in the out-of-hospital setting. Multivariate regression estimated that neonates born out-of-hospital had higher odds of poor outcomes (neonatal seizures (adjusted odds ratio [aOR] 8.53, 95% confidence interval [CI] 2.87-25.4); Apgar <7 (aOR, 1.62; 95% CI, 1.35-1.96); Apgar <4 (aOR 1.77, CI 1.12-2.79)). While odds of neonatal death (aOR, 2.1; CI 0.73-6.05, $p = 0.18$) and ventilator support (aOR 1.36, CI 0.75-2.46) appeared to be increased in out-of-hospital settings, findings did not reach statistical significance. Women birthing their second child by VBAC in out-of-hospital settings had higher odds of neonatal morbidity and mortality compared to women of higher parity. Women without a history of vaginal birth prior to out-of-hospital VBAC delivery had higher odds of neonatal morbidity and mortality compared to those with a history of vaginal birth. Sensitivity analyses generated distributions of plausible alternative estimates by outcome

Conclusions—Fewer than 1 in 10 US women with a prior CD delivered by VBAC in any setting and increasing proportions of these women delivered out-of-hospital. Adverse outcomes were more frequent for neonates born out-of-hospital, with risk concentrated among women birthing their second child and women without a history of vaginal birth. This information urgently signals the need to increase availability of in-hospital VBAC as well as suggests there may be benefit associated with increasing options that support physiologic birth and safely prevent primary cesareans. Results may inform evidence-based recommendations for birthplace among women seeking VBAC.

Index words

Cesarean; Birth center; Birth setting; Home birth; Labor after cesarean; Neonatal outcomes; Vaginal Birth After Cesarean; VBAC

Introduction

Reducing the overall cesarean delivery (CD) rate is a national priority,¹ and vaginal birth after cesarean (VBAC) is effective for reaching this goal.² National guidelines recommend

that women with one prior CD have the option for trial of labor after cesarean (TOLAC);³ however, not all hospitals allow TOLAC. Increasing numbers of US women seek out-of-hospital birth,^{4, 5} including those seeking VBAC.^{6, 7} While it is well-established that in-hospital VBAC carries a small but significantly increased risk for neonatal mortality^{8, 9} and evidence suggests a small but significant relative increase in intrapartum fetal and neonatal mortality associated with out-of-hospital birth,^{10, 11} less is known about neonatal outcomes for out-of-hospital VBAC.

A limited body of research informs questions of VBAC outcomes by birth setting. One population-based German study compared women with (n = 1927) and without (n = 22,618) prior CD planning their second birth at home,¹² finding that women with prior CD had worse neonatal outcomes. A prospective cohort study compared UK women who planned TOLAC at home (n = 209) and in-hospital (n = 1227), finding a non-significant pattern suggesting increased neonatal morbidity and mortality associated with out-of-hospital VBAC.¹³ Three studies assessed US neonatal outcomes for out-of-hospital TOLAC. One retrospective study described outcomes of 57 women who planned TOLAC at home, finding one TOLAC-unrelated stillbirth.¹⁴ A second prospective cohort study of women seeking TOLAC in a birth center (n = 1453) found increased neonatal mortality among these women relative to those delivering in a birth center without prior CD.¹⁵ The third study utilized data on planned home births from a national, voluntary registry, comparing outcomes among multiparous women with prior CD (n = 1052) to those without (n = 12,092), finding significantly elevated rates of poor neonatal outcomes in the TOLAC sub-sample.¹⁶ Despite the increasing frequency of out-of-hospital VBAC,^{6, 7} to our knowledge there are no US studies comparing VBAC outcomes between hospital and out-of-hospital settings.

Using vital statistics data, the purpose of this study was to: 1) characterize US women completing VBACs in home, birth center, and hospital settings; 2) compare neonatal outcomes by birth setting (in vs. out-of-hospital); and, 3) apply advanced statistical modeling techniques to account for intended versus actual delivery setting.

