VAGINAL BIRTH AFTER CESAREAN SECTION: INCIDENCE AND OUTCOMES IN RURAL, URBAN NON-TEACHING, AND URBAN TEACHING HOSPITALS FOR THE YEAR 2000

by
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CERTIFICATE OF APPROVAL

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Vaginal Birth After Cesarean Section: Incidence and Outcomes in Rural, Urban Non-teaching, and Urban Teaching Hospitals for the year 2000.

Background

Little evidence exists regarding the influence of hospital type on risks of vaginal birth after cesarean (VBAC). The perception of increased risks associated with VBAC combined with challenges for providing the heightened surveillance recommended for this population during labor has caused many physicians, hospitals, and insurance providers to reduce or stop allowing VBACs. The objectives of the study were 1) compare the incidence of VBAC in urban non-teaching, urban teaching, and rural hospitals, and 2) compare the incidence of uterine rupture and other poor maternal outcomes associated with VBAC in all three settings, in order to determine whether hospital factors affect maternal outcomes for VBAC.

Methods

Women with prior cesarean were identified from Healthcare and Cost Utilization Project (HCUP) National Inpatient Sample 2000 dataset. Multiple logistic regression analysis was used to develop statistical models of the relationship of maternal and hospital factors to VBAC rates, and maternal health outcomes including uterine rupture.

Results

Cases with adequate data on delivery type (n= 89,536) were included in the main analysis. The overall incidence of VBAC was 19.5%, and the overall incidence of uterine rupture was 0.48. Univariate analyses revealed that rates of VBAC differed significantly across hospital types with rural hospitals reporting the lowest rate at 15.6%, urban non-teaching 18.5% and urban teaching 21.8%. Multiple logistic regression analyses revealed that maternal age and hospital type were associated with uterine rupture. Specifically, women over 35 years of age in rural hospitals were almost half as likely to VBAC and twice as likely to have a uterine rupture compared to women aged 20-35 in urban teaching hospitals. Maternal morbidity was not associated with hospital type. Additionally, women under 20 years of age in urban non-teaching hospitals experienced a 70% reduction in risk for uterine rupture compared to women aged 20-35 in urban teaching hospitals although the VBAC rate was similar between these groups. Induction of labor was also strongly associated with increased risk of uterine rupture (OR=3.711, $p<.001$).

Conclusions

Age and hospital type were both found to influence risk of uterine rupture with age greater than 35 and rural hospital experiencing the highest UR risk and women under age 20 in urban non-teaching hospitals experiencing the lowest. This study found that induction of labor increased the risk of uterine rupture, similar to other studies. Importantly, maternal morbidity was not found to be associated with hospital type. These are important data to inform practitioners, policy-makers, and the general public regarding the safety of VBAC.

Vaginal Birth After Cesarean Section: Incidence and Outcomes in Rural, Urban Non-teaching, and Urban Teaching Hospitals for the year 2000

INTRODUCTION

Confusion exists regarding the actual versus the perceived risks of VBAC. This lack of clarity influences the practices of physicians, hospitals, and insurance providers regarding the allowance of VBAC. In 1981, the U.S. rate of VBAC was 3% (i.e., 3% of all women potentially eligible for VBAC actually delivered vaginally), with the overall C-section delivery rate of 17.9% ***(see Table I)***. (1, 2) By 1997, the incidence of VBAC had risen to 27.4%, with the overall U.S. C-section rate climbing to only 20.8% during the same time period. (1) In the mid 1990's, a series of articles suggested that VBAC was associated with higher risks of uterine rupture and maternal and perinatal morbidity. (2, 3, 4) Since the highest U.S. VBAC incidence rate of 28.3% in 1996, the VBAC rate declined to 20.7% in 2000, while the overall C-section rate rose from 20.7% to 22.9% over the same time period. Based on the latest data available, this trend has continued; in 2003 the overall Cesarean rate was 27.6%, and the VBAC rate was 10.6% (1, 2, 5). This has occurred despite the fact that on average 75.9% of women attempting trial of labor (TOL) achieved a vaginal birth, according to combined data from all prospective cohort studies between 1985 and 2002.* (2)

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* *(TOL, a term implying uncertain outcome of labor, is what a woman hoping to deliver by VBAC actually attempts; VBAC can be described as a successful TOL, whereas an unsuccessful TOL implies that the woman required a repeat C-section despite wanting to deliver vaginally (i.e., by VBAC).)*

TABLE I. Total Cesarean and VBAC rates in the U.S.

YEAR	**U.S. rate of C-sections** (% of live births delivered by C-section)	**U.S. rate of VBACs** (number of VBAC deliveries per 100 live births to women with a prior C-section)
1981	17.9%	3%
1996	20.7%	28.3% (highest rate ever)
2000	22.9%	20.7%
2003	27.6%	10.6%

(2, 4, 5)

A concurrent malpractice crisis is decreasing the availability of maternity care providers, and limiting patient and provider maternity care options, with VBAC being one of the most commonly limited services. (2) Rural areas (where 25% of the U.S. population is estimated to reside) are most affected, such that high malpractice rates are resulting in many of the already few rural providers discontinuing to provide obstetric services or moving their practices out of rural areas altogether. (6) Those providers choosing to continue practicing obstetrics in rural locations are faced with both high malpractice premiums in relation to their salaries, as well as restrictions on what options they are covered to provide.

American College of Obstetricians and Gynecologists (ACOG) states that, "Because uterine rupture may be catastrophic, VBAC should be attempted in institutions equipped to respond to emergencies with physicians immediately available to provide emergency care." (1, 7) ACOG guidelines have been cited to clearly influence physician behavior. (8)

Case series – level evidence suggests that time to cesarean may impact neonatal outcomes for women experiencing uterine rupture. One large case series found that increased time to delivery (>18 minutes) was associated with poorer neonatal outcomes for women with uterine rupture. (2, 5) Uterine rupture rates and associated morbidity are difficult to assess due to the multitude of definitions in the literature and difficulty distinguishing between different degrees of rupture and the consequences of each. (2) The body of evidence suggests that the rate of uterine rupture for women with prior Cesarean is less than 1% of all deliveries, and approximately 2.7% of women attempting TOL. (2, 8) Neonatal death secondary to rupture is estimated at 1.5 deaths per ten thousand. (6)

VBAC rates are known to be somewhat higher in teaching hospitals as compared to private, community, regional, or non-teaching hospitals, and it is estimated that women at tertiary care facilities are twice as likely to choose TOL as compared to women at any other facility. (2) There is no data, however, comparing urban and rural rates of TOL and VBAC. (2) There have been very few studies regarding the safety of VBAC in smaller more rural communities. (5) A single study in 2003 of VBAC and TOL success rates in a small rural community with a solo practice and level 1 care facility reported TOL in 74.5% (n=413) of women with at least one prior C-section, with a successful VBAC (defined as vaginal delivery) in 75% (n=308) of women attempting TOL. (6) These are comparable to the rates published in studies of urban and tertiary care facilities.

Determination of the national incidence of VBAC in both urban (teaching and non-teaching) and rural hospitals would enable a better understanding of the geographical variation in the availability of VBAC for women with prior cesarean. Similarly, examination of the incidence of uterine rupture and other maternal morbidity associated with VBAC at urban teaching, urban non-teaching and rural hospitals may shed light on whether there is any geographical variation in outcomes for women with prior cesarean and will provide an initial investigation into whether safety is related to hospital issues.

RESEARCH DESIGN and METHODS

Objectives

The objectives of this retrospective cohort analysis were 1) to compare the incidence of VBAC in rural, urban non-teaching and urban teaching hospitals in the United States, and 2) to compare maternal outcomes associated with VBAC in all three hospital settings utilizing the Health Care Utilization Project (HCUP) dataset from the year 2000.

Multivariate logistic regression modeling was used to characterize the relationship of multiple maternal and hospital factors, including maternal age, hospital type, induction of labor, and preterm delivery, to outcomes including VBAC, uterine rupture, and other outcomes including maternal death, hysterectomy, post partum hemorrhage, and transfusion.

Study Population

The HCUP National Inpatient Sample dataset is composed of a representative sample of 20% of all U.S. hospital discharges for the year 2000. From this very large data set, cases of women with at least one prior Cesarean delivery, discharged following a subsequent delivery, were selected. From that case group, women with multiple gestations were excluded. Finally, cases with missing data for route of delivery, required to make a determination as to whether the delivery of interest was by VBAC or by repeat Cesarean, were separated out into a group of "indeterminates", excluded from the main analysis but evaluated in an attempt to characterize this group as behaving more like cases delivered by VBAC or more like cases delivered by repeat Cesarean. Cases that were inaccurately or erroneously lacking the code for "prior cesarean section" were excluded from this analysis.

Data Source and Data Management

Data Source

"The Healthcare Cost and Utilization Project (HCUP) is sponsored by the Agency for Healthcare Research and Quality (AHRQ). The HCUP Nationwide Inpatient Sample (NIS) is a database of hospital inpatient stays, and is the largest all-payer inpatient care database that is publicly available in the United States, containing from 5 to 8 million hospital stays from about 1000 hospitals sampled to approximate a 20-percent stratified sample of U.S. community hospitals, defined by the AHA to be "all non-federal, short-term, general, and other specialty hospitals, excluding hospitals of institutions." Included among community hospitals are specialty hospitals, public hospitals, and academic medical centers.

