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# Practice variation of vaginal birth after cesarean and the influence of risk factors at patient level: a retrospective cohort study

EMY VANKAN[1], ELLEN N. SCHOOREL[1], SANDER M. VAN KUIJK[2], BEN-WILLEM J. MOL[3], JAN G. NIJHUIS[1], ROBERT AARDENBURG[4], MARLEEN ALINK[1], KARIN DE BOER[5], FRISO M.C. DELEMARRE[6], CARMEN D. DIRKSEN[2], IVO M. VAN DOOREN[7], MAUREEN T.M. FRANSSEN[8], MESRURE KAPLAN[9], GUNILLA KLEIVERDA[10], SIMONE M.I. KUPPENS[11], ANNEKE KWEE[12], JOSJE LANGENVELD[13], FRANS T. LIM[14], SONJA MELMAN[1], MARKO J. SIKKEMA[15], LUC J. SMITS[16], HARRY VISSER[17], MALLORY WOISKI[18], HUBERTINA C. SCHEEPERS[1] & ROSELLA P. HERMENS[19]

*[1]Department of Obstetrics and Gynecology, GROW-School for Oncology and Developmental Biology, Maastricht University Medical Center+, Maastricht, [2]Department of Clinical Epidemiology and Medical Technology Assessment (KEMTA), Maastricht University, Maastricht, the Netherlands, [3]Department of Obstetrics and Gynecology, The Robinson Research Institute, University of Adelaide, Adelaide, South Australia, Australia, [4]Department of Obstetrics and Gynecology, Zuyderland Medical Center, Sittard, [5]Department of Obstetrics and Gynecology, Hospital Rijnstate, Arnhem, [6]Department of Obstetrics and Gynecology, Elkerliek Hospital, Helmond, [7]Department of Obstetrics and Gynecology, Sint Jans Gasthuis, Weert, [8]Department of Obstetrics and Gynecology, Groningen University Medical Center, Groningen, [9]Department of Obstetrics and Gynecology, Röpcke-Zweers Hospital, Hardenberg, [10]Department of Obstetrics and Gynecology, Flevo Hospital, Almere, [11]Department of Obstetrics and Gynecology, Catharina Hospital, Eindhoven, [12]Department of Obstetrics and Gynecology, University Medical Center Utrecht, Utrecht, [13]Department of Obstetrics and Gynecology, Zuyderland Medical Center, Heerlen, [14]Department of Obstetrics and Gynecology, IJsselland Hospital, Capelle aan den IJssel, [15]Department of Obstetrics and Gynecology, ZiekenhuisGroep Twente, Almelo, [16]Caphri School for Public Health and Primary Care, Maastricht University, Maastricht, [17]Department of Obstetrics and Gynecology, Tergooi Hospital, Hilversum, [18]Department of Obstetrics and Gynecology, Radboud University Nijmegen Medical Center, Nijmegen, and [19]Scientific Institute for Quality of Healthcare (IQ healthcare), Radboud University Nijmegen Medical Center, Nijmegen, the Netherlands*

**Key words**
Cesarean section, practice variation, risk factors, trial of labor, vaginal birth after cesarean

**Correspondence**
Emy Vankan, Maastricht UMC+, Department of Obstetrics and Gynecology, P.O. Box 5800 6202 AZ Maastricht, the Netherlands.
E-mail: emy.vankan@maastrichtuniversity.nl

**Conflict of interest**
The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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## Abstract

*Introduction.* Large practice variation exists in mode of delivery after cesarean section, suggesting variation in implementation of contemporary guidelines. We aim to evaluate this practice variation and to what extent this can be explained by risk factors at patient level. *Material and methods.* This retrospective cohort study was performed among 17 Dutch hospitals in 2010. Women with one prior cesarean section without a contraindication for a trial of labor were included. We used multivariate logistic regression analysis to develop models for risk factor adjustments. One model was derived to adjust the elective repeat cesarean section rates; a second model to adjust vaginal birth after cesarean rates. Standardized rates of elective repeat cesarean section and vaginal birth after cesarean per hospital were compared. Pseudo-$R^2$ measures were calculated to estimate the percentage of practice variation explained by the models. Secondary outcomes were differences in practice variation between hospital types and the correlation between standardized elective repeat cesarean section and vaginal birth after cesarean rates. *Results.* In all, 1068 women had a history of cesarean section, of whom 71% were eligible for inclusion. A total of 515 women (67%) had a trial of labor, of whom 72% delivered vaginally. The elective repeat cesarean section rate at hospital level ranged from 6 to 54% (mean 29.8, standard deviation 11.8%). Vaginal birth after cesarean rates ranged from 50 to 90% (mean 71.8%, standard


