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Labour characteristics of women achieving successful vaginal birth after caesarean section in three European countries

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1. Conflict of Interest

Two authors report grants from European Union.

2. Ethical Approval

The OptiBIRTH trial received ethics approval from the Faculty of Health Sciences Ethics Committee, Trinity College Dublin, Ireland and from the relevant ethics bodies in the participating sites.

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Abstract

Objective: Knowledge about labour characteristics of women achieving successful vaginal birth after caesarean section (VBAC) might be used to improve labour and birth management. This study examined sociodemographic and labour process-related factors regarding a) differences between countries, b) the comparison of successful VBAC with unplanned caesarean section, and c) predictors for the success of planned VBAC in three European countries.

Design: We analysed observational data collected within the OptiBIRTH trial, a cluster-randomised controlled trial.

Setting: Fifteen study sites in Ireland, Italy and Germany, five in each country.

Participants: 790 participants going into labour for planned VBAC.

Measurements: Descriptive statistics and random-effects logistic regression models were applied.

Findings: The pooled successful VBAC-rate was 74.6%. Italy had the highest proportion of women receiving none of the four intrapartum interventions amniotomy (ARM), oxytocin, epidural or opioids (42.5% vs Ireland: 26.8% and Germany: 25.3%, p<0.001). Earlier performance of ARM was associated with successful VBAC (3.50 hrs vs 6.08 hrs, p=0.004). A positive predictor for successful vaginal birth was a previous vaginal birth (OR=3.73, 95% CI [2.17, 6.44], p<0.001). The effect of ARM increased with longer labour duration (OR for interaction term=1.06, 95% CI [1.004, 1.12], p=0.035). Higher infant birthweight (OR per kg=0.34, 95% CI [0.23, 0.50], p<0.001), ARM (reference spontaneous rupture of membranes (SROM), OR=0.20, 95% CI [0.11, 0.37], p<0.001) and a longer labour duration (OR per hour=0.93, 95% CI [0.90, 0.97], p<0.001) decreased the odds of a vaginal birth.

Key conclusion: Women with a previous vaginal birth, an infant with a lower birth weight, SROM and a shorter labour duration were most likely to have a successful vaginal birth. If SROM did not occur, an earlier ARM increased the odds of a vaginal birth.

Implication for practice: Labour progress should be accelerated by fostering endogenous uterine contractions. With slow labour progress and intact membranes, ARM might increase the chance of a vaginal birth.

Keywords: VBAC; predictors; labour management; rupture of membranes; labour duration

Introduction

Knowledge about intrapartum characteristics of women achieving a successful VBAC is important in providing optimal intrapartum care. Current research suggests that there are no improvements in maternal and perinatal mortality when more than 10-15% of births in a population are performed by caesarean section (c-section) (Betran et al., 2016; WHO, 2015; Ye et al., 2016). However, the proportion of women giving birth by c-section in most European countries is considerably higher (Euro-Peristat, 2018), leading to an increasing proportion of pregnant women with at least one previous c-section (Sabol et al., 2015). Promoting vaginal birth after caesarean section (VBAC) is one way to decrease overall c-section rates (Sabol et al., 2015) and while VBAC is the preferred mode of birth for women with no additional risk factors, unplanned intrapartum c-section should be minimised because of increased risks for mother and child (Scott, 2014).

The proportion of women who have VBAC varies considerably between countries, regions and hospitals, and the variations can only be partially explained by characteristics such as age and parity (American College of Obstetricians and Gynecologists (College) et al., 2014; Euro-Peristat, 2018; Gross et al., 2015; Macfarlane et al., 2016; Mikolajczyk et al., 2013). A lack of consensus about optimal labour management methods may contribute to the variations (Gross et al., 2015). Scott et al (2014) recommended an intrapartum management similar to parturients without a c-section in history. Due to an increased risk of uterine rupture in women with a previous c-section, the author advised adopting a cautious approach with selective induction in women with an unfavourable cervix and with labour augmentation avoiding uterine overstimulation in order to achieve a safe and successful VBAC. However, more detailed knowledge about what constitutes optimal intrapartum management is limited.