This universe of U.S. community hospitals is divided into strata using five hospital characteristics: ownership/control, bed size, teaching status, urban/rural location, and U.S. region. The NIS is a stratified probability sample of hospitals in the frame, with sampling probabilities proportional to the number of U.S. community hospitals in each stratum. All discharges from sampled hospitals are included in the NIS database. The NIS is available for every year between 1988 and 2000. The NIS includes persons covered by Medicare, Medicaid, private insurance, and the uninsured. Inpatient stay records in the NIS include clinical and resource use information typically available from discharge abstracts. Access to the NIS is open to users who sign data use agreements. Uses are *limited to research and aggregate statistical reporting.". (9) The HCUP NIS dataset is provided in ASCII format, along with programming source code for loading ASCII data into SAS and SPSS. (9)*

Data Management

The NIS dataset was initially loaded into SAS, in order to select cases of women with previous Cesarean deliveries, discharged following a subsequent singleton delivery. Once this initial case selection was complete, the new smaller file was loaded into SPSS, in which all subsequent data analysis was completed.

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS Version 13.0. The initial analysis included determining the incidence for both predictor and outcome variables listed below in multiple ways: 1) overall incidence, 2) by hospital group, 3) by delivery type, 4) by uterine rupture. Chi-square tests were performed for each contingency table. Multiple logistic regression analysis was used to evaluate the relationships between selected independent and dependent, or predictor and outcome variables.

Potential Predictor Variables

- Hospital location and teaching status: rural, urban non-teaching, urban teaching
- Bed size: small, medium, large
- Maternal age
- Induction of labor

Potential Outcome Variables

- VBAC vs Repeat Cesarean
- Uterine rupture
- Maternal death
- hysterectomy
- Post partum hemorrhage
- Transfusion

- Preterm delivery (delivery at less than 37 weeks gestational age) vs not preterm (delivery on or after 37 weeks gestational age)

Potential Confounding Variables

- Patient race
- Maternal co-morbidities

It was not possible to assess associated neonatal outcomes from this HCUP dataset.

Creation of New Variables

In order to complete the necessary analyses for this study, several new variables were created from the original variables in the HCUP NIS dataset.

1. *Age Group* was created from the continuous variable for age that was an original variable in the HCUP NIS dataset. Cases were simply divided into three age group categories: <20 yrs, 20-35yrs, and >35yrs. While it is probable that using age as a continuous variable would have made for better logistic regression modeling, we believe that use of age group categories makes our results easier to interpret with regards to probable interactions and clinical relevance. A more complete discussion of the rationale behind the choice of age group over age as a continuous variable can be found in the results section under logistic regression.

2. *Uterine Rupture* was created by selecting cases that included one or more of several possible ICD-9 codes for uterine rupture (665.10, 665.11, 665.12, 665.14) within any of the possible 15 ICD-9 diagnosis code slots. The new variable does not distinguish between types of uterine rupture.

3. *Hospital Type* is a variable *that incorporates hospital location and teaching status.* This variable was somewhat more difficult to create, as the information was contained in one digit of a four digit variable (NIS_STRATUM) included in

the HCUP NIS dataset, in which 3 other pieces of information existed, namely geographic region, control/ownership of the hospital, and bed size. We recoded this variable into our new hospital type variable.

Per the HCUP NIS overview document, "*A metropolitan statistical area is considered urban. A hospital is considered to be a teaching hospital if it has an AMA-approved residency program, is a member of the Council of Teaching Hospitals (COTH) or has a ratio of full-time equivalent interns and residents to beds of 0.25 or higher. Rural hospitals were not split according to teaching status, because rural teaching hospitals were rare.*" (9)

4. *Induction of Labor (IOL)* was created by selecting cases that included one or more of several possible ICD-9 codes for induction of labor (medical induction 73.4, artificial rupture of membranes 73.01) within any of the possible 15 ICD-9 procedure code slots. The new variable does not distinguish between types of induction of labor.

5. *Post partum hemorrhage* ICD-9 was created by selecting cases that included one or both of two possible ICD-9 codes for post partum hemorrhage (666.0-1) within any of the possible 15 ICD-9 diagnosis code slots. The new variable does not distinguish between the two types of post partum hemorrhage, nor does it provide any information about the cause or treatment of post partum hemorrhage.

6. *Transfusion* was created by selecting cases that included one or more of several possible ICD-9 codes for transfusion (99.00-99.09) within any of the

possible 15 ICD-9 procedure code slots. The new variable does not distinguish between types of or reasons for transfusion.

7. *Hysterectomy* was created by selecting cases that included one or more of several possible ICD-9 codes for hysterectomy (subtotal abdominal hysterectomy 68.3, total abdominal hysterectomy 68.4, total vaginal hysterectomy 68.5) within any of the possible 15 ICD-9 procedure code slots. The new variable does not distinguish between types of hysterectomy.

8. *Preterm delivery* (delivery prior to 37 weeks gestational age) was created by selecting cases that included the ICD-9 code for preterm delivery (664.21) within any of the possible 15 ICD-9 diagnosis code slots. Term and post dates deliveries were initially treated separately, but the numbers were so small that they were collapsed back into "not pre-term".

9. *Bed size* (small, medium, large) was somewhat more difficult to create, as this information was contained in one digit of a four digit variable (NIS_STRATUM) included in the HCUP NIS dataset, in which 3 other pieces of information existed, namely geographic region, control/ownership of the hospital, and hospital location and teaching status. After recoding this variable into our new bed size variable, however, it was determined that the methods for assigning bed size (included here) would not allow for the analysis of this variable previously planned. Per the HCUP NIS overview document, "*Bed size categories are based on hospital beds, and are specific to the hospital's location and teaching status. Bed size cut points were chosen so that approximately one-third of the hospitals in a given region and location/teaching combination would be in each bed size*

category (small, medium, large)." (9) A table with specific cutpoints appears in the AHRQ's "Overview of The HCUP Nationwide Inpatient Sample for the year 2000".

Sample Selection

Initial selection of our sample was completed in SAS because of the ease with which very large datasets can be handled in this program. All cases that had, within any of 15 possible diagnosis code slots, the ICD-9 for "Previous C-Section, delivered" were selected from the original dataset, with the exception of cases with ICD-9 codes for multiple gestation (found in any of those same 15 diagnosis code slots), which was an exclusion criteria. The initial sample selection resulted in inclusion of approximately one hundred thousand cases, and will be referred to as dataset "A".

Cases were identified as repeat Cesarean delivery if the ICD-9 procedure codes for classical or low transverse Cesarean Section (74.0 or 74.1) and/or the CCS code for Cesarean Delivery (CCS 134) appeared in any of 15 possible CCS procedure code slots.*

Cases were identified as delivering by VBAC based on the presence of the ICD-9 diagnosis code for Normal delivery (650). Running a frequency for all of the 15 possible diagnosis code slots this code could appear in, it became obvious that almost no cases utilized this code (about 15 out of 100k). Given the codes available as part of the HCUP NIS dataset, the remaining strategies for positively identifying VBAC cases were use of the ICD-9 procedure codes for

* CCS codes are used specifically for research purposes and represent collapsed ICD-9 categories. Just as the ICD-9 codes have 2 categories, diagnosis and procedure, the CCS codes also have separate diagnosis and procedure codes.

forceps, vacuum, and manually assisted delivery (one of the two codes contained in manually assisted delivery included assisted spontaneous delivery, and accounted for the vast majority of all cases identified as delivering vaginally), (ICD-9 codes 72.0-72.9, 73.5, 72.21-72.79, 73.51, or 73.59), any of which could appear in the 15 possible procedure code slots.

Cases that could not be positively identified as delivering by either repeat Cesarean or VBAC were separated out at this time, and kept as a third group labeled "indeterminates", excluded from the main analysis. In order to achieve this, it was necessary to select out from dataset "A" the cases positively identified as repeat Cesarean in one procedure to create dataset "RC" in which repeat Cesareans were assigned a "1" and all other cases were assigned "0", and in another procedure select out from dataset "A" all cases positively identified as VBAC to create dataset "V" in which VBACs were assigned a "0" and all other cases were assigned "1". Datasets "RC" and "V" were then compared, Kappa = 0.77, indicating that there were many cases that were identified by default as being VBAC or repeat Cesarean in the two datasets respectively, but that were not able to be identified by positive criteria as being an actual VBAC or repeat Cesarean case. These "indeterminate" cases were separated out from datasets "RC" and "V" respectively, after which the Kappa test was repeated with a value of 0.977, meaning that both positive identification methods (employed for datasets "RC" and "V" respectively) arrived at a very similar but not identical grouping of cases into repeat CS and VBAC.

The size of the datasets did not allow for a case by case review in order to assess which of the two was more accurate or valid, so it was necessary to develop a strategy for which dataset to use (that in which VBAC cases are positively identified and all others are assigned as repeat Cesareans, after filtering out cases that could not be identified as either, or the dataset created in the same manner but based on positive identification as a repeat Cesarean). The choice was made using the following: The rationale for choosing one over the other might be that while the positive selection for repeat CS was based on the presence of any of PRCCS 134, PR 740, or PR741, the positive selection for VBAC was based on the presence of any of PR 720-729, 735, 7221-7279, 7351, or 7359, representing significantly more codes that possibly would result in greater sensitivity. Another way to determine which to use was to see what the percentage of VBAC is for each group, and choose the one closest to the literature. Although the second method would have taken precedence were the two in disagreement, both strategies pointed to using the dataset created based on the positive identification of VBAC, in which the rate of VBAC is 19.5% in a group of 89,536 cases as opposed to 18.7% in the positive selection for repeat CS variable.

Of interest, our original gross estimate of the number of VBAC cases we would come up with was based on the calculation that in the year 2000 there were approximately 4 million births, multiplied by 20% (the estimation of the percentage of all discharges included in HCUP NIS), multiplied by 12.1% (the estimated percentage of births by women with a previous Cesarean section) = 96,800. We then estimated the number of VBAC cases we would have by multiplying by 20.7% (the VBAC rate in the literature for the year 2000), and arrived at 20,037. This gross estimation seemed reasonably similar to the sample size arrived at in our initial sample selection.