 

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deviation 11.1%). More than 85% of this practice variation could not be explained by risk factors at patient level. *Conclusion.* A large practice variation exists in elective repeat cesarean section and vaginal birth after cesarean rates that can only partially be explained by risk factors at patient level.

**Abbreviations:** B, Ballotable; BMI, body mass index; CS, cesarean section; EFW, estimated fetal weight; ERCS, elective repeat cesarean section; GA, gestational age; HELLP, Hemolysis Elevated Liver enzymes and Low Platelets; H, Hodge; SD, standard deviation; TOL, trial of labor; VBAC, vaginal birth after cesarean.

## Introduction

The numbers of women who are pregnant following a cesarean section (CS) have increased in many parts of the world. Guidelines were developed that advise on how to counsel women on mode of birth after CS and how to organize care (1–5). In this counseling, women should be given information including benefits and risks of both options and ideally, shared decision making has to take place. Women can choose for elective repeat CS (ERCS) or start a vaginal delivery [trial of labor (TOL)], ending in a vaginal birth after cesarean (VBAC) or an unplanned CS. Studies show large practice variation in TOL rates (6,7) both at national and international levels, suggesting large variation in implementation of contemporary guidelines. Yet these studies did not correct for factors at patient level, hence the results should be interpreted with caution as variation in patient populations might induce this practice variation. One would expect that when patients are counseled according to risk status, higher ERCS rates would be associated with higher actual VBAC in those women attempting VBAC. Besides, practice variation might not only be dependent on factors at a patient level, but also on type of hospital. University hospitals could have an organization different from non-university teaching and non-teaching hospitals. Insight into these factors is necessary before full implementation of guidelines can be achieved.

In order to accurately analyze practice variation we aim to evaluate practice variation in mode of delivery after CS and particularly to what extent it can be explained by factors at patient level. Secondly, we aim to evaluate if the type of hospital influences practice variation as well. Finally, we will analyze the correlation between ERCS rates and VBAC rates.

## Material and methods

In a nationwide retrospective cohort study we compared care regarding mode of delivery for women who are pregnant after a CS, among 17 Dutch hospitals in terms of practice variation.

All enrolled hospitals participated in the Dutch consortium of obstetrics and gynecology and were representative for Dutch geographic regions and hospital types. The present study was performed in academic teaching hospitals ($n = 5$), non-academic teaching hospitals ($n = 7$) and non-academic non-teaching hospitals ($n = 5$). Consecutive deliveries were recorded per site starting at 1 January 2010. All enrolled sites were requested to include 30 consecutive women who had a TOL and all women who had an ERCS in the same time-interval. This resulted in an overview of all women who had delivered within the set time-interval and had one or two or more prior CSs. Data collection for all hospitals was completed within the year 2010. Subsequently, a database was constructed that included all women who had one prior CS.

We included women with a history of one prior CS and a vertex singleton pregnancy who delivered at ≥37 weeks of gestation. Women were excluded when they had an unknown indication of prior CS or in the current pregnancy an intrauterine fetal demise or a contraindication for a TOL. A contraindication for TOL was defined as a previous uterine rupture, a placenta previa or a relevant uterine scar. Eligible women received oral and/or written information on the mode of delivery from their obstetrician or midwives during one or, if preferred, more consultations in their pregnancy. The discussion and decision on mode of delivery takes place around 36 weeks during consultation with the obstetrician.