Materials and Methods

This was a retrospective cohort study using 2007-2010 US birth and death records. An infant death file was linked to the corresponding birth certificate in year of birth, regardless of year of death. Cohort-linked birth/infant death files are available through 2010.^{4, 5}

Records were excluded if the woman: a) did not have a CD history, b) had a multiple gestation, c) delivered preterm (< 37 weeks) or extremely postterm (>43 weeks), d) had a breech fetus, e) had a fetus with congenital anomalies, f) experienced stillbirth (fetal death), or g) if there was obvious data miscoding (e.g., both nulliparity and CD history were marked; removed < 2% of sample). Thus, our study compares outcomes for women with singleton, term, vertex, non-anomalous, live born neonates who delivered by VBAC in or out-of-hospital (n = 109,970). Our key exposure variable was birth setting, defined as completed home or freestanding birth center birth versus completed hospital birth.

We analyzed several neonatal outcomes including: neonatal death (death within the first 28 days after birth), depressed 5-minute Apgar score (both <7 and <4), neonatal seizures, infant ventilator support > 6 hours, neonatal intensive care unit (NICU) admission, and birth injury (skeletal fracture(s), peripheral nerve injury, and/or soft tissue/solid organ hemorrhage requiring intervention).

We calculated descriptive statistics for demographic and outcome variables, comparing completed VBACs out-of-hospital and completed hospital VBACs. All statistical tests were performed using the chi-square or Fisher's exact test; statistical significance was $p < 0.05$. Logistic regressions were performed using multivariable models controlling for demographic and prenatal care characteristics. Models compared outcomes in the out-of-hospital VBAC category to the in-hospital VBAC category (the referent). For regression analyses and descriptive statistics of outcomes, we combined completed birth center and completed home VBACs into a single out-of-hospital birth category. This decision was scientifically and practically motivated. We posit that during obstetric emergencies, proximity to medical intervention is often similar for those laboring at home or freestanding birth centers. Practically, given the rare exposure (out-of-hospital birth), exposure subgroup (VBAC), and very rare outcomes (neonatal death), small cell sizes and limited statistical power precluded us from analyzing out-of-hospital settings separately.

Covariates included in the models were: maternal race/ethnicity (White [referent], Black, Hispanic, Asian/Pacific Islander, and American Indian/Alaskan Native), parity (1 [referent], 2, and ≥ 3), tobacco use (no/yes), maternal age (≤ 20 years, 21-34 years [referent], and ≥ 35 years), maternal education (less than a high school education, high school only [referent], undergraduate college of any duration, and graduate school of any type), number of previous CDs (1 [referent], 2, ≥ 3), prenatal care after first trimester (no/yes), prenatal care adequacy as identified by the Kotelchuck Index¹⁷ (adequate plus [referent], adequate, intermediate, and inadequate),¹⁷ and weight gain > 40 pounds (no/yes). It is valuable to consider measures of both relative and absolute risk when comparing outcomes by birth setting;^{18, 19} thus, absolute birth setting risk differences were calculated for each regression. All analyses were conducted using Stata (version 12, StataCorp, College Station, TX).

As both parity and history of vaginal birth are important predictors of perinatal outcomes for women who choose TOLAC, we conducted stratified regression analyses examining the association between birth setting and each outcome. Models were fit as described above, stratified by parity (1 prior birth, 2, and 3 or more) and history of vaginal birth (no/yes).

Because it is not possible to disaggregate women who intended out-of-hospital birth but ultimately delivered in-hospital from women who planned and birthed in-hospital,¹⁰ we conducted sensitivity analyses to estimate effects of this misclassification bias.^{20, 21} We utilized random resampling to estimate how odds of neonatal death and Apgar < 4 might be affected if transfers were identifiable. Because Oregon birth certificates enable disaggregation by intended birth setting, Oregon vital statistics were used to estimate that 0.44% of observed hospital births were likely out-of-hospital-to-hospital transfers.¹⁰ This rate informed calculation of the number of transfers from the out to in-hospital setting;

records equaling this number were randomly chosen under different scenarios and placed in the out-of-hospital birth category to assess outcome odds ratio sensitivity reclassification.

Three scenarios were explored: 1) transfer status was randomly assigned to 470 hospital records (0.44% of hospital births sample); 2) hospital births with the outcome of interest were given the lowest probability of being among the reclassified; 3) hospital births with the outcome of interest were given a high probability of being among the reclassified (modeling presumed transfers had 5x greater neonatal death risk and 4x greater Apgar <4 risk). After reassignments, the changed outcome odds ratio was computed using the same logistic regression approach. For both extreme scenarios (2 and 3), a single random reclassification was made for each outcome. To explore odds ratio variations resulting from different random reassignments, bootstrap analysis of the permutation distribution of random transfer status was performed for 470 new births 50,000 times for the neonatal death outcome and 100,000 times for the Apgar <4 outcome. This repeatedly and randomly scrambled which 470 births were reclassified.