Incidence Calculation

The cases in this study compose a large representative sample of women with at least one prior Cesarean section who were discharged in the year 2000 following an admission for childbirth. All cases with adequate data were included in this study, without regard for delivery type (VBAC or repeat Cesarean section), hospital group, uterine rupture, or any other factor or outcome. Because of the dataset and study design, it was thus possible to calculate incidence of VBAC, repeat Cesarean section, and, within the population of women with at least one Cesarean section, uterine rupture, post partum hemorrhage, transfusion, hysterectomy, maternal death, induction of labor, and preterm delivery, all for this one year period. We used a normal approximation to the standard error rather than an exact approximation. Confidence intervals were calculated for all incidence rates of interest.

Chi-Square testing

For each factor or outcome of interest, a contingency table was constructed in order to look at how the factor or outcome varied as a function of 1) delivery type, 2)uterine rupture, and 3) hospital location and teaching status. For nearly all contingency tables, a Chi-square test of independence was performed to determine whether the proportions of the factor or outcome of interest differed significantly as a function of the above factor and outcomes. For all analyses, a $p<.05$ was required to be deemed a significant difference.

Multiple Logistic Regression Models

For selected outcomes, namely delivery type and uterine rupture, logistic regression analysis was used to determine whether specific maternal and hospital factors were predictive of these outcomes. The specific maternal and hospital factors were chosen based on hypothesized clinical relevance. The two main models created and tested were 1) delivery type as predicted by maternal age, and hospital location and teaching status, and any interaction term, and 2) uterine rupture as predicted by maternal age, hospital location and teaching status, their interaction, induction of labor, and preterm delivery.

The forward stepwise method was used for entering selected factors into the model predictive for delivery type, whereby a $p \leq 0.05$ was required in order to gain entry into the model. Once the main effects model was established, selected interactions were then evaluated by testing each individually with the main effects. Again, only interactions with $p \leq 0.05$ gained entry into the model. Once the model for delivery type with main effects and any interactions was identified, these same factors were used in the logistic regression model for uterine rupture. For the uterine rupture model, however, we used the forced entry method for any factors (main effects only) that were accepted as part of the model for delivery type, and only then did we proceed to test the remaining factors of interest for their significance within the model for uterine rupture by using the forward stepwise procedure.

After creating these main models of interest, several other logistic regression analyses were performed to determine 1) for VBAC cases only, does hospital group predict transfusion and/or hysterectomy, 2) for VBAC cases only, does hospital group predict induction of labor, 3) for uterine rupture cases only, does hospital group predict hysterectomy, and 4) for uterine rupture cases only, does hospital group predict transfusion and/or hysterectomy.

Model Testing

After arriving at a final model for both delivery type and uterine rupture, each underwent an assessment of fit to evaluate the overall "fit" of the model to the data. The assessment of fit included the Hosmer and Lemeshow Goodness-of-Fit statistic, and the assessment of variation accounted or unaccounted for included the Cox & Snell R^2 and Nagelkerke R^2. R^2 values were used for relative comparisons of possible models within logistic regression analysis, thus there were no cut points or R^2 criteria for acceptance of a particular model.

Statistical Power and Sample Size

The sample size of this study was fixed, given that secondary data was used, and a certain number of cases were missing the data to be included in the main analysis. While our sample size was "limited" by these factors, the size was so large as to not limit our ability to conduct well powered analyses (see power calculation in results section). On the contrary, because nearly all our analyses achieved statistical significance and were adequately powered, the determination of clinical relevance is all the more essential if this research is to be useful.

RESULTS

Study Participants

Of an original 100,642 cases known to have a previous Cesarean discharged following a subsequent delivery, 89.0% or 89,536 cases had adequate data to identify the delivery type of the admission, and were included in the main analyses. Of this cohort, 19.5% (n=17,417) (SD .4, 95% CI=19.2-19.7%) delivered by VBAC vs. 80.5% (n=72,119) (SD .4, 95% CI=80.3-80.8%) who delivered by repeat Cesarean. The remaining 11.0% (n=11,106) of cases were separated out into an "indeterminate" category based on missing data, and excluded from the main analysis. All tables and figures, unless noted otherwise, do not include the indeterminate cases.

Demographic data available and judged relevant to our specific research questions was limited to maternal age. Table 2 shows that maternal age differed significantly by hospital type (p<.001), although it is questionable whether a difference that small is clinically interesting. Table 3 shows a significant and interesting difference in age group by hospital type, such that the two smallest groups are women <20 at rural hospitals who make up 7.3% of rural patients (n=883), followed by women >35 at rural hospitals who make up 10.8% (n=1302) of the rural population (p<.001). While there seems to be a higher percentage of women <20, there also seems to be a significantly lower percentage of women >35 at rural hospitals when compared with urban non-teaching or urban teaching hospitals.

In Table 4, maternal age by delivery type, mean age for repeat Cesarean delivery (RCD) was shown to be slightly higher than that for VBAC cases, (29.4 vs. 30.1 years), but probably not enough to be clinically relevant.

Table 2. Maternal Age by Hospital Type
Age in years at admission

Hospital Type	Mean	N	Std. Deviation	Minimum	Maximum
rural	28.11	12050	5.528	14	48
urban non teaching	30.06	40810	5.610	12	53
urban teaching	30.51	36676	5.732	14	54
Total	29.98	89536	5.701	12	54

(p<.001)

Table 3. Maternal Age Group by Hospital Type

			Hospital Type			
			rural	urban non teaching	urban teaching	Total
Age group	<20	Count	883	1713	1425	4021
		% within rural vs urban nt vs urban t	7.3%	4.2%	3.9%	4.5%
	>35	Count	1302	7483	7745	16530
		% within rural vs urban nt vs urban t	10.8%	18.3%	21.1%	18.5%
	20-35	Count	9865	31614	27506	68985
		% within rural vs urban nt vs urban t	81.9%	77.5%	75.0%	77.0%

(p<.001)

Table 4. Maternal Age by Delivery Type
Age in years at admission

VBAC positive selection on PRs	Mean	N	Std. Deviation	Minimum	Maximum
VBAC	29.43	17417	5.671	14	52
RCD	30.11	72119	5.701	12	54
Total	29.98	89536	5.701	12	54

(p<.001)

The overall incidence of VBAC was found to be 19.5% (95% CI 19.19, 19.71). The VBAC rate differed by hospital type (Table 5), such that the VBAC rate for rural hospitals was lowest (15.4%) (95% CI 14.73, 16.02), followed by urban non-teaching hospitals (18.5%) (95% CI 18.15, 19.00), and urban teaching hospitals had the highest rate (21.8%)(95% CI 21.40,22.00), (p<.001).

Table 5. Delivery Type by Hospital Type(% (n))

	VBAC	RCD	Total
Rural	15.4% (1853)	84.6% (10197)	100.00% (12050)
Urban Non-Teach	18.5% (7561)	81.5% (33249)	100.00% (40810)
Urban Teaching	21.8% (8003)	78.2% (28673)	100.00% (36676)
Total	19.5% (17417)	80.5% (72119)	100.00% (89536)

Pearson's Chi-Square = 281.285, p<.001

The next measure included in our original research questions was uterine rupture, for which we found an overall incidence of 0.48% (n=426, 95% CI .43, .52). Uterine rupture rates differed significantly by delivery type, 0.17% (95% CI .11,.23) for VBACs vs. 0.55% (95% CI .50,.60) for repeat Cesareans, (p<.001). The clinical utility of rupture by delivery type data is limited, however, as most patients who are identified as having uterine rupture are taken to Cesarean, and we are unable to distinguish between those who failed TOL because of a uterine rupture and were taken to RCD vs. those who spontaneously ruptured and went to RCD.

The effect of hospital type on uterine rupture achieved statistical significance (p=.036), but the 95% confidence intervals overlapped, and the difference was so small as to be clinically irrelevant. The incidence of uterine rupture in rural hospitals was 0.40% (95% CI .29, .51), 0.44% (95% CI .37, .50) for urban non-teaching hospitals, and 0.55% (95% CI .47, .62) in urban teaching hospitals. Furthermore, after adjusting for induction of labor in the analysis of uterine rupture by hospital type there was no significant difference in rupture rate by hospital type (p=.139), suggesting that any difference in UR rate was associated with induction of labor.

The influence of age on uterine rupture was evaluated as both a continuous and categorical variable (<20, 20-35, >35). The crude association of age and uterine rupture was significant (mean age of rupture patients was 30.8 vs. 30.0 for non-ruptured patients, p=.003). The crude association of age group and uterine rupture, however, was not significant (p=.117). Adjusting for hospital type revealed that for rural hospitals only, the difference in uterine rupture rates based on age group resulted in a p-value of <.05, but with wide and overlapping confidence intervals for the <20 and >35 groups. The rural hospital uterine rupture rate for the <20 group is 0.57% (95% CI .07, 1.06) vs. a rate of 0.29% (95% CI .19, .40) for 20-35yrs, and 1.07% (95% CI .51, 1.64), for >35yrs (p<.001). P-values for the difference of rupture rates by age group within urban non-teaching hospitals and urban teaching hospitals were .167 and .958, respectively.

A total of seven maternal deaths occurred in this cohort. All of these deaths were coded as having delivered by repeat Cesarean, although because of the small sample size this difference by delivery type did not achieve statistical significance (fisher's exact test p-values: 0.359 for 2-sided, 0.220 for 1-sided). No maternal deaths occurred in patients with uterine rupture (p<.001). There was a non-significant difference in deaths by hospital type, with five of the seven occurring at urban teaching hospitals, one at urban non-teaching and one at rural (fisher's exact 1-sided p=.182) or age (p=.966).

We attempted to evaluate the likely cause of death for each of the seven cases based on additional diagnosis codes, recognizing that the data does not allow for us to verify any of our suspicions as to the direct cause of death. The causes of death included PE and amniotic fluid embolism (2 cases), severe PET, abruption (2 cases), cardiac disease (2 cases), and for one case we were unable to determine.