Approximately 60-80% of women planning a VBAC have a vaginal birth (Knight et al., 2014; Landon and Grobman, 2016; Scott, 2014). Previous studies have suggested that younger, non- smoking, married women of Caucasian race, who are taller, have a lower weight gain during pregnancy, a lower body mass index (BMI) and higher levels of education might be more likely to achieve a successful VBAC (Landon et al., 2005; Perez et al., 2019). Having a history of a previous vaginal birth and no recurrence of the indication for the first c-section are positive predictors for successful VBAC (Grobman et al., 2007; Landon et al., 2005). Maternal diabetes mellitus, foetal macrosomia, labour augmentation and complications during pregnancy and labour before the first c-section increase the odds of repeat c-section (Fagerberg et al., 2013; Macones et al., 2001). Index pregnancy, labour and birth characteristics associated with a successful VBAC include lower gestational age, lower mean infant birthweight, spontaneous labour onset, greater cervical dilatation on admission, deeper vertex station (meaning a foetal head which is deeper in the maternal pelvis), rupture of the amniotic membranes and epidural analgesia (Birara and Gebrehiwot, 2013; Landon et al., 2005; Macones et al., 2001; Metz et al., 2013).

Most previous studies and prediction models have been limited to the inclusion of sociodemographic and pre-existing obstetric characteristics (Grobman et al., 2007). Knowledge of intrapartum factors associated with successful VBAC might help identify women with increased odds of unplanned c-section and enable adaptation of labour and birth management to avoid c-section. The aims of our study were to investigate sociodemographic, peripartum and labour process-related factors with regard to a) differences between countries, b) the comparison of women achieving successful VBAC and those undergoing unplanned c-section, and c) predictors for the success of planned VBAC in three European countries (Germany, Italy and Ireland).

Methods

Study design and sampling

We conducted an analysis of observational labour and birth data collected within the OptiBIRTH trial. OptiBIRTH is a cluster-randomised controlled trial evaluating the effectiveness of a complex intervention to increase VBAC rates in Ireland, Italy and Germany (X1). Fifteen study sites, five in each of these countries, were allocated randomly into nine intervention and six control sites (X1). The study centres had between 1,500 and 8,000 births per annum and all of them offered neonatal care. Pregnant women who were at least 18 years old with one previous lower segment c-section; having a singleton pregnancy; had sufficient oral and written knowledge in one of the three national languages, English, Italian or German, and gave informed consent were eligible for inclusion in the OptiBIRTH trial. Women who planned an elective repeat c-section, gave birth before 34 weeks' gestation or did not have their mode of birth or onset of labour recorded, were excluded. Women giving birth after 34 completed gestational weeks were included in the analysis, because German guidelines consider births ≥ 34 weeks as a single target group and this criteria for a cut-off point has previously been used in studies investigating labour processes (DGGG, 2012, 2010; X2; Petersen et al., 2011). For the current analysis, we generated a variable for "intention to give birth vaginally" to exclude women who did not plan to give birth vaginally but who went into labour and had an unplanned c-section. The indications for all unplanned c-sections after onset of labour were coded independently by two researchers, with an overall agreement of 91% and a moderate interrater of kappa of 0.60. Disagreements were resolved by discussion and data from 25 women were excluded subsequently. Of the 2,002 women recruited to the OptiBIRTH trial between April 2014 and December 2015, data from 790 women who planned to have a VBAC were included in the current analysis.

Potential participants received oral and written information and gave written informed consent before participation. The OptiBIRTH trial received ethics approval from the Faculty of Health Sciences Ethics Committee, Trinity College Dublin, Ireland and from the relevant ethics bodies in the participating sites.