Results

Demographics

Women who delivered by VBAC out-of-hospital were significantly more likely to be White and of advanced maternal age (≥ 35 years) compared with women delivered by VBAC in-hospital ($p<0.001$) (Table 1). Those who completed VBAC delivery out-of-hospital were less likely to smoke, to initiate prenatal care in the first trimester, and to meet criteria for adequate or adequate plus prenatal care according to the Kotelchuck index ($p<0.001$).¹⁷ Compared to those birthing in-hospital, women who delivered via VBAC at home had both more frequently not completed high school and also more frequently achieved college education ($p<0.001$) while those in birth centers had more frequently not completed high school ($p<0.001$).

More than half of VBAC births out-of-hospital were among women with parity ≥ 3 (out-of-hospital 56.72% vs. hospital 40.48%, $p<0.001$). In contrast, women who delivered via VBAC in-hospital were more frequently of lower parity (e.g., parity 1: hospital 31.65%; out-of-hospital 20.59, $p<0.001$). A majority of women in all settings had a history of one prior CD (out-of-hospital 88.69% vs. in-hospital 88.44%, $p = 0.14$). A higher proportion of women delivering via VBAC out-of-hospital had a history of prior vaginal birth than women delivering via VBAC in-hospital (out-of-hospital 76.01% vs. in-hospital 62.92% $p < 0.001$).

A small proportion of the total number of US women with a history of cesarean ($n = 1,138,813$) delivered by VBAC in any setting ($n = 109,970$, 9.65%) with a large majority of these delivering in-hospital ($n = 106,823$, 97.14%; Table 1). Between 2007 and 2010, the proportion of completed VBAC births in the home setting increased from 1.78% to 2.45% (Table 2).

Outcomes

A pattern of increased neonatal morbidity was noted in unadjusted analysis of outcomes (Apgar score <7 or <4, neonatal seizures) by birth setting, with higher morbidity in the out-

of-hospital setting (Table 3). For example, Apgar score <7 was observed in 4.4% of out-of-hospital VBACs and 2.7% of in-hospital VBACs ($p < 0.001$). A similar, but non-significant, pattern of increased risk was observed for neonatal death and ventilator support in the out-of-hospital setting. NICU admission was significantly lower among neonates delivered via VBAC out-of-hospital as compared to in-hospital (1.1% vs. 3.1%, $p < 0.001$); birth injury was lower, but non-significant, out-of-hospital compared to in.

In multivariable regression analyses adjusting for confounders, associations between birth setting and rare adverse outcomes were estimated with low statistical precision due to small cell sizes. Neonates born in the out-of-hospital setting were over 8 times as likely to have neonatal seizures and almost twice as likely to have lower Apgar scores compared with babies delivered in-hospital (neonatal seizures (adjusted odds ratio [aOR] 8.53, 95% confidence interval [CI] 2.87-25.4); Apgar <7 (aOR, 1.62; 95% CI, 1.35-1.96); Apgar <4 (aOR 1.77, CI 1.12-2.79)) (Table 4). While odds of neonatal death (aOR, 2.1; CI 0.73-6.05, $p = 0.18$) and ventilator support (aOR 1.36, CI 0.75-2.46, $p = 0.31$) were increased in out-of-hospital settings, findings did not reach statistical significance. Decreased NICU admission and birth injury among out-of-hospital VBACs persisted after regression analysis: NICU admission (aOR 0.4, CI 0.29-0.57); birth injury (aOR 0.78, CI 0.58-1.04).

Parity and history of vaginal birth

Stratification of outcomes by parity, adjusting for previously described covariates, demonstrated that among women delivering via VBAC out-of-hospital, those birthing their second child had higher odds of neonatal mortality (Parity 1: aOR 4.4, CI 0.51-37.82 vs. Parity 2: aOR 2.27, CI 0.29-17.93) and several morbidities (e.g. Apgar < 4, Parity 1: aOR 4.11, CI 2.17-7.78 vs. Parity 2: aOR 0.98, CI 0.30-3.17) compared to women of higher parity (Table 5). Similar results were noted comparing women delivering via VBAC out-of-hospital without vs. with a history of vaginal birth (e.g. Apgar < 4, no history of vaginal birth: aOR 3.47, CI 1.84-6.55 vs. history of vaginal birth: aOR 1.11, CI 0.58-2.16) (Table 6).