Our analysis of post partum hemorrhage revealed an overall incidence of 1.60% (95% CI 1.49, 1.66). Post partum hemorrhage rates by delivery type were 3.40% (95% CI 3.14,3.67) for VBACs and 1.14% (95% CI 1.06,1.22) for repeat Cesareans ($p<.001$). Patients with uterine rupture were more likely to have post partum hemorrhage compared to women without uterine rupture 5.40% (95% CI 3.24, 7.55) vs. 1.56% (95% CI 1.47, 1.64), respectively ($p<.001$). An analysis of post partum hemorrhage by hospital type found urban non-teaching hospitals to have the lowest rate 1.34% (95% CI 1.23,1.45), followed by rural hospitals 1.40% (95% CI 1.19,1.61) and urban teaching hospitals 1.90% (95% CI 1.76,2.04) ($p<.001$).

Our analysis of transfusion revealed an overall incidence of 0.67% (95% CI .62,.72). Rates of transfusion by delivery type were 0.47% (95% CI .37,.58) for VBACs and 0.72% (95% CI .66,.78) for repeat Cesareans ($p<.001$). The data confirmed that patients with uterine rupture were more likely to have transfusion than their non-ruptured counterparts (5.9% vs. 0.65%, $p<.001$). An analysis of transfusion by hospital type found no significant difference (rural 0.62%, urban non-teaching hospitals 0.64%, urban teaching hospitals 0.72%, $p=.287$).

Our analysis of hysterectomy showed an overall incidence of 0.23% (95% CI .19,.26). Rates of hysterectomy by delivery type were 0.09% (95% CI .04, .13) for VBACs and 0.26% (95% CI .22, .30) for repeat Cesareans ($p<.001$). The data confirmed that patients with uterine rupture were more likely to have hysterectomy than their non-ruptured counterparts, 4.23% (95% CI 2.31, 6.14) vs. 0.2% (95% CI.18, .24) , $p<.001$). An analysis of hysterectomy by hospital type found rural hospitals to have the lowest rate (0.09%) (95% CI .04,.15), followed by urban non-teaching hospitals (0.20%) (95% CI .15,.24) and urban teaching hospitals (0.30%) (95% CI .25,.36) ($p<.001$). Again, however, this difference is not clinically interesting.

Our analysis of induction of labor (IOL) showed an overall incidence for women with prior cesarean of 5.38% (95% CI 5.23, 5.52). Rates of IOL by delivery type were 15.95% (95% CI 15.41,16.49) for VBACs and 2.82%(95% CI 2.78, 2.94) for repeat Cesareans ($p<.001$). Of the 5.38% induced, 42.28% (95% CI 40.89, 43.68) delivered by repeat Cesarean, leaving 57.72% (95% CI 56.32, 59.11) to VBAC ($p<.001$). An analysis of IOL by hospital type found rural hospitals to have the lowest induction rate (3.83%) (95% CI 3.49, 4.17), followed by urban non-teaching hospitals (5.12%) (95% CI 4.91, 5.33) and urban teaching hospitals (6.17%) (95% CI 5.92, 6.41) ($p<.001$).

An analysis of IOL and uterine rupture without regard for delivery type revealed that patients with uterine rupture were more likely to have been induced than their non-ruptured counterparts, 17.4% (95% CI 13.76, 20.98) vs. 5.3% (95% CI 5.17, 5.47) respectively ($p<.001$). Conversely, for the 5.38% of women induced, the rate of uterine rupture was 1.54% (95% CI 1.19,1.89) compared with the rate of rupture for those not induced 0.42% (95% CI .37,.46) ($p<.001$). While uterine rupture remains a rare event, those induced had three and a half times the rate of rupture compared with those who were not induced.

For VBAC cases only, the analysis of IOL and uterine rupture revealed that those patients who ruptured were more likely to have been induced than their non-ruptured counterparts (30.0% vs. 15.9%) (p=.035). Conversely, the rate of rupture for induced VBAC cases was greater than for those not induced (0.3% vs. 0.1%, p=.035).

While 42.3% of induced patients ultimately delivered by repeat Cesarean, hospital type was not associated with a difference in the rate of RCD (p=.181). Similarly, for induced patients there was no significant difference in rate of repeat Cesarean by age group (p=.297).

Our analysis of preterm delivery by delivery type, uterine rupture, hospital type found statistically significant differences, but nothing surprising or clinically interesting. The overall rate of preterm delivery was 6.09% (95% CI 5.94, 6.25), by delivery type 7.42% (95% CI 7.04, 7.82) for VBACs, and 5.77% (95% CI 5.60,5.94), and by hospital type 3.77% (95% CI 3.43, 4.19) for rural, 5.32% (95% CI 5.10, 5.54) for urban non-teaching, and 7.72% (95% CI 7.44, 7.99) for urban teaching hospitals. Preterm delivery as a variable was tested both as a binary and 3-category variable, with the other categories being post-term and term, however the post-term and term categories did not warrant the separation and so the variable was collapsed back into a binary variable (preterm and other).

A summary of univariate analyses described appears in Tables 6 and 7.

Table 6. Incidence of independent and dependent variables by delivery type (%)

N=89536	VBAC (n=17,417)	RCD (n=72,119)	All Cases (n=89536)
Uterine Rupture	0.17	0.55	0.48
Maternal Death*	0	.0001	.00001
PP Hemorrhage	3.40	1.14	1.60
Transfusion	0.47	0.72	0.67
Hysterectomy	0.09	0.26	0.23
Induction of Labor	15.95	2.82	5.38
Preterm Delivery	7.42	5.77	6.09

* All results except maternal death were significant at the p<.05 level.

Table 7. Incidence of independent and dependent variables by hospital type (%)

N=89536	Rural (n=12050)	Urban Non-teaching (n=40,810)	Urban Teaching (n=36,676)
Uterine Rupture*	0.40	0.44	0.55
Maternal Death*	.00008	.00002	.00014
PP Hemorrhage	1.40	1.34	1.90
Transfusion*	0.62	0.64	0.72
Hysterectomy	0.09	0.20	0.30
Induction of Labor	3.83	5.12	6.17
Preterm Delivery	3.77	5.32	7.72

* All results except uterine rupture, maternal death and transfusion were significant at the p<.05 level.

Indeterminate Group

Because of the size of the indeterminate group excluded from the main analyses (n= 11,106) we evaluated it for its "behavior" as being more similar to the group of VBACs or of repeat Cesarean delivery cases. None of this group died during the admission, the mean age was 29.8 (SD 5.568, min-max 15-48). As for the distribution over hospital groups, 10.9% were at rural hospitals, 43.9% were at urban non-teaching hospitals, and 45.2% were from urban teaching hospitals. The rate of uterine rupture in this group was .06% (95% CI .02, .11), which was lower than the rate of rupture we found for either the VBAC cases or the RCD cases, but much closer to the rupture rate in VBAC cases. It is possible that these cases could account for the 1.2% difference between the VBAC rate published nationally and the incidence we determined in our main analysis

(20.7% vs 19.5%). Given that they were missing data on delivery type, however, our confidence that there will be reliable data on uterine rupture is somewhat diminished.

Logistic Regression Analysis

LR Model for VBAC

Multiple logistic regression analysis was used to develop a model predictive of VBAC as delivery type. Select variables were chosen based on judged clinical relevance, and tested for use in the model: maternal age, age squared, maternal age group and hospital type. Of these, age, age group, and hospital type were all individually significant. When tested together using forward stepwise (conditional) entry methods, models using either age or age group (but not both) in addition to hospital type were significant with equivalent R squared values. While age group was judged to have relative superior clinical relevance and greater ease of interpretation in regards interaction terms and to Odds Ratios, the decision to use age group rather than age as a continuous variable was made after substantial examination of the dataset in relation to age for both the delivery type and uterine rupture models. Our findings when evaluating the choice of age vs. age group in the model for uterine rupture were most compelling, so we have included the discussion of our examination in the section discussing that model. In order to be consistent, we used age group in all logistic regression models.

After creating the main effects model with age group and hospital type, the interaction of age group and hospital type was tested and met criteria for entry into the model. Table 8 includes the odds ratios, confidence intervals and p-values for all significant variables. Table 9 shows the combined odds ratios and 95% CIs for all possible combinations of age group and hospital type, which take into consideration the two main effects and the interaction term to provide an overall odds ratio for VBAC, using women aged 20-35 at urban teaching hospitals as the reference group.

Table 8. Multiple Logistic Regression Model for VBAC as delivery type.