The main outcome measures of this study were the amount of variation in ERCS and VBAC rates between hospitals corrected for risk factors at patient level. Concerning these factors, we selected variables based on their

### Key Message

The a priori probability of having a cesarean section after a previous cesarean section independent of woman's individual risk factors varies strongly by hospital.

predictive ability for VBAC found in literature, existing prediction models and expert opinion (8,9). Secondary outcome measures were the differences in practice variation between hospital types and whether there was a correlation between standardized ERCS and VBAC rates.

There is consensus about the maximum number of predictors that can be validly included in a prediction model. It is recommended that at least 10 events are collected for each potential predictor that is evaluated in the multivariable regression analysis (10). An event is defined as the least frequent outcome status, which is in our case an unplanned CS. In the Netherlands the estimated event rate, i.e. TOL failure rate, is 24–28% (11,12). Therefore, in order to develop a model with 14 potential predictors, at least 140 events were required. Hence, a sample size of at least 500 participants was required (140/28*100).

We collected data on frequencies of mode of delivery after CS per hospital. To investigate the influence of risk factors at patient level, data were gathered with regard to demographic factors (maternal age and ethnicity), past obstetric factors and pre-existing and current obstetric factors. Obstetric factors included variables that are predictive for mode of birth after CS and for VBAC. These variables were chosen based on published prediction models on VBAC, original research articles that report on predictors for mode of birth after CS, VBAC and on expert opinion (8,9). The variables considered relevant for assessing the influence of risk factors at patient level included maternal age, prepregnancy body mass index (BMI), ethnicity, prior nonprogressive labor, any prior VBAC, any prior vaginal delivery, estimated fetal weight (EFW) ≥p90, diabetes mellitus, hypertension, preeclampsia/HELLP (Hemolysis Elevated Liver enzymes and Low Platelets) syndrome. Prepregnancy BMI was defined as $kg/m^2$ obtained prepregnancy or within the first trimester. EFW was measured in the third trimester by either ultrasound or upon physical examination. Diabetes mellitus and hypertension could be either pre-existent or pregnancy-induced. For prediction of VBAC we added to this set whether labor was induced and labor parameters upon presentation to the labor ward (cervical dilatation, cervical effacement and fetal station). Cervical dilatation was registered per centimeter (range 0–10). Cervical effacement was categorized in three measures: 0–25%, 25–50%, >50%. Fetal engagement was recorded according to the "Hodge classification system" (range H0–H4) and converted to the American classification system ranging from ballotable (B) to +5. This variable was defined as follows: H0, −5; H1, −3; H2, −1; H3, 0; H4, +3.

Data were extracted from medical records by trained research staff using customized case report forms. Data were checked for completeness and inconsistencies. Inconsistent and incomplete data were double-checked directly with the hospital concerned.

All missing data were imputed using single stochastic regression imputation because omission of incomplete cases can result in loss of precision and may bias the results (13,14). For imputation, all quantitative baseline characteristics were used for estimation of the missing values. We assumed data were missing at random, which is an assumption of the imputation model that we used.

For assessing the influence of risk factors at patient level, we derived two multivariate logistic regression models that predicted ERCS and VBAC, respectively. One model was used to correct ERCS rates for risk factors at patient level, whereas the second model was used to correct VBAC rates for risk factors at patient level. The multivariate logistic regression models were developed using a backwards stepwise elimination method. At first, we performed univariate analyses to assess which risk factors at patient level could be related to the outcome variables. To minimize the risk of exclusion of important variables, we used a liberal $p$-value of 0.2 to estimate which variables were univariate significantly related to the outcome variables (8). Subsequently, the multivariate logistic regression formula was applied to the data set to calculate both the probability of ERCS and VBAC per woman. Mean predicted outcomes per hospital represented the expected ERCS and VBAC rates per hospital. Expected ERCS and VBAC rates per hospital were compared to the "true," "observed" rates. Accordingly, for each hospital, standardized rates were computed by dividing observed rates by expected rates and multiplying this by the population mean. The standardized rate represents the ERCS and VBAC rates that the hospital would have if all hospitals had a similar patient population. Pseudo-$R^2$ measures were obtained for estimation of the total percentage of practice variation that was explained by the models. Subsequently correlation between standardized ERCS rates and VBAC rates was tested using Spearman's rank correlation test (reference $p < 0.05$) (as the data were not normally distributed) and by visually inspecting the plot. Statistical analyses were performed using SPSS version 20.0 (IBM Corp., Armonk, NY).