Random resampling to assess the sensitivity of outcome odds ratios to transfer into the hospital during labor but prior to delivery generated distributions of plausible alternative estimates by outcome (Table 7). As hypothesized, the increases in adverse outcomes associated with the out-of-hospital setting were attenuated in scenario 1 (e.g., Apgar score <4 was no longer statistically significant; OR; 95%CI), and were increased in scenario 2 (e.g., increased odds of neonatal mortality became statistically significant; OR; 95%CI).

Comment

Findings from this study indicate that while VBAC is one of the most effective mechanisms to reduce the CD rate, fewer than 1 in 10 women with a prior CD delivers by VBAC in any setting. Our study also suggests that among US women delivering by VBAC, adverse outcomes were generally more frequent for neonates born out-of-hospital, while in-hospital VBACs had higher rates of NICU admission and birth injury. For adverse outcomes that occurred proportionally more frequently in out-of-hospital VBACs, we found disproportionately increased risk concentrated in women with lower parity and those without a history of vaginal delivery. Many factors likely contribute to these findings.

Uterine rupture is one important factor affecting risks associated with TOLAC/VBAC.⁸ When this occurs out-of-hospital, delayed obstetric intervention may have significant consequences, including increased risk for severe neonatal morbidity and mortality.¹⁵ Distance from hospital interventions may at least partially explain the finding that neonates delivered via VBAC out-of-hospital have increased odds of low and very low five minute Apgar scores. Higher NICU admission rates and birth injury among hospital VBACs may simply reflect proximity to the NICU or could be a function of increased in-hospital access to assisted vaginal delivery. Differences in diagnostic practice patterns by setting may also importantly shape our findings.²²

Prior research indicates that women delivering in-hospital who are of lower parity or without a history of vaginal birth are at higher risk for VBAC-related complications.²³ Our findings suggest that this is also true among women delivering by VBAC out-of-hospital. Congruent with prior research,¹⁶ results of this study signal that women birthing their second child or without a history of vaginal birth are more vulnerable to poor neonatal outcomes when delivering by VBAC in out-of-hospital settings.

Results showing parity and vaginal birth history demographic differences by setting may reflect more conservative VBAC care practices in out-of-hospital setting. Among women intending VBAC, it is possible that out-of-hospital providers less frequently agree to care for or more rapidly transfer those with lower parity or no history of vaginal birth. It is also possible that women seeking VBAC are selecting birth setting based on these, and other, factors. This pattern of higher parity and large proportions of women with a history of vaginal birth among out-of-hospital VBACs is consistent with practice patterns noted in prior research.^{12, 13, 16}

Study findings also suggest other birth setting differences. In out-of-hospital settings, we found fewer women initiating care in the first trimester or meeting the Kotelchuck criteria for 'adequate plus' prenatal care utilization. As out-of-hospital prenatal care generally involves longer visits²⁴ while 'adequate plus' is defined by quantity of visits,¹⁷ the measure may fail to provide broader insight on the quality of care. In addition, certified professional midwives (CPM), who attend the majority of US home births, are unregulated in several states. This may create barriers to obtaining prior records when women transfer care to a CPM mid-pregnancy, leaving onset and total quantity of prenatal visits uncertain. Understanding such birth setting practice pattern differences and maternal care preferences is critical to increasing integration of maternity care services across birth settings in the US,¹⁰ a change that we see as essential for improving maternal and neonatal outcomes.²⁵ Evidence from Canada and Europe have demonstrated that integration of maternal care across birth settings is associated with lower rates of adverse outcomes in all settings and smaller or no morbidity differentials between settings.^{26, 27}

Our findings suggesting higher rates of low five minute Apgar among neonates delivered out-of-hospital, in tandem with results showing increasing rates of out-of-hospital VBAC, highlight the importance of increasing childbirth safety for this growing population of women and further considering factors that may drive women to choose out-of-hospital TOLAC. These factors likely include barriers women encounter when seeking TOLAC.²⁸

such as VBAC bans, narrow hospital TOLAC selection criteria, and cultures favoring CD.²⁹⁻³¹ Low-risk women seeking TOLAC in many US communities may find out-of-hospital settings their only option^{7, 32, 33} or may perceive out-of-hospital delivery as their best option for avoiding unsatisfactory labor care.²⁸

Several study limitations should be noted. There may be important differences between women who deliver via VBAC in vs. out-of-hospital which are not captured in vital records data. Given pragmatic and ethical barriers to conducting experimental studies on this topic, secondary analysis of existing data remains the best approach.