Variable	OR	95% CI	P-Value
Age Group			0.000
<20	1.406	1.250, 1.581	0.000
20-35*	1.0	-	
>35	.706	.661, .754	0.000
Hospital Type			0.000
Rural	.629	.591,.668	0.000
Urban Non-teaching	.791	.760, .823	0.000
Urban Teaching*	1.0	-	
Age Group / Hospital Type Interaction	-	-	0.000
<20, rural	.787	.633,.979	.031
<20, urban non-teach	.782	.660, .925	.004
>35, rural	1.096	.911, 1.319	.331
>35, urban non-teach	1.211	1.103, 1.330	.000

**** Referent categories (Age 20-35, Urban Teaching hospital type, and their interaction)***

Table 9. Standardized Combined Odds Ratios for VBAC

	n	OR	95% Lower CI	95% Upper CI
<20, Rural	883	.685	0.658	0.714
<20, Urban NT	1713	1.031	1.018	1.043
<20, Urban T	1425	1.660	1.654	1.666
20-35, Rural	9865	.743	0.742	0.744
20-35, Urban NT	31,614	.792	0.792	0.792
20-35, Urban T*	27,506	1.0		
>35, Rural	1302	.576	0.567	0.585
>35, Urban NT	7483	.678	0.673	0.683
>35, Urban T	7745	.707	0.706	0.708

1. Combined OR is equal to the exponentiated sum of beta coefficients for a given age group, hospital type, and their interaction. 2. Estimation of Odds Ratios in the presence of interaction calculated according to Hosmer and Lemeshow, *Applied Logistic Regression*, equation 3.10. (9)
* reference category

LR Model for Uterine Rupture

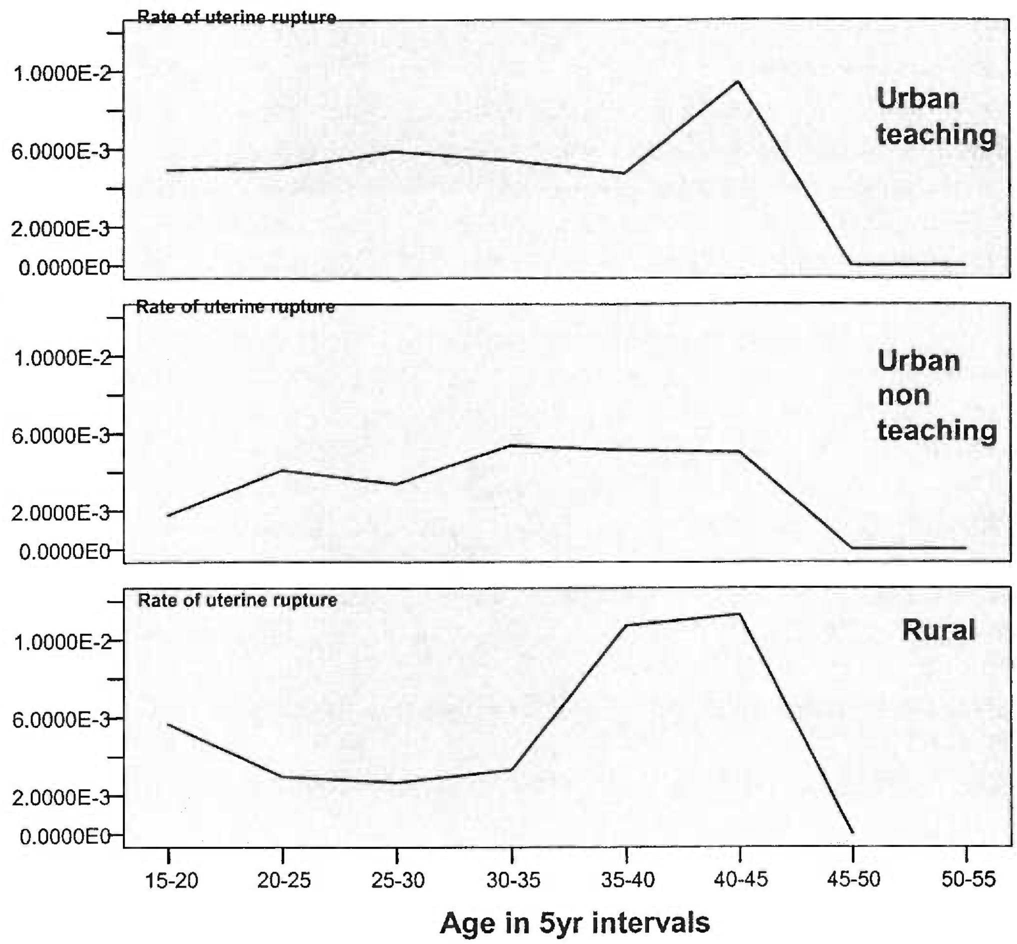
Logistic regression analysis was then used to develop a model predictive of uterine rupture. For this model, the two main effect variables included in the model for delivery type (age group and hospital type) were included by using forced entry methods. Then the forward stepwise entry method was used to test the predictive value of induction of labor (IOL) and preterm delivery, of which only induction of labor met the criteria for entry into the model. After creating the main effects model, the addition of the interaction of age group and hospital type was tested, and found to be significant. Thus the final model for uterine rupture included age group, hospital type, induction of labor, and the interaction of age group and hospital type. Within this model, induction of labor was the most predictive of uterine rupture based on the magnitude of the beta coefficient and the p-value of <.001. We were able to compare the betas of the individual variables because all of them were binary or categorical. Such a comparison would not have been useful were we to have used age as a continuous variable.

We also tested the interaction terms for IOL and age group, and for IOL and hospital type by adding each of these two interaction terms individually to the main effects model for uterine rupture. Neither were significant in the main effects model. We then tested them individually in the model for uterine rupture containing both main effects and the interaction term of age group and hospital type, and again found both interactions to be non-significant.

In order to choose the most appropriate measure of age for use in logistic regression analysis, we performed a series of tests. First we compared the R squared values for the models with age vs. age and age squared vs. age group.

While the model including age and age squared was eliminated early on account of a large p-value, the models with age and age group were not distinguishable by R squared values. We next plotted uterine rupture against age in 5 year intervals, broken down by hospital type (see Figure I). This allowed us to see that while there was a fairly linear relationship between age and uterine rupture risk within urban teaching and urban non-teaching hospitals, this was not true for rural hospitals. In our judgment, the marked increase of uterine rupture cases for women over age 35 in rural hospitals was captured best by a 3-category age group variable. While this effect of age group in rural hospitals may represent a small sample size effect, it was important to reflect our data as clearly as possible.

Figure I. Uterine Rupture by Maternal Age, Broken Down by Hospital Type.



The final multiple logistic regression model for uterine rupture is summarized in Table 10. In Table 11, the combined odds ratios for this model, including age group, hospital type, and their interaction have been calculated. These were calculated as if all patients were *not* induced, although induction of labor is part of the final model for uterine rupture and all combined odds ratios could be calculated for the induction scenario as well.

Table 10. Multiple Logistic Regression Model for uterine rupture.

Variable	OR	95% CI	P-Value
Age Group			0.940
<20	.872	.408, 1.866	0.725
20-35*	1.0	-	
>35	.998	.708, 1.406	0.989
Hospital Type			0.010
Rural	.562	.377,.837	0.005
Urban Non-teaching	.806	.639, 1.017	0.069
Urban Teaching*	1.0	-	
Induction of Labor	3.711	2.882, 4.779	0.000
Age Group / Hospital Type INTERACTION	-	-	0.003
<20, rural	2.281	.675, 7.715	.185
<20, urban non-teach	.467	.118, 1.848	.278
>35, rural	3.788	1.831, 7.838	.000
>35, urban non-teach	1.192	.725, 1.961	.489

**** Referent categories (Age 20-35, Urban Teaching hospital type, and their interaction)***

Table 11. Standardized Combined Odds Ratios for Uterine Rupture

	n	Odds Ratio	95% Lower CI	95% Upper CI
<20, Rural	883	1.118	0.257	4.871
<20, Urban NT	1713	0.330	0.166	0.653
<20, Urban T	1425	0.873	0.751	1.015
20-35, Rural	9865	0.562	0.540	0.586
20-35, Urban NT	31,614	0.808	0.796	0.819
20-35, Urban T*	27,506	1.0		
>35, Rural	1302	2.127	1.460	3.098
>35, Urban NT	7483	0.801	0.648	0.990
>35, Urban T	7745	0.998	0.968	1.029

1. Combined OR is equal to the exponentiated sum of beta coefficients for a given age group, hospital type, and their interaction. Although the final model for Uterine Rupture included Induction of Labor, Odds Ratios shown are calculated for the non-induced scenario. 2. Estimation of Odds Ratios in the presence of interaction calculated according to Hosmer and Lemeshow, *Applied Logistic Regression*, equation 3.10. (9) * reference category

Additional logistic regression analysis found that hospital type was not related to risk of uterine rupture-related hysterectomy (p=.483), hysterectomy and/or transfusion (p=.129) nor risk of transfusion and/or hysterectomy in general related to VBAC (p=.105).

Testing the models

After finalizing our logistic regression models predictive for VBAC and uterine rupture, we tested them to see how well they actually fit.

For the model predicting VBAC, the model fits well according to the Hosmer and Lemeshow test (p=1.00), in which a non-significant value is actually a positive indicator. (9) R squared values were low, however (Cox & Snell=0.005, Nagelkerke R square=0.009), which indicate that there is a great deal of unexplained variation.

For the model predicting uterine rupture, the Hosmer and Lemeshow test indicates a good fit (p=.991), while the R square values remained low (Cox & Snell=0.001, Nagelkerke R square=0.020), again indicating that there is a great deal of unexplained variation.

Power Calculation

In order to ensure that our analyses had enough power to conclude that, if we found no difference, there was no difference in proportion, we performed a power calculation for one of the rarest events, uterine rupture, by hospital type. When the total sample size across the 3 hospital groups is 89,536, a 0.05 level Chi-square test with an average incidence of 5 per 1000 will have >99% power to detect a difference of 0.72 per 1000. From this we concluded that we have >99% power to detect a difference for any of the other proportions we are testing.

DISCUSSION

Summary of the Results

We determined the overall incidence of VBAC and uterine rupture for the year 2000 to be 19.5% and 0.48% respectively. The rate of VBAC is slightly lower than the previously reported 20.7% for 2000, while the rate of uterine rupture found in our study is similar to previously reported population-based estimates. (1, 2, 11, 12, 13)

In our univariate analyses, the factors and outcomes that change *based on delivery type* in a significant manner both statistically and clinically are age, age group, uterine rupture, and induction of labor. Postpartum hemorrhage, transfusion, and hysterectomy were all statistically different by delivery type, but the differences were not clinically significant. Also in our univariate analyses, the factors and outcomes that change *based on hospital type* in a significant manner both statistically and clinically are age, delivery type, and induction of labor, while the magnitudes of change for uterine rupture, post partum hemorrhage, transfusion, hysterectomy, and preterm delivery were weakly statistically significant but clinically unimportant.

In univariate analyses, hospital type was strongly associated with a difference in VBAC rate, with rural hospitals having the lowest rate (15.4%), and urban teaching the highest rate (21.8%). This was for the most part expected and in and of itself does not add much to the conversation about how restricted rural hospitals should be in offering a trial of labor and VBAC to patients. It is outcomes data at each hospital that will provide new questions to ponder.