The Medical Ethical Committee (CMO) of Maastricht (Maastricht University Medical Center/University of Maastricht) declared that no ethical approval was required for this study protocol (MEC number 12-4-034).

## Results

We reviewed 9833 consecutive medical records, and 1068 women (11%) had a history of CS, of whom 763 (71%) met the inclusion criteria. The baseline characteristics of this study cohort are shown in Table 1.

On average, maternal age, ethnicity, and having preeclampsia/HELLP or hypertension did not differ between ERCS and TOL.

In our cohort, 248 (33%) women had an ERCS. The other 515 women (67%) had a TOL of whom 371 (72%) had a VBAC, resulting in a VBAC rate of 49%. Women who underwent an ERCS more often had a prior CS due to failure to progress, more often had diabetes mellitus, and had a higher BMI or an EFW ≥ p90. Women who underwent an ERCS less often had a prior vaginal delivery or prior VBAC.

We entered all with univariate analyses preselected variables in the multivariate regression model to develop a model for correction for risk factors at patient level. These results are shown in Table 2. The variables that showed significance for correction for risk factors at patient level of the ERCS rates were prepregnancy BMI, prior nonprogressive labor, prior VBAC and diabetes mellitus.

Table 3 shows the number of included deliveries per hospital, the observed ERCS rates, expected ERCS rates and standardized ERCS rates. Also, the mean differences between the expected and standardized rates are shown, which represent the amount of CSs by which a hospital deviates from its expected rate when it would be presented with the mean patient population. Among the 17 participating hospitals, the crude observed ERCS rate was 29.8 ± 11.8% (range 6.0–54.0%). After correction for risk factors at patient level, 86.1% of the observed practice variation remained unexplained.

Prepregnancy BMI and a prior vaginal delivery were two significant variables for correction of VBAC rates. These variables were significant in a multivariate model as well. These data are shown in more detail in Table 4.

Table 5 shows observed, expected and standardized VBAC rates and the amount that a hospital deviates from its expected rate when it would be presented with the mean patient population. Among the 17 included hospitals, the overall crude observed VBAC rate was 71.8 ± 11.1% (range 50.0–90.0%). After correction for risk factors at patient level, 85.3% of the observed practice variation remained unexplained.

Figures 1 and 2 show standardized ERCS rates and VBAC rates, respectively, per hospital type. Figure 1 illustrates that a wider range of ERCS rates exists among

**Table 1.** Baseline characteristics of study population.

| | | Missing data | | | |
|---|---|---|---|---|---|
| | | TOL ($n$ = 515) | | ERCS ($n$ = 248) | |
| Characteristic ($n$ = 763) | Women ($n$ = 763) | $n$ | % | $n$ | % |
| Maternal age (years, mean ± SD) | 32.5 ± 4.5 | 2 | 0.4 | 4 | 1.6 |
| Ethnicity, $n$ (%) | | 15 | 2.9 | 12 | 4.8 |
| Caucasian | 608 (79.7) | | | | |
| Mediterranean | 48 (6.3) | | | | |
| African | 30 (3.9) | | | | |
| Indo-Surinamese | 8 (1.0) | | | | |
| Asian | 19 (2.5) | | | | |
| Other | 23 (3.0) | | | | |
| Unknown | 27 (3.5) | | | | |
| Previous CS due to failure to progress, $n$ (%) | 336 (44.0) | 0 | 0 | 0 | 0 |
| Any previous vaginal delivery, $n$ (%) | 152 (19.9) | 0 | 0 | 0 | 0 |
| Previous VBAC, $n$ (%) | 107 (14.0) | 0 | 0 | 0 | 0 |
| First trimester BMI (kg/m$^2$, mean ± SD) | 26.1 (5.9) | 124 | 24.1 | 79 | 31.9 |
| PE/HELLP, $n$ (%) | 15 (2.0) | 0 | 0 | 2 | 0.8 |
| Hypertension, $n$ (%) | 50 (6.6) | 1 | 0.2 | 3 | 1.2 |
| Diabetes mellitus, $n$ (%) | 34 (4.5) | 2 | 0.4 | 1 | 0.4 |
| EFW ≥ p90, $n$ (%) | 22 (2.9) | 201 | 39.0 | 105 | 42.3 |
| Induction of labor, $n$ (%) | 132 (26) na | 0 | 0 | na | – |
| Cervical dilatation (cm, mean ± SD) | 3 ± 2 na | 11 | 2.1 | na | – |
| Cervical effacement (%, mean ± SD) | 64 ± 19 na | 56 | 10.9 | na | – |
| Fetal station (B, −5 to +5, mean ± SD) | −2 ± 2 na | 57 | 11.1 | na | – |