During the study period more than one version of the U.S. birth certificate was in use. The 1989 revision of the U.S. Standard Certificate of Live Birth did not differentiate between planned and unplanned home birth,³⁴ while the 2003 revision does.⁴ Using only the 2003 birth certificate limited sample size.

One feature of vital statistics data collection is that it identifies actual but not intended mode of delivery, preventing use of this data to build knowledge regarding those who intended TOLAC but ultimately delivered by repeat CD in each setting. Additionally, vital statistics data do not differentiate planned from unplanned hospital births, preventing us from accurately identifying planned birth setting. To address this exposure misclassification, we conducted a novel random resampling analysis which suggested uncertainty bounds to clarify the likely magnitude of bias associated with this misclassification.

In the publically-available fetal death certificate, the difference between an antepartum fetal death and intrapartum fetal death are not distinguishable. Therefore, we could not analyze intrapartum death, a crucial outcome shown to differ by US birth setting. Nonetheless, there are major evidence gaps in US population-based results on this topic, and the birth certificate is one of the rare sources of national population-based birth data. These shortcomings highlight the need to leverage additional data resources,^{16, 35} to continue refining US vital statistics collection capacity.¹⁰

One in three pregnant US women delivers her child via CD;³⁶ those who desire future fertility will face the decision to deliver via repeat CD or to seek TOLAC. Planned repeat CD and TOLAC each incur important risks to a pregnant or laboring woman,^{37, 38} to her fetus or neonate,⁹ and to future children.^{8, 37} Study results add to prior work showing that a growing share of US women are choosing VBAC out-of-hospital.^{6, 28} Our findings demonstrate increased odds of some neonatal morbidity measures and a trend toward increased neonatal mortality among those making this choice. This urgently signals the need to advance evidence-based policies and care which can mitigate this increased risk, as well as to decrease the frequency with which US women are faced with this decision. This includes efforts to support physiologic birth³⁹ and safely prevent primary cesarean deliveries.¹ Given recent ACOG committee opinion recommending that all TOLAC/VBAC occur in-hospital,⁴⁰ effective national and clinical leadership⁴¹ to increase availability of in-hospital TOLAC/VBAC is imperative.

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Table 1

Demographic and health care characteristics of US VBACs, comparing hospital, home, birth center, and combined out-of-hospital location