Data collection and data management

OptiBIRTH data used for these analyses were collected by means of a self-completed antenatal questionnaire during pregnancy and a labour and birth case report form completed after birth by a study midwife.Onset of labour was defined as regular or irregular uterine contractions associated with progressive cervical dilatation and was assessed by the midwife providing care. This approach has been adopted in previous studies investigating labour processes, because onset of labour is a complex event lacking a homogeneous definition X2; Hanley et al., 2016). Interventions and events which were recorded simultaneously with onset of labour or birth were considered to have taken place one minute after onset of labour or one minute before birth, because the simultaneous occurrence of intervention and events to the precise minute is unlikely. This was also done in previous studies investigating the timing of intrapartum interventions and events (Petersen et al., 2013). If amniotic membranes were not ruptured before c-section, women were considered as having had amniotomy one minute before birth. Women with no intrapartum intervention before spontaneous vaginal birth were censored for Kaplan Meier analysis as is commonly done for cases that do not reach the target endpoint during the observed time interval.

Data analysis

Descriptive statistics were used to present data on the whole analysed study sample, for women in the individual countries, and to show the comparison between countries as well as the comparison between successful VBACs and unplanned c-sections. Groups were compared using chi-squared tests, Fisher’s exact tests, Mann-Whitney-U-tests and Kruskal-Wallis tests, as appropriate. Time intervals between onset of labour and events, interventions and birth were calculated to the nearest minute and Kaplan Meier estimates, log rank tests and Wilcoxon tests were used for the description and comparisons (Sedgwick, 2014). For c-section and vaginal instruments births, labour duration was considered as right-censored: Censoring enables to include cases which do not reach the endpoint of interest and no exclusion because of incomplete data is required (Prinja et al., 2010). This was also done in previous studies using time to event analysis to investigate labour duration (X2; Petersen et al., 2011). However, this meant that all participants in the unplanned c-section subsample had censored labour durations and Kaplan Meier estimates could not be applied. Usual statistics and Mann-Whitney-U-tests were therefore used describe and compare labour duration between successful VBAC and unplanned c-section.

Multivariable analysis was used for the whole study group and for each country separately using random effects logistic regression models with the dependent variable “success of planned VBAC”. Variations in labour and birth management for planned VBAC had been observed at the sites prior to the trial in Germany (Gross et al., 2015) and were accounted for by using a random effects term for all study sites. Multiple imputation (Stata “mi set” with fivefold imputation) was used for the variables “BMI”, “married/living with partner”, “health insurance”, “cervical dilatation on admission” and “rupture of membranes” because of up to 14% missing data. This was mostly due to the response rate to the antenatal questionnaire. Potential predictors were entered in the main effect model if crude associations with the outcome variable showed a p-value <0.25 in the univariable analysis, according to Hosmer and Lemeshow’s model-building strategy (Hosmer, DW and Lemeshow, S, 2000). Stepwise backward elimination based on Wald tests was then performed. Interactions of the remaining predictors with the variable “labour duration”, were tested and were included in the model if the association showed a p-value <0.05. Maternal age and infant birthweight were retained in the model as *a priori* confounders (Annessi et al., 2016; Grobman et al., 2007; Landon et al., 2005). To ensure comparability of results between countries, all predictors found in the individual models (Supplement Table S1) were then entered in all models. The variable “labour duration” was used as an indicator for labour progression and included in the models. However, sensitivity analyses were conducted excluding the variable “labour duration”. Statistical analyses were performed with Stata 13 (StataCorp, Tx, USA).

Results

The comparison between countries

Of the 790 participants, 258 (32.7%) gave birth in Ireland, 145 (18.4%) in Italy and 387 (49.0%) in Germany. The highest proportion of women aged 35 years or older was in Italy (46.9% vs Germany: 37.0% and Ireland: 29.8%, p=0.003). Private or supplementary insurances were most frequent in Ireland (35.9% vs Germany: 25.4% and Italy: 10.7%, p<0.001), and the proportion of women with an academic qualification, Bachelor level or higher, was highest in Germany (56.4% vs Italy: 44.3% and Ireland: 44.0%, p=0.005). There was no significant difference in BMI (p=0.267) and being married or living with a partner between countries (p=0.188).