B, ballottement; BMI, body mass index; CS, cesarean section; EFW, estimated fetal weight; ERCS, elective repeat cesarean section; HELLP, HELLP syndrome – hemolysis, elevated liver-enzymes, low platelets; na, not applicable; PE, pre-eclampsia; SD, standard deviation; TOL, trial of labor.

| Variable | Coefficient | SE | *p*-value | Odds ratio | 95% CI |
|---|---|---|---|---|---|
| Intercept | −3.012 | 0.897 | 0.001 | 0.049 | – |
| Maternal age (years) | 0.034 | 0.023 | 0.144 | 1.034 | 0.989–1.082 |
| Prepregnancy BMI (kg/m$^2$) | 0.038 | 0.016 | 0.016 | 1.039 | 1.007–1.072 |
| Prior nonprogressive labor (yes/no) | 0.578 | 0.199 | 0.004 | 1.783 | 1.207–2.634 |
| Prior VBAC (yes/no) | −1.454 | 0.399 | <0.001 | 0.234 | 0.107–0.510 |
| Diabetes mellitus (yes/no) | 1.391 | 0.466 | 0.003 | 4.020 | 1.613–10.018 |
| Hypertension (yes/no) | −0.550 | 0.406 | 0.175 | 0.577 | 0.260–1.278 |

BMI, body mass index; SE, standard error; VBAC, vaginal birth after cesarean.

**Table 2.** Overview of multivariate logistic regression model for predicting elective repeat cesarean delivery rates.

| Hospital type[a] | Hospital number | Included deliveries | Observed rate (%) | Expected rate (%) | Standardized rate (%) | Mean difference (%) expected – standardized |
|---|---|---|---|---|---|---|
| 1 | 1 | 61 | 54.0 | 34.7 | 51.4 | –16.8 |
| 1 | 2 | 51 | 39.0 | 33.3 | 38.7 | –5.5 |
| 1 | 4 | 45 | 33.0 | 33.6 | 32.4 | 1.3 |
| 1 | 12 | 55 | 38.0 | 34.7 | 36.1 | –1.4 |
| 1 | 15 | 40 | 43.0 | 29.0 | 47.8 | –18.7 |
| 2 | 5 | 28 | 32.0 | 33.9 | 31.1 | 2.8 |
| 2 | 7 | 36 | 17.0 | 31.5 | 17.8 | 13.7 |
| 2 | 9 | 39 | 28.0 | 30.6 | 30.2 | 0.5 |
| 2 | 10 | 41 | 24.0 | 29.6 | 26.8 | 2.8 |
| 2 | 11 | 48 | 35.0 | 32.9 | 35.1 | –2.2 |
| 2 | 13 | 24 | 17.0 | 28.1 | 19.9 | 8.2 |
| 2 | 16 | 42 | 26.0 | 31.7 | 27.1 | 5.7 |
| 3 | 3 | 39 | 23.0 | 29.3 | 25.9 | 3.4 |
| 3 | 6 | 100 | 41.0 | 32.4 | 41.8 | –9.4 |
| 3 | 8 | 36 | 17.0 | 31.5 | 17.8 | 13.7 |
| 3 | 14 | 46 | 35.0 | 31.9 | 36.2 | –4.2 |
| 3 | 17 | 32 | 6.0 | 28.6 | 6.9 | 21.7 |

[a]Hospital types: 1, non-teaching non-academic hospital; 2, teaching non-academic hospital; 3, academic teaching hospital.