Variable	Hospital n (%)	Home Birth n (%)	<i>P</i> value	Birth Center n (%)	<i>P</i> value	Out-of-hospital (home + birth center) n (%)	<i>P</i> value
N	106,823 (97.14)	2,352 (2.14)	<0.001	795 (0.72)	<0.001	3,147 (2.86)	<0.001
Race/ethnicity			<0.001 *		<0.001 *		<0.001 *
White	53,226 (49.83)	2,094 (89.03)		634 (79.75)		2,728 (86.69)	
Black	15,396 (14.41)	76 (3.23)		18 (2.26)		94 (2.99)	
Hispanic	31,030 (29.05)	141 (5.99)		132 (16.60)		273 (8.67)	
Asian	6,106 (5.72)	34 (1.45)		8 (1.01)		42 (1.33)	
AI/AN	1,065 (1.00)	7 (0.30)		3 (0.38)		10 (0.32)	
Parity			<0.001		<0.001		<0.001
1	33,813 (31.65)	483 (20.54)		165 (20.75)		648 (20.59)	
2	28,423 (26.61)	495 (21.05)		165 (20.75)		660 (20.97)	
3	43,237 (40.48)	1,331 (56.59)		454 (57.11)		1,785 (56.72)	
Tobacco use	7,842 (7.34)	12 (0.51)	<0.001	13 (1.64)	<0.001	25 (0.79)	<0.001
Maternal age (years)			<0.001		<0.001		<0.001
20	2,302 (2.15)	2 (0.09)		3 (0.38)		5 (0.16)	
21–34	81,386 (76.19)	1,623 (69.01)		569 (71.57)		2,192 (69.65)	
35	23,135 (21.66)	727 (30.91)		223 (28.05)		950 (30.19)	
Education			<0.001 *		<0.001 *		<0.001 *
Not completed HS	9,044 (8.47)	421 (17.90)		252 (31.70)		673 (21.39)	
High School	41,668 (39.01)	404 (17.18)		181 (22.77)		585 (18.59)	
College	45,093 (42.21)	1,289 (54.80)		298 (37.48)		1,587 (50.43)	
Graduate Sch.	9,744 (9.12)	222 (9.44)		61 (7.67)		283 (8.99)	
# Previous Cesareans			0.105 *		0.033 *		0.137 *
1	94,478 (88.44)	2,061 (87.63)		730 (91.82)		2,791 (88.69)	
2	7,916 (7.41)	187 (7.95)		45 (5.66)		232 (7.37)	
3	1,676 (1.57)	36 (1.53)		6 (0.75)		42 (1.33)	
History of vaginal birth	67,217 (62.92)	1,780 (75.68)	<0.001	612 (76.98)	<0.001	2,392 (76.01)	<0.001
Prenatal Care Initiation After 1st Trimester	31,415 (29.41)	1,143 (48.60)	<0.001	441 (55.47)	<0.001	1,584 (50.33)	<0.001
Kotelchuck Index			<0.001 *		<0.001 *		<0.001 *
Adequate Plus	21,011 (19.67)	159 (6.76)		49 (6.16)		208 (6.61)	
Adequate	35,629 (33.35)	744 (31.63)		254 (31.95)		998 (31.71)	

Variable	Hospital	Home Birth	<i>P</i> value	Birth Center		Out-of-hospital (home + birth center)	
	n (%)	n (%)		n (%)	<i>P</i> value	n (%)	<i>P</i> value
Intermediate	20,748 (19.42)	594 (25.26)		128 (16.10)		722 (22.94)	
Inadequate	22,486 (21.05)	800 (34.01)		331 (41.64)		1,131 (35.94)	
Weight gain > 40 pounds	20,477 (19.17)	431 (18.32)	0.252	138 (17.36)	0.115	569 (18.08)	0.072

* χ^2 test of independence

Table 2

VBAC deliveries by year and birth location (n (% by row)).

Year	Hospital	Home Birth	Birth Center	Out-of-hospital
2007	21,505 (96.79)	395 (1.78)	150 (0.68)	545 (2.47)
2008	25,273 (96.65)	514 (1.97)	197 (0.75)	711 (2.74)
2009	27,062 (96.51)	604 (2.15)	209 (0.75)	813 (2.92)
2010	32,983 (96.21)	839 (2.45)	239 (0.70)	1,078 (3.16)

Table 3

Neonatal outcomes by birth setting.

	Hospital n (%)	Out-of-hospital n (%)	<i>p</i>
Neonatal death	84 (0.08)	4 (0.13)	0.326
Apgar score <7	2,859 (2.68)	139 (4.42)	<0.001
Apgar score <4	431 (0.40)	23 (0.73)	0.010
Neonatal seizures	23 (0.02)	6 (0.19)	<0.001
Ventilator support	309 (0.29)	12 (0.38)	0.315
NICU admission	3,292 (3.10)	35 (1.11)	<0.001
Birth injury	109 (0.10)	1 (0.03)	0.382

Table 4

Logistic regression results^a comparing neonatal outcomes in women with out-of-hospital VBAC to women with hospital VBAC.

	Adjusted for covariates		<i>P</i>
	aOR ^b (95% CI)	ARD ^c (95% CI)	
Neonatal death	2.10 (0.73, 6.05)	0.0005 (−0.0002, 0.0013)	0.176
Apgar score <7	1.62 (1.35, 1.96)	0.0129 (0.0079, 0.0179)	<0.001
Apgar score <4	1.77 (1.12, 2.79)	0.0022 (0.0004, 0.0041)	0.016
Neonatal seizures	8.53 (2.87, 25.4)	0.0005 (0.0002, 0.0009)	0.003
Ventilator support	1.36 (0.75, 2.46)	0.001 (−0.0009, 0.0028)	0.311
NICU admission	0.40 (0.29, 0.57)	−0.0262 (−0.0363, −0.0161)	<0.001
Birth injury	0.78 (0.58, 1.04)	−0.0002 (−0.0004, 0.0000)	0.089

^a Models controlled for maternal race, maternal age, maternal education (HS education as referent), Kotelchuck Index (adequate plus as referent), parity, number of previous cesarean deliveries, and maternal weight gain >40 lbs.