Ireland had the highest proportion of women who had had a previous vaginal birth (31.8% vs Italy: 24.1% and Germany: 15.6%, p<0.001, Table 1). Labour was induced most frequently in Germany (22.2% vs Ireland: 12.0% and Italy: 3.5%, p<0.001) and the proportion of women with first cervical dilation ≥4cm on admission was higher in Italy (38.0% vs Ireland: 26.5% and Germany: 21.6%, p<0.01). Amniotomy (ARM) was performed most frequently in Ireland (35.5% vs Italy 30.4% and Germany: 25.7%, p=0.035); oxytocin augmentation more often in Germany (49.1% versus Italy: 18.6% and Ireland: 12.4%, p<0.001); epidural analgesia most frequently in Ireland (51.9% vs Germany: 37.2% and Italy: 31.7%, p<0.001) and opioid analgesia more often in Germany (22.2% vs Ireland: 7.8% and Italy 0.0%, p<0.001). Italy had the highest proportion of women receiving none of the four intrapartum interventions (42.5% vs Ireland: 26.8% and Germany 25.3%, p<0.001). Women in Italy also gave birth spontaneously more often (71.7% compared to Germany: 62.0% and Ireland: 45.0%, p<0.001, Table 1) and the proportion of c-sections performed during the second stage of labour was lowest in Ireland (4.0% compared to Italy: 28.6% and Germany: 32.3%, p<0.001). Furthermore, neonates were heavier in Ireland (median 3.54kg compared to Italy: 3.34kg and Germany: 3.49kg, p<0.001) and the arterial blood pH was highest in Italy (7.29 compared to Germany: 7.25 and Ireland: 7.22, p=0.012).

In Ireland, the median duration from onset of labour until birth was longest (13.67 hours vs Germany: 7.90 and Italy: 5.83, p<0.001), as was the duration of the first stage of labour (Ireland: 7.67 hours vs Germany: 5.75 and Italy: 4.58, p<0.001). The second stage of labour duration, however, lasted longer in women giving birth in Germany (1.10 hours vs Ireland: 0.97 and Italy: 0.83, p=0.007). In Germany, the median timing of intrapartum spontaneous rupture of membranes (SROM) (3.08 hours vs Italy: 1.50 and Ireland: 1.17, p<0.01), ARM (5.87 hours vs Ireland: 3.50 and Italy 2.67, p<0.001) and the start of oxytocin augmentation (5.70 hours vs Italy: 4.00 and Ireland: 2.83, p<0.01) was the latest. In contrast, epidural analgesia was administered later in Ireland (4.00 hours vs Germany: 3.75 and Italy 1.83, p<0.001). There was no significant difference in the timing of opioid analgesia (p=0.321) and the interval between onset of labour and either amniotomy, oxytocin augmentation, epidural analgesia, opioid or birth between countries (p=0.397).

Successful VBAC compared to unplanned c-section

Successful VBAC was achieved by 74.7% of the women in this cohort; 70.5% in Ireland, 80.7% in Italy and 75.2% in Germany (p=0.076). Women with successful VBAC had a lower BMI compared to women with unplanned c-section (whole analysed study sample 24.4kg/m^2 vs 25.1kg/m^2, p=0.011, Table 2). Women who were married or living with a partner were significantly more likely to achieve a successful VBAC in the Irish subsample (VBAC: 97.2% vs c-section: 85.5%, p=0.001), but the proportions did not differ in the other countries.