Hospital type alone did not appear to increase the risk of uterine rupture or any other poor maternal outcome studied. In univariate analyses, evaluation of the interplay between advanced maternal age and hospital type, however, suggested that at rural hospitals, maternal age >35 is associated with a greater risk of uterine rupture as compared with women aged 20-35 at rural hospitals (p<.001). But evaluation of the overlapping 95% confidence intervals revealed that there was no significant difference between either >35 and <20, or between <20 and 20-35. The stability of this result is thus questionable, and the fact that this was an unplanned comparison makes this a suggestion for future testing and not a basis for conclusion. While this association is uncertain in univariate analyses, it is much more convincing when examined as part of the logistic regression model for uterine rupture.

In univariate analyses of induction of labor, for patients who were induced, there was no significant difference in delivery type based on hospital type (p=.181). In addition, for patients who were induced there was no association between delivery type and age group (p=.297). Of the 5.4% of patients induced overall, 42.3% (95 CI 40.9, 43.7) delivered by repeat Cesarean, leaving 57.7% (95% CI 56.3,59.1) to VBAC (p<.001). An analysis of IOL by hospital type found rural hospitals to have the lowest induction rate (3.8%) (95% CI 3.5, 4.2), followed by urban non-teaching hospitals (5.1%) (95% CI 4.9, 5.3) and urban teaching hospitals (6.2%) (95% CI 5.9, 6.4) (p<.001).

An analysis of IOL and uterine rupture (without regard for delivery type) revealed that patients with uterine rupture were more likely to have been induced than their non-ruptured counterparts (17.4% vs. 5.3%, p<.001). Conversely, for the 5.4% of women induced, the rate of uterine rupture was 1.54% (95% CI 1.19, 1.89) compared with the rate of rupture for those not induced 0.42% (95% CI .37, .46) (p<.001). The observation that those induced had three and a half times the rate of rupture compared with those who were not induced is of interest, since there has been a great deal of attention paid to the risks of induction for women attempting TOL.

We found that 42.3% of patients induced actually went on to have a repeat Cesarean section, which we also thought quite interesting in light of the debate over induction of patients with a prior Cesarean delivery. If a significant proportion of induced patients fail TOL for reasons related to the induction itself, then it would be important to also know the relative risks of failed TOL with induction vs. those of failed TOL without induction. Unfortunately, our data did not allow for this analysis. Furthermore, for VBAC cases only, the analysis of IOL and uterine rupture revealed that those patients who ruptured were again more likely to have been induced than their non-ruptured counterparts (30.0% vs. 15.9%) (p=.035). Conversely, the rate of rupture for induced VBAC cases was greater than for those not induced (0.3% vs. 0.1%, p=.035). So it is possible that induction might increase the rate of failing TOL, but also increase the rupture rate for those patients who successfully VBAC.

In our multiple logistic regression analyses for VBAC, we determined using standardized combined odds ratios (calculated in the presence of an interaction according to Hosmer and Lemeshow) that women under 20 in urban teaching hospitals were most likely to VBAC (OR=1.660, 95% CI 1.654, 1.666), while women over 35 in rural hospitals were least likely to VBAC (OR=.576, 95% CI .567, .585).

In our multiple logistic regression analyses for uterine rupture, we determined using standardized combined odds ratios (calculated in the presence of an interaction according to Hosmer and Lemeshow) that women over 35 in rural hospitals were most likely to have uterine rupture (OR=2.127, 95% CI 1.46, 3.10), while women under 20 at urban non-teaching hospitals were least likely to have uterine rupture (OR=.330, 95% CI .166, .653). We also found that induction of labor was associated with an increased risk of rupture (OR=3.711, 95% CI 2.882, 4.779)

Interpretation of the Results

The main purpose of this study was to evaluate whether hospital type affected the safety of VBAC. We did not find that hospital type alone affected maternal morbidity from VBAC or uterine-rupture. Similar to other published studies, we found that induction of labor was strongly associated with increased risk of rupture (with almost a 4-fold increased risk of uterine rupture for induced patients). We also found an intriguing association between age and hospital type combined on uterine rupture with women over age 35 in rural hospitals experiencing a 2-fold increased risk of rupture and women under age 20 in urban non-teaching hospitals experiencing a 70% reduction in rate of rupture compared to women aged 20-35 in urban teaching hospitals. This is the first report that we know of finding this combined effect and deserves further investigation to determine the validity of this finding.

The fact that the incidence of VBAC in our study is less than that reported in the literature for the year 2000 (19.5% vs. 20.7%) cannot be well explained. While it is possible that we were unable to capture all of the VBAC cases due to some systematic error, multiple strategies for identifying VBAC cases were employed and compared, as discussed in the methods section. After exploring the subset of cases excluded from the main analysis based on lack of data indicating delivery type, we did not find any evidence that these cases were more likely to be VBAC cases than RCD cases.

Maternal age differed significantly by hospital type ($p<.001$), such that the youngest population was found in rural hospitals (28.1 vs. 30.1 for urban non-teaching hospitals vs. 30.5 at urban teaching hospitals). This was somewhat unexpected, as the assumption is generally of an aging rural population, although this could simply mean that the obstetrical population is getting smaller, so that while fewer young women live in rural areas, those that do are having babies at approximately the same age as previously.

Most of our interest is in regards to the multiple logistic regression analyses. While the model for VBAC did not reveal anything unexpected, combined odds ratios showed that women <20 at urban teaching hospitals are most likely to VBAC (OR=1.660, 95% CI 1.654, 1.666), while women >35 at rural hospitals are least likely to VBAC when compared to other combinations of age group and hospital type (OR=.576, 95% CI .567, .585), using women 20-35 at urban teaching hospitals as the reference group. A possible explanation of this finding is that women <20 are, on average, going to have had fewer total deliveries as compared with women >35, and thus fewer prior CDs, putting a provider at greater ease with offering TOL/VBAC as compared to that decision for women >35 with greater parity.

Our model for uterine rupture was very interesting for several reasons. First, the interaction of age group and hospital type appears more important than either of those main effects. Combined odds ratios calculated for this model (assuming no induction) showed that being > 35 when delivering at a rural hospital was associated with the greatest risk of rupture (OR=2.127, 95% CI 1.46, 3.10), while women <20 at urban non-teaching hospitals were the least likely to rupture (OR=.330, 95% CI .166, .653), when compared to other combinations of age group and hospital type, using women 20-35 at urban teaching hospitals as the reference group. An analysis of parity would be helpful here, as age may simply be serving as a proxy for parity, and parity may be the more predictive of uterine rupture risk. This would make sense given that on average, rural women have more children by a younger age as compared with urban women. Another possibility is that uterine rupture is either more likely to be symptomatic, or more likely to be detected in older women, although then one should see the rise in uterine rupture across hospital type.

When comparing the two models using the combined odds ratios, we find that women >35 at rural hospitals are the group least likely to VBAC but also the group most likely to have uterine rupture. Several explanations are possible for this observation. First, it may be that providers recognize that women >35 are at greatest risk of rupture and are less apt to offer TOL/VBAC in rural hospitals. On the other hand, this may suggest that restriction of TOL/VBAC is not an effective means to reduce uterine rupture. Another possibility is that this may be coincidental and due to a small sample size effect, and would not be replicated in a similar study with another sample. Coupled with the fact that the percentage of women in the >35 age group was lower as compared with urban hospitals (composing only 10.8%, n=1302, of the rural population as compared with 18.3% for urban non-teaching and 21.1% for urban teaching hospitals), more study of this relationship is warranted. Given that two of the most important findings are based on the second smallest cell size (see Table 3), it is essential that they be replicated and that more related detailed clinical data explored before drawing any conclusions.

The second reason the uterine rupture model is clinically interesting is the finding that the risk of rupture is strongly associated with induction of labor (OR=3.711, 95% CI 2.882, 4.779). The degree to which induction increases rupture risk was striking, and provides more information to the evidence on safety of induction for patients attempting TOL. Interestingly, the interaction terms for induction of labor with both age and hospital type were tested in the main effects model and in the model including the interaction of age and hospital type, but in no case was either interaction involving IOL significant. In combination with the univariate analyses demonstrating that 42.3% of patients deliver by RCD, our results suggest that inducing TOL patients is both potentially ineffective and hazardous. More study of this association is clearly indicated.

Limitations

A major limitation is our inability to capture the difference in clinical decision making around determining eligibility for TOL that may differ across setting types. Thus it is not possible for us to account for selection bias that may occur among the settings. It is possible that urban teaching hospitals with 24-hour in-house coverage may allow a broader range of women to VBAC and that providers without 24-hour coverage may be more selective in their criteria. Either way, there was no apparent trend in morbidity associated with hospital type alone. That said, however, the explanation for the trend based on the interaction of hospital type and age group may require exactly the type of information about clinical decision making that we do not have available to us.

Another major part of any comprehensive analysis of the safety of VBAC which is not addressed in this study is the difference in maternal outcomes for women who fail TOL vs. those that choose ERCD. Approximately 24.9% of women who attempt TOL ultimately deliver by RCD. There is preliminary evidence in the literature to suggest that the maternal outcomes may not be different (Guise, 2003), however this analysis is not possible using the dataset, and is thus outside the scope of our study.

The lack of parity data truly limits our ability to explain several of the findings from the logistic regression models. It is quite possible that maternal age serves as a proxy for parity, and answering that question would impact significantly the practice guidelines for offering TOL/VBAC.