**Table 3.** Standardized elective repeat cesarean delivery rates per hospital type.

| Variable | Coefficient | SE | *p*-value | Odds ratio | 95% CI |
|---|---|---|---|---|---|
| Intercept | 1.886 | 1.259 | 0.134 | 6.591 | – |
| Maternal age (years) | −0.045 | 0.030 | 0.130 | 0.956 | 0.903–1.013 |
| Prepregnancy BMI (kg/m$^2$) | −0.047 | 0.021 | 0.025 | 0.954 | 0.916–0.994 |
| Prior nonprogressive labor (yes/no) | −0.426 | 0.259 | 0.100 | 0.653 | 0.393–1.085 |
| Prior vaginal delivery (yes/no) | 1.612 | 0.402 | <0.001 | 5.011 | 2.278–11.026 |
| Caucasian (yes/no) | 0.582 | 0.349 | 0.096 | 1.790 | 0.903–3.550 |
| Cervical dilatation (yes/no) | 0.104 | 0.067 | 0.122 | 1.110 | 0.973–1.267 |
| Cervical effacement (yes/no) | 0.292 | 0.157 | 0.063 | 1.339 | 0.984–1.821 |

BMI, body mass index; SE, standard error.

**Table 4.** Overview of multivariate logistic regression model for predicting vaginal birth after cesarean delivery rates.

academic teaching hospitals. Also, the hospitals with the highest ERCS rates appear to be among the nonacademic nonteaching hospitals. Figure 2 shows that with regard to VBAC, hospital types are more similar in terms of VBAC rates. The highest success rates appear to be among non-academic teaching hospitals.

Data were not normally distributed, so correlation was tested using the Spearman's rank correlation test. The test

**Table 5.** Standardized vaginal birth after cesarean rates per hospital type.

| Hospital type[a] | Hospital number | Included deliveries | Observed rate (%) | Expected rate (%) | Standardized rate (%) | Mean difference (%) expected – standardized |
|---|---|---|---|---|---|---|
| 1 | 1 | 28 | 60.7 | 72.1 | 60.7 | 11.4 |
| 1 | 2 | 31 | 71.0 | 68.3 | 74.9 | −6.6 |
| 1 | 4 | 30 | 83.3 | 74.5 | 80.7 | −6.2 |
| 1 | 12 | 34 | 70.6 | 73.2 | 69.5 | 3.8 |
| 1 | 15 | 23 | 50.0 | 68.5 | 54.9 | 13.6 |
| 2 | 5 | 19 | 68.4 | 62.0 | 79.6 | −17.6 |
| 2 | 7 | 30 | 86.7 | 77.1 | 81.1 | −4.0 |
| 2 | 9 | 29 | 71.4 | 73.2 | 67.9 | 5.3 |
| 2 | 10 | 31 | 86.7 | 70.1 | 89.1 | −19.0 |
| 2 | 11 | 31 | 71.0 | 65.8 | 77.8 | −12.0 |
| 2 | 13 | 20 | 90.0 | 71.2 | 91.2 | −19.9 |
| 2 | 16 | 31 | 77.4 | 71.5 | 78.1 | −6.6 |
| 3 | 3 | 30 | 70.0 | 72.3 | 69.8 | 2.5 |
| 3 | 6 | 59 | 76.3 | 75.3 | 73.1 | 2.3 |
| 3 | 8 | 30 | 56.7 | 73.4 | 55.7 | 17.8 |
| 3 | 14 | 30 | 56.7 | 65.7 | 62.2 | 3.5 |
| 3 | 17 | 30 | 73.3 | 70.1 | 75.5 | −5.4 |

[a]Hospital types: 1, non-teaching non-academic hospital; 2, teaching non-academic hospital; 3, academic teaching hospital.