There were significantly more women with a previous vaginal birth among those who achieved a successful VBAC compared to those who had an unplanned c-section (whole analysed study sample: 26.9% vs 9.5%, p<0.001, Table 2). The median gestation of Irish women with unplanned c-section was longer compared to those birthing vaginally (41.0 vs 40.0 weeks, p<0.001). Women who had a cervical dilation ≥4cm on hospital admission had a higher proportion of successful VBAC (whole analysed study sample: 28.8% vs 18.4%, p=0.006). Furthermore, intrapartum SROM occurred more frequently in women who achieved VBAC than in those who had unplanned c-sections in all countries (whole analysed study sample: 47.7% vs 27.5%, p<0.001) and consequently ARM was performed more frequently in women who had unplanned c-sections (whole analysed study sample: 48.0% vs 22.8%, p<0.001). Women who had unplanned c-sections more often had epidural analgesia (whole analysed study sample: 51.0% vs 37.6%, p<0.01). In contrast, women achieving a successful VBAC were significantly more likely to have none of the intrapartum interventions (ARM, oxytocin augmentation, epidural analgesia and opioid analgesia) in all study samples (whole analysed study group: 34.3% vs 13.5%, p<0.001).

Overall, labour duration as well as the duration of the first and second stage of labour were significantly shorter in women achieving successful VBAC compared to those with unplanned c-section (whole analysed study sample, overall labour duration: 5.71 vs 8.28 hours, p<0.001; duration first stage of labour: 4.68 vs 7.83 hours, p<0.001 and duration second stage of labour: 0.70 vs 2.13 hours, p<0.001, Table 2). ARM was performed significantly earlier in women with successful VBAC compared to those with unplanned c-section (whole analysed study sample: 3.50 vs 6.08 hours, p<0.004) but the timing of SROM was similar. Opioid analgesia was also administered earlier in successful VBAC compared to unplanned c-section (whole analysed study sample: 2.62 vs 5.00 hours, p=0.037). In contrast, the interval between onset of labour and either intervention (amniotomy, oxytocin augmentation, epidural analgesia, opioid) or birth was significantly longer in women achieving successful VBAC than in those with unplanned c-section in the Italian subsample (4.58 vs 3.00 hours, p=0.020). The timing of oxytocin augmentation and epidural analgesia did not differ significantly between successful VBAC and unplanned c-section in any country.

Predictors of successful planned VBAC

The chance of birthing vaginally was higher in women who had had a previous vaginal birth (whole analysed study sample: OR=3.73, 95% CI [2.17, 6.44], p<0.001, Table 3); the effect of ARM increased with longer labour duration (OR for interaction term=1.06, 95% CI [1.004, 1.12], p=0.035). In contrast, higher infant birthweight (OR per kg=0.34, 95% CI [0.23, 0.50], p<0.001), ARM (reference SROM (either prelabour or intrapartum), OR=0.20, 95% CI [0.11, 0.37], p<0.001) and a longer labour duration (OR per hour=0.93, 95% CI [0.90, 0.97], p<0.001) decreased the chance of achieving a successful VBAC. The empty random effect model showed no relevant clustering in study sites (random effect parameters ε=1.76, p=0.093).

Being married or living with a partner increased the chance of a successful VBAC in Ireland (OR=4.25, 95% CI [1.07, 16.84], p=0.040). In the whole study group and in Germany, the OR for women being married or living with a partner differed, and the association with the outcome variable was not significant (whole analysed study group: OR=1.50, 95% CI [0.67, 3.38], p=0.328 and Germany: OR=0.66, 95% CI [0.08, 5.14], p=0.675). In Italy, all women with a successful VBAC were married making it impossible to include this variable in the model, because the outcome was uniquely determined by this variable. The estimates for all other variables were similar in all countries.

Sensitivity analyses excluding the variable “labour duration”, which was used as an indicator for labour progress, did not show any significant variations in the estimates (Table 4).

Discussion

This study is the first to compare labour-related features and factors associated with the success of planned VBAC across three European countries. We found differences between Ireland, Italy and Germany in labour duration as well as in the use of intrapartum interventions. The proportion of women receiving one of the four intrapartum interventions ARM, oxytocin augmentation, epidural analgesia or opioid analgesia during labour was highest in Germany and lowest in Italy, and Italy had the highest proportion of women giving birth vaginally. A previous vaginal birth, a lower infant birthweight, intrapartum SROM and shorter labour duration were the strongest predictors for successful VBAC. Amniotomy was the most constant negative predictor in all three countries.