There are several other aspects to this study that warrant further investigation. The first is the large number of cases for which missing data excluded them from the main analysis, paired with the fact that the rate of VBAC in this study is slightly less than the rate established in the literature (19.5% vs. 20.7%). The number of cases excluded gave us pause, as we considered the possibility that something about this group was systematically different from the cohort included in the main analysis. As outlined in the methods section, we tried several different strategies for identifying the delivery type of cases, and felt our final strategy was the most accurate and logical. We continued to explore the population of cases excluded but were unable to identify whether the patients delivered by VBAC or repeat Cesarean in any systematic way. While we have no reason to believe that the cases excluded distribute differently with regard to delivery type, the number of cases forces us to consider that the incidence of VBAC might approximate the value in the literature more closely were they included.

While the large size of the cohort was an asset in terms of achieving statistical significance and adequately powering our analyses, the size in combination with a lack of detailed clinical information also imposed limitations on the strategies for analysis, primarily because reviewing one hundred thousand cases on an individual basis was not feasible, and even the review of a random sample was unlikely to be useful.

It is always possible that assumptions we make in designing a research protocol may lead to the introduction of systematic error into our study. In this protocol, the fact that the sample sizes are so large may have lead to amplification of any bias resulting from our design. This is a concern, especially because have a very limited amount of data on each subject, and are thus unable to understand the possible complexities of each individual delivery situation and how it unfolded. Any misinterpretation of the way in which codes were designed to be used might heavily impact our results. Alternatively, because of the cohort size nearly every difference achieved statistical significance. This makes the judgments of clinical relevance all the more essential if we are to make good use of the data. With every significant result we needed to ask ourselves if the difference was important or interesting to our care of patients.

There are several important research questions that naturally arise in the discussion of VBAC, but that will not be answered by the results of our study. The study of neonatal outcomes in a large cohort such as this is necessary in developing a complete understanding of the risks associated with VBAC and TOL, especially as there is no discussion in the literature of the scope of neonatal morbidity that can be directly attributed to VBAC vs. repeat C-section. In our original study design we hoped to connect the maternal and neonatal records, allowing for the assessment of both maternal and neonatal outcomes. This was not possible within the HCUP NIS dataset, however, and so these questions remain unanswered. Thus, future research will need to address the possible scope of neonatal outcomes, as they are attributable to mode of delivery.

Our results do not address the possible differences in education and counseling that women receive regarding VBAC, and their individual likelihood of success, based on whether they are at an urban or rural hospital. Thus, we cannot draw conclusions about whether the difference in VBAC rates is in part due to a difference in education and information, rather than to a difference in the frequency with which TOL is offered.

Our results do not take into account women living in rural areas who intentionally sought maternity care and delivered in urban settings, knowing that they would be more likely to have the option of attempting TOL, but who otherwise would have stayed at their local hospital. We are making the assumption that this subset of women represents a very small percent of the cohort.

Despite these limitations, the results obtained in this research study advance our understanding of the ways in which maternity options differ for women based on the hospital in which they deliver. In addition, it provides evidence on outcomes that do not necessarily support the disparity in provision of VBAC as part of a full range of maternity options.

Future Research

As with any study involving findings that may potentially impact health care practices, the most important questions in regards to future research are whether these results can be replicated within another large sample, and whether these results are conclusive enough that we can act on them. In addition, results of this study suggest that more investigation both of the difference in maternal outcomes for ERCD vs. failed TOL, and of the influence of induction of labor on uterine rupture risk are warranted.

CONCLUSIONS

In conclusion, we did not find that hospital type alone affected maternal morbidity from VBAC or uterine-rupture. Similar to other published studies, we found that induction of labor was strongly associated with increased risk of rupture. We also found an association between age and hospital type combined on uterine rupture with women over age 35 in rural hospitals experiencing a 2-fold increased risk of rupture, and women under age 20 in urban non-teaching hospitals experiencing a 70% reduction in rate of rupture compared to women aged 20-35 in urban teaching hospitals. This is the first report that we know of finding this combined effect and deserves further investigation to determine the validity of this finding.

REFERENCES

1. Harer W. Vaginal Birth After Cesarean Delivery; Current Status. JAMA, 2002, 287(20):2627-2630.
2. Guise J-M, McDonagh M, Hashima J, et al. Vaginal Birth After Cesarean (VBAC). Evidence Report/Technology Assessment No. 71. (Prepared by the Oregon Health & Science University Evidence-based Practice Center inder Contract No. 290-97-0018). AHRQ Publication No. 03-E018. Rockville, MD: Agency for Healthcare Research and Quality. March 2003.
3. Leung AS, Leung EK, Paul RH. Uterine Rupture after previous Cesarean delivery: maternal and fetal consequences. American Journal of Obstetrics and Gynecology 1993;169(4):945-50.
4. Cohen B and Atkins M. Brief history of vaginal birth after cesarean section. Clinical Obstetrics and Gynecology,2001; 44(3):604-8.
5. QuickStats: Total and Primary Cesarean Rate and Vaginal Birth After Previous Cesarean (VBAC) Rate --- United States, 1989—2003. April 13, 2005.
6. Upadhyaya C et al. Vaginal Birth After Cesarean Delivery in a small rural community with a solo practice. American Journal of Perinatology, 2003, 20(2):63-67.
7. ACOG practice bulletin. Vaginal birth after previous cesarean delivery. Number 2, October 1998. Clinical management guidelines for obstetrician-gynecologists. American College of Obstetricians and Gynecologists. Int J Gynaecol Obstet. 1999 Feb;64(2):201-8. Review.
8. Zinberg, S. Vaginal Delivery After Previous Cesarean Delivery: A Continuing Controversy. Clinical Obstetrics and Gynecology, 2001;44(3):561-70.
9. AHRQ. Overview of the HCUP Nationwide Inpatient Sample (NIS) 2000. Rockville, MD: Agency for Healthcare Research and Quality. May 2002.
10. Hosmer DW, Lemeshow S. *Applied Logistic Regression, 2nd ed.* New York: John Wiley, 2000.
11. Smith GC, Pell JP, Pasupathy D, Dobbie R. Factors predisposing to perinatal death related to uterine rupture during attempted vaginal birth after cesarean section: retrospective cohort study. British Medical Journal, 2004 Aug 14;329(7462):375. Epub 2004 Jul 19.
12. Landon MB, Hauth JC, Leveno KJ, Spong CY, Leindecker S, Varner MW, Moawad AH, Caritis SN, Harper M, Wapner RJ, Sorokin Y, Miodovnik M, Carpenter M, Peaceman AM, O'Sullivan MJ, Sibai B, Langer O, Thorp JM, Ramin SM, Mercer BM, Gabbe SG; National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Maternal and perinatal outcomes associated with a trial of labor after prior cesarean delivery. N Engl J Med. 2004 Dec 16;351(25):2581-9.
13. Guise, J-M et al. Systematic review of the incidence and consequences of uterine rupture in women with previous cesarean section. British Medical Journal, 2004, 329:19-23.

Appendix

****** The Chi-square statistic was used for testing unless otherwise noted. Other statistics appearing in the following tables should be disregarded.**

Table A1. Uterine Rupture by Hospital Type(% (n))

	No Rupture	Yes Rupture	Total
Rural	99.6% (12002)	0.4% (48)	100.00% (12050)
Urban Non-Teaching	99.6% (40632)	0.4% (178)	100.00% (40810)
Urban Teaching	99.5% (36476)	0.5% (200)	100.00% (36676)
Total	99.5% (89110)	0.5% (426)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	6.623	2	.036

Table A2. Age by Uterine Rupture

uterine rupture in DX codes	Mean Age	N	Std. Deviation	Minimum	Maximum
no rupture	29.98	89110	5.701	12	54
yes rupture	30.79	426	5.791	18	45
Total	29.98	89536	5.701	12	54

Table A3. Uterine Rupture by Age Group

age group * uterine rupture in DX codes Crosstabulation

			uterine rupture in DX codes		
			no rupture	yes rupture	Total
age group	< 20 yrs	Count	4006	15	4021
		% within age group	99.6%	.4%	100.0%
		% within uterine rupture in DX codes	4.5%	3.5%	4.5%
	20-35 yrs	Count	68668	317	68985
		% within age group	99.5%	.5%	100.0%
		% within uterine rupture in DX codes	77.1%	74.4%	77.0%
	>35 yrs	Count	16436	94	16530
		% within age group	99.4%	.6%	100.0%
		% within uterine rupture in DX codes	18.4%	22.1%	18.5%
Total		Count	89110	426	89536
		% within age group	99.5%	.5%	100.0%
		% within uterine rupture in DX codes	100.0%	100.0%	100.0%

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.293(a)	2	.117
Likelihood Ratio	4.192	2	.123
Linear-by-Linear Association	[illegible]	1	.039
N of Valid Cases	89536		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 19.13.

Table A4. Chi-Square test for Uterine Rupture by Age Group, Adjusted for Hospital Type

Chi-Square Tests

rural vs urban nt vs urban t		Value	df	Asymp. Sig. (2-sided)
rural	Pearson Chi-Square	18.374[a]	2	.000
	Likelihood Ratio	13.773	2	.001
	Linear-by-Linear Association	6.240	1	.012
	N of Valid Cases	12050		
urban non teaching	Pearson Chi-Square	3.578[b]	2	.167
	Likelihood Ratio	4.326	2	.115
	Linear-by-Linear Association	2.657	1	.103
	N of Valid Cases	40810		
urban teaching	Pearson Chi-Square	.085[c]	2	.958
	Likelihood Ratio	.088	2	.957
	Linear-by-Linear Association	.007	1	.935
	N of Valid Cases	36676		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.52.

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.47.

c. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.77.