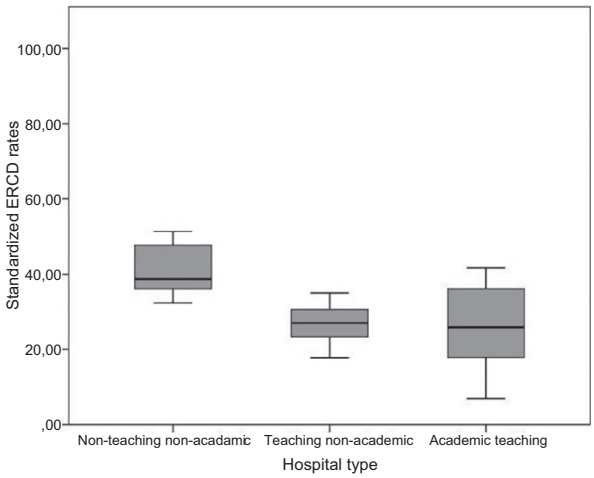


**Figure 1.** Standardized elective repeat cesarean section (ERCS) rate per hospital type.

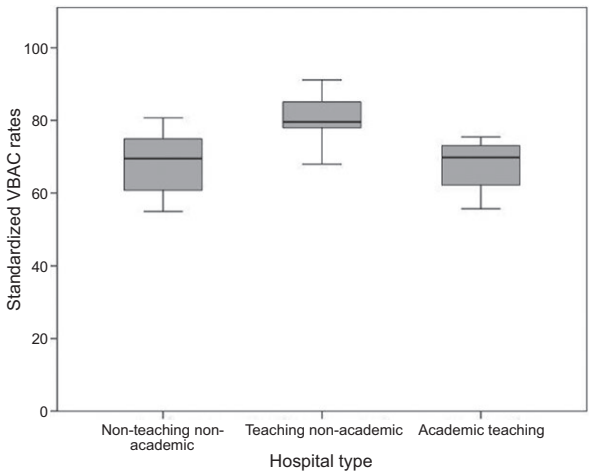


**Figure 2.** Standardized vaginal birth after cesarean (VBAC) rate per hospital type.

for correlation between ERCS and VBAC resulted in a rho of −0.46 with a *p*-value of 0.065 showing that there was a trend to a negative correlation between VBAC and ERCS (Figure 3).

## Discussion

This study showed that in spite of the high VBAC rate, there is a striking amount of practice variation on mode of delivery after CS in the Netherlands regardless of risk factors at patient level. Among the 17 participating Dutch hospitals, ERCS rates corrected for these risk factors varied between 6.9 and 51.4%. For VBAC, this variation was less distinct but was still from 52.7 to 90.0%. Yet, we showed that correcting for risk factors at patient level only partly explained the observed practice variation. Hence, the a priori risk of having a CS independent of woman's individual risk factors varies per hospital.

When estimating the effect of hospital type, it appeared that the largest variation exists among nonacademic

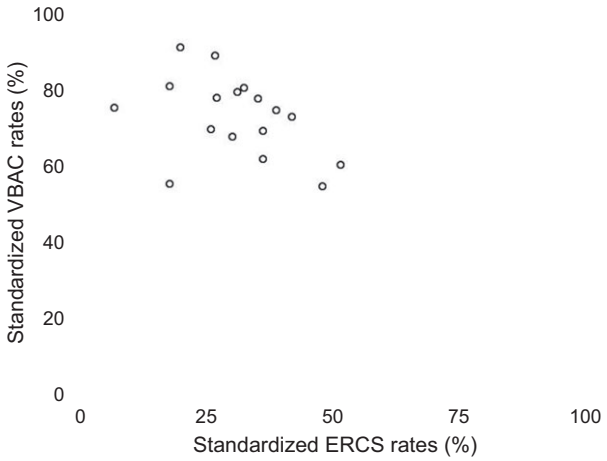


**Figure 3.** Correlation vaginal birth after cesarean (VBAC) and elective repeat cesarean section (ERCS) rates.

teaching hospitals. Furthermore, there was a trend towards a negative correlation between VBAC and ERCS. This implicates that hospitals tend to perform CS regardless of the probability of VBAC.