^b aOR = adjusted odds ratio

^c ARD = adjusted risk difference for the marginal effects of out-of-hospital status

Table 5

Regression model results^a stratified by parity (aOR (95% CI)^b) comparing VBAC neonatal outcomes out-of-hospital to in-hospital

	Adjusted for covariates		
	Parity Category		
	1	2	3+
Neonatal death	4.40 (0.51, 37.82)	2.27 (0.29, 17.93)	1.77 (0.40, 7.90)
Apgar score <7	2.01 (1.42, 2.83)	1.41 (0.92, 2.14)	1.57 (1.20, 2.05)
Apgar score <4	4.11 (2.17, 7.78)	0.98 (0.30, 3.17)	1.15 (0.52, 2.54)
Neonatal seizures	20.66 (1.89, 225.44)	32.75 (2.24, 477.94)	5.3 (1.34, 21.00)
Ventilator support	2.18 (0.79, 6.03)	1.17 (0.28, 4.87)	1.1 (0.47, 2.58)
NICU admission	0.56 (0.31, 1.02)	0.49 (0.24, 0.99)	0.31 (0.18, 0.52)
Birth injury	0.62 (0.33, 1.16)	1.05 (0.62, 1.79)	0.71 (0.47, 1.09)

^aCovariates – maternal race (white as referent), maternal age (normal MA (21-34) as referent), maternal education (HS education as referent), Kotelchuck Index (adequate plus as referent), and maternal weight gain 40 lbs.

^bOR = adjusted odds ratio

Table 6

Logistic regression results^a stratified by history of vaginal delivery (aOR (95% CI)^b) comparing VBAC outcomes out-of-hospital to in-hospital.

	Adjusted for covariates	
	No vag hx	Vag hx
Neonatal death	2.53 (0.31, 20.62)	2.26 (0.67, 7.66)
Apgar score <7	2.02 (1.46, 2.80)	1.48 (1.17, 1.86)
Apgar score <4	3.47 (1.84, 6.55)	1.11 (0.58, 2.16)
Neonatal seizures	16.44 (1.59, 170.11)	6.48 (1.90, 22.09)
Ventilator support	2.28 (0.91, 5.67)	1.01 (0.46, 2.20)
NICU admission	0.62 (0.36, 1.06)	0.32 (0.20, 0.51)
Birth injury	NA ^c	0.30 (0.04, 2.22)

^a Covariates – maternal race, maternal age, maternal education, Kotelchuck Index, number of previous cesarean deliveries, and maternal weight gain 40 lbs.

^b aOR = adjusted odds ratio

^c NA; models not run due to non-variance in outcome by birth location/parity combination.

Table 7Transfer status resampling results^a

	Neonatal Death			Apgar < 4		
	aOR ^b (95% CI)	aRD (95% CI)	p	aOR (95% CI)	aRD (95% CI)	p
Scenario 1	2.10 (0.73, 6.05)	0.0005 (−0.0002, 0.0013)	0.170	1.77 (1.12, 2.79)	0.0022 (0.0004, 0.0041)	0.015
Scenario 2	1.81 (0.63, 5.15)	0.0004 (−0.0003, 0.0012)	0.269	1.55 (0.98, 2.45)	0.0017 (−0.0001, 0.0035)	0.059
Scenario 3	2.89 (1.20, 6.97)	0.0007 (0.0001, 0.0014)	0.018	2.59 (1.78, 3.77)	0.0038 (0.0022, 0.0053)	<0.001
Bootstrap	1.95 (1.79, 2.70)	NA ^c	NA	1.67 (1.53, 1.93)	NA	NA

^aCovariates – maternal race, maternal age, maternal education, Kotelchuck Index, number of previous cesarean deliveries, and maternal weight gain 40 lbs.

^baOR = adjusted odds ratio

^cNA; the bootstrap sensitivity analysis considered only the distribution of adjusted odds ratios under repeated random reassignments of birth location.