Table A5. Uterine Rupture by Delivery Type (% (n))

	Yes Rupture	Total
VBAC	0.2% (30)	100.00% (17417)
RCD	0.5% (396)	100.00% (72119)
Total	0.5% (426)	100.00% (89536)

	Value	**Asymp. Sig (2-sided)**
Chi-Square	42.074	.000

Table A6. Maternal Death during hospital admission by Delivery Type, n

	Did Not Die	DIED	Total
VBAC	17417	0	17417
RCD	72112	7	72119
Total	89529	7	89536

	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Fisher's Exact Test	.359	.220

Table A7. Maternal Death during hospital admission by Hospital Type, n

	Did Not Die	DIED	Total
Rural	12049	1	12050
Urban Non-Teach	40809	1	40810
Urban Teaching	36671	5	36676
Total	89529	7	89536

	Exact Sig. (1-sided)
Fisher's Exact Test	.182

Table A8. Death by Uterine Rupture, n

	Did Not Die	DIED	Total
No Rupture	89103	7	89110
Yes Rupture	426	0	426
Total	89529	7	89536

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	42.074	1	.000

Table A9. Suspected causes of death

When each of the maternal death cases was reviewed individually in order to determine exactly what these women died from, the following reasons were determined, although there is no way to verify that these are the direct causes of death:

Case 1 – PE and infarction/OB blood clot embolism;
Case 2 – severe PET, abruption;
Case 3 – amniotic fluid embolism;
Case 4 – unable to determine;
Case 5 – abruption/post partum coagulation defects;

Case 6 – cardiac disease/post partum coagulation defects;
Case 7 – cardiac disease/splenic artery aneurysm

Table A10. Post Partum Hemorrhage by Delivery Type, % (n)

	No PPH	**Yes PPH**	**Total**
VBAC	96.6% (16824)	3.4% (593)	100.00% (17417)
RCD	98.9% (71298)	1.1% (821)	100.00% (72119)
Total	98.4% (88122)	1.6% (1414)	100.00% (89536)

	Value	**Df**	**Asymp. Sig (2-sided)**
Pearson's Chi-Square	463.586	1	.000

Table A11. Post Partum Hemorrhage by Uterine Rupture, % (n)

	No PPH	**Yes PPH**	**Total**
No Rupture	98.4% (87719)	1.6% (1391)	100.00% (89110)
Yes Rupture	94.6% (403)	5.4% (23)	100.00% (426)
Total	98.4% (88122)	1.6% (1414)	100.00% (89536)

	Value	**Df**	**Asymp. Sig (2-sided)**
Pearson's Chi-Square	40.181	1	.000

Table A13. Post Partum Hemorrhage by Hospital Location/Teaching Status, % (n)

	No PPH	**Yes PPH**	**Total**
Rural	98.6% (11881)	1.4% (169)	100.00% (12050)
Urban Non-Teach	98.9% (71298)	1.1% (821)	100.00% (40810)
Urban Teaching	98.1% (35978)	1.9% (698)	100.00% (36676)
Total	98.4% (88122)	1.6% (1414)	100.00% (89536)

	Value	**Df**	**Asymp. Sig (2-sided)**
Pearson's Chi-Square	42.162	1	.000

Table A14. Transfusion by Delivery Type, % (n)

	No Transfusion	**Yes Transfusion**	**Total**

VBAC	99.5% (17334)	0.5% (83)	100.00% (17417)
RCD	99.3% (71601)	0.7% (518)	100.00% (72119)
Total	99.3% (88935)	0.7% (601)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	12.293	1	.000

Table A15. Transfusion by Uterine Rupture, % (n)

	No Transfusion	Yes Transfusion	Total
No Rupture	99.4% (88534)	0.6% (576)	100.00% (89110)
Yes Rupture	94.1% (401)	5.9% (25)	100.00% (426)
Total	99.3% (88935)	0.7% (601)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	173.415	1	.000

Table A16. Transfusion by Hospital Location/Teaching Status, % (n)

	No Transfusion	Yes Transfusion	Total
Rural	99.4% (11975)	0.6% (75)	100.00% (12050)
Urban Non-Teach	99.4% (40549)	0.6% (261)	100.00% (40810)
Urban Teaching	99.3% (36411)	0.7% (265)	100.00% (36676)
Total	99.3% (88935)	0.7% (601)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	2.494	1	.287

Table A17. Hysterectomy by Delivery Type, % (n)

	No Hyst	Yes Hyst	Total
VBAC	99.9% (17402)	0.1% (15)	100.00% (17417)
RCD	99.7% (71932)	0.3% (187)	100.00% (72119)
Total	99.8% (89334)	0.2% (202)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	18.690	1	.000

Table A 18. Hysterectomy by Uterine Rupture, % (n)

	No Hyst	Yes Hyst	Total
No Rupture	99.8% (88926)	0.2% (184)	100.00% (89110)
Yes Rupture	95.8% (408)	4.2% (18)	100.00% (426)
Total	99.8% (89334)	0.2% (202)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	304.209	1	.000

Table A19. Hysterectomy by Hospital Location/Teaching Status, % (n)

	No Hyst	Yes Hyst	Total
Rural	99.9% (12039)	0.1% (11)	100.00% (12050)
Urban Non-Teach	99.8% (40730)	0.2% (80)	100.00% (40810)
Urban Teaching	99.7% (36565)	0.3% (111)	100.00% (36676)
Total	99.8% (89334)	0.2% (202)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	20.915	1	.000

Table A20. Induction of Labor by Delivery Type, % (n)

	No IOL	Yes IOL	Total
VBAC	84.1% (14369)	15.9% (2778)	100.00% (17417)
RCD	97.2% (70084)	2.8% (2035)	100.00% (72119)
Total	94.6% (84723)	5.4% (4813)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	18.690	1	.000

TableA21. Induction of Labor by Uterine Rupture – ALL CASES, % (n)

	No IOL	Yes IOL	Total
No Rupture	94.7% (84371)	5.3% (4739)	100.00% (89110)
Yes Rupture	82.6% (352)	17.4% (74)	100.00% (426)
Total	94.6% (84723)	5.4% (4813)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Chi-Square	121.084	1	.000

Table A22. Induction of Labor by Uterine Rupture – VBAC CASES ONLY, % (n)

uterine rupture in DX codes * induction of labor Crosstabulation

			induction of labor		Total
			no iol	yes iol	
uterine rupture in DX codes	no rupture	Count	14618	2769	17387
		% within uterine rupture in DX codes	84.1%	15.9%	100.0%
		% within induction of labor	99.9%	99.7%	99.8%
	yes rupture	Count	21	9	30
		% within uterine rupture in DX codes	70.0%	30.0%	100.0%
		% within induction of labor	.1%	.3%	.2%
Total		Count	14639	2778	17417
		% within uterine rupture in DX codes	84.1%	15.9%	100.0%
		% within induction of labor	100.0%	100.0%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.425(b)	1	.035		
Continuity Correction(a)	3.438	1	.064		
Likelihood Ratio	3.696	1	.055		
Fisher's Exact Test				.045	.039
Linear-by-Linear Association	4.425	1	.035		
N of Valid Cases	17417				

a Computed only for a 2x2 table
b 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.78.

Table A23. Induction of Labor by Hospital Location/Teaching Status, % (n)

	No IOL	Yes IOL	Total
Rural	96.2% (11588)	3.8% (462)	100.00% (12050)
Urban Non-Teach	94.9% (38721)	5.1% (2089)	100.00% (40810)
Urban Teaching	93.8% (34414)	6.2% (2262)	100.00% (36676)
Total	94.6% (84723)	5.4% (4813)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	106.807	2	.000

Table A24. Preterm by Delivery Type, % (n)

	Not Preterm	Preterm	Total

VBAC	92.6% (16123)	7.4% (1294)	100.00% (17417)
RCD	94.2% (67956)	5.8% (4163)	100.00% (72119)
Total	93.9% (84079)	6.1% (5457)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	67.311	1	.000

Table A25. Preterm by Uterine Rupture, % (n)

	Not Preterm	Preterm	Total
No Rupture	93.9% (88926)	6.1% (5424)	100.00% (89110)
Yes Rupture	92.3% (393)	7.7% (33)	100.00% (426)
Total	93.9% (84079)	6.1% (5457)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	2.040	1	.153

Table A26. Preterm by Hospital Location/Teaching Status, % (n)

	Not Preterm	Preterm	Total
Rural	96.2% (11596)	3.8% (454)	100.00% (12050)
Urban Non-Teach	94.7% (38639)	5.3% (2171)	100.00% (40810)
Urban Teaching	92.3% (33844)	7.7% (2832)	100.00% (36676)
Total	93.9% (84079)	6.1% (5457)	100.00% (89536)

	Value	Df	Asymp. Sig (2-sided)
Pearson's Chi-Square	326.46	2	.000

Table A27. Chi-square test for Uterine Rupture by Hospital Type, Adjusted for Induction of Labor

Chi-Square Tests

induction of labor		Value	df	Asymp. Sig. (2-sided)
no iol	Pearson Chi-Square	3.948[a]	2	.139
	Likelihood Ratio	3.916	2	.141
	Linear-by-Linear Association	3.541	1	.060
	N of Valid Cases	84723		
yes iol	Pearson Chi-Square	1.002[b]	2	.606
	Likelihood Ratio	1.002	2	.606
	Linear-by-Linear Association	.913	1	.339
	N of Valid Cases	4813		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 48.14.

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.10.

Table A28. Chi-square test for Uterine Rupture by Age Group, Adjusted for Hospital Type

Chi-Square Tests

rural vs urban nt vs urban t		Value	df	Asymp. Sig. (2-sided)
rural	Pearson Chi-Square	18.374[a]	2	.000
	Likelihood Ratio	13.773	2	.001
	Linear-by-Linear Association	6.240	1	.012
	N of Valid Cases	12050		
urban non teaching	Pearson Chi-Square	3.578[b]	2	.167
	Likelihood Ratio	4.326	2	.115
	Linear-by-Linear Association	2.657	1	.103
	N of Valid Cases	40810		
urban teaching	Pearson Chi-Square	.085[c]	2	.958
	Likelihood Ratio	.088	2	.957
	Linear-by-Linear Association	.007	1	.935
	N of Valid Cases	36676		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.52.

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.47.

c. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.77.