In line with other studies, our study showed a large variation in TOL rates between different hospitals (6,7). Large variation in TOL rates is seen between countries, but also at a national level (6). Even in a small country with high TOL rates, such as the Netherlands, there is a remarkable amount of practice variation, comparable to countries with lower TOL rates (6). Our results are in line with the cohort study of Kwee et al. (11) In this study, performed in the Netherlands, practice variation was studied in 38 hospitals and showed a variation in TOL from 46 to 87% (11).

The review of Guise et al. reports a range in TOL rates from 28 to 70% in USA (6). TOL was more often performed in hospitals with a high birth rate, which are tertiary and teaching hospitals. They showed a large variation in VBAC as well, from 52 to 85% in USA. However, the review by Guise et al. included mainly studies performed in academic and nonacademic teaching hospitals (6). Hence, this may cause a distorted view and the results may not be representative for nonacademic nonteaching hospitals, because retrospective studies show that TOL is less often attempted in small nonacademic nonteaching hospitals (15). Our results confirm these findings and show an ERCS rate of 33–54% in nonacademic nonteaching hospitals compared with 6–41% in academic and nonacademic teaching hospitals.

We can debate whether the observed ERCS rate is appropriate in relation to the type and abilities of specific hospitals. From the viewpoint of feasibility, it is understandable that obstetricians in small nonteaching nonacademic hospitals would rather perform an ERCS than a TOL as obstetric and theater staff are not on hand 24/7. In the USA, guidelines even advise that hospitals attempting VBAC require equipment and staff able to perform an emergency CS immediately (6).

At the same time, doctors have to cope with an increased risk of liability, which may result in a decreased performance of TOL (6). Furthermore, it may change the approach in counseling, despite the fact that contemporary guidelines state that women without a contraindication should have a choice in mode of delivery and counseling is ideally discussed in a shared decision-making setting. These factors may influence or induce practice variation as well.

A strength of this study is that this is the first study to examine practice variation in vaginal birth after CS in a European country correcting for risk factors at patient level. We compared different levels of hospitals, from tertiary to small non-academic non-teaching hospitals. The distribution of the different levels of hospitals is representative for the national distribution. Another strength is that data selection occurred systematically by checking every single patient. In addition, the selection process of predictive variables for VBAC was in line with contemporary insights within prediction research (8,9). We chose to correct only for predictive variables for VBAC as every woman should be counseled the same way. Furthermore, this study provides insight into the level at which possible interventions would be meaningful.

A drawback of the chosen methodology, stepwise elimination for predictor selection, is that it implies the risk of missing contributing predictors. For example, the predictor "thickness of lower uterine segment" appears to be a probable independent predictor for failed TOL but was not taken into account during data collection (16). However, we expect this effect to be small as predictors were chosen based on contemporary literature. Another limitation is that, due to lack of data, we could not further specify the exact amount of practice variation that is derived from factors at hospital and provider levels. However, by performing an additional analysis in which we clustered types of hospital we were able to mainly visualize variation on a hospital level. Nevertheless, analysis by type of hospital is a rough measurement. Reasons for differences between hospital levels might be the presence of theater staff 24/7 or the total birth rate. These might be more specific measures. Clustering by types of hospital, however, still implies the assumption that hospitals within the clusters are comparable and is therefore less precise. Also, probably not all women are counseled the same way, suggesting large practice variation at provider level as well.

In our study we only performed analysis using patient level because we assumed practice variation correlates

with risk factors at patient level. Future research could focus on multiple levels. Effects of availability of medical staff and level of experience, methods of counseling and shared decision making may play a role as well. The practice variation resulting from this can probably be reduced and the quality of healthcare can be enhanced by more structured general information. We developed a decision aid including a prediction model to calculate the probability of a patient having a VBAC (12,17). By implementing this decision aid in daily healthcare, and informing women about their chances and the risks and benefits of both options in a structured way, reducing practice variation on patient level, provider level, and hospital level might be possible.

In conclusion, variation in mode of delivery after CS between hospitals is large and can only for the smaller part be explained by risk factors at patient level, which might indicate that local policy plays a more important role in the derivation of practice variation. Hence, to enhance guideline implementation and to reduce practice variation, further research is essential, for example, in the benefit of better counseling; and shared decision making by using the developed prediction model and decision aid is essential.

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