Previous studies have also found differences in VBAC rates, the use of interventions and labour duration between and within countries and have suggested that variations in labour and birth management might be the cause (Gross et al., 2015; Mikolajczyk et al., 2013; Hildingsson et al., 2015). However, it remains unclear, why intervention rates in Italy were much lower compared to Ireland and Germany, because the Italian guideline addressing VBAC does not provide any recommendations about intrapartum intervention (Ministry of Health Italy, 2016). It can only be assumed that the lack of VBAC tradition in Italy has an impact on the intrapartum management. Differences in timing of interventions between countries have not been researched previously and, therefore, our findings cannot be compared to existing studies.

Our study confirmed the findings of previous research that a previous vaginal birth is a strong predictor for achieving a vaginal birth after c-section (Annessi et al., 2016; Grobman et al., 2007; Landon et al., 2005). The most inconsistent factor associated with a successful VBAC in our study was being married or living with a partner. In Ireland, where the proportion of mothers who were not married or living with the partner was highest, this seemed to considerably decrease the chance of birthing vaginally. This is consistent with the study of Landon et al (2005) who found that being unmarried was associated with higher odds of an unplanned c-section. An explanation for this finding could be that unmarried women and those not living with the partner were more likely to have fewer children and were less likely to have had a previous vaginal birth. Further research is needed to fully understand the association between the partnership status and successful VBAC.

Rupture of the membranes (ROM) is a key event in the process of labour; SROM, however, is poorly researched in women at term gestation (Gross MM, 2001). Significantly higher rates of intrapartum SROM and lower rates of ARM indicate the importance of ROM for achieving a vaginal birth, a finding previously reported by Birara and Gebrehiwot (2013). However, SROM is a natural event which does not always occur. Our study shows that in cases of slow labour progress with intact membranes, performing ARM might increase the chance of giving birth vaginally, because the interaction term between ARM and longer labour duration, a variable which was used as an indicator for slow labour progress, was associated with a slightly increased chance of a successful VBAC. Additionally, not only the proportion but also the timing of ARM was found to be associated with the success of VBAC, because women giving birth vaginally showed significantly shorter intervals between onset of labour and ARM compared to those with unplanned c-section. It might seem contradictory, that ARM is a negative predictor for a successful VBAC but its earlier performance, especially in case of slow labour progress, seems advantageous. Time to event analysis, which was used for this study, provides information beyond the decision, if an intervention should be performed or not. It also indicates when and in which cases this could be meaningful. However, further research is needed to provide recommendations about the optimal timing of ARM.

Women with shorter labour duration, indicating quicker labour progress, were more likely to give birth vaginally in our study. In contrast, other studies found that labour lasted longer in settings with low c-section rates (X3; Hildingsson et al., 2015). This might indicate that women with longer labour durations have a reduced chance of birthing vaginally if they do not receive enough time. The American College of Obstetricians and Gynecologists (ACOG,

2014) recommends that the definition of labour dystocia as the most common cause for c-section during labour should be revisited, acknowledging that some women need more time for labour and birth. As women with shorter labour duration without medical interventions were most likely to birth vaginally, labour management should include strategies that are known to facilitate progress by fostering endogenous uterine contractions such as, for example, encouraging upright maternal positions (Lawrence et al., 2013). Women should also be encouraged to stay at home until uterine contractions become stronger, because greater cervical dilatation at admission was positively associated with a successful vaginal birth as stated also by Landon et al. (2005). The variations in interventions and VBAC rates in our study indicate, that counselling for pregnant women with a previous caesarean section should consider locally derived VBAC statistics as proposed by the Royal College of Obstetricians and Gynaecologists (RCOG, 2015).

A strength of the analyses of the observational data collected within the OptiBIRTH trial, was the relatively large sample size of women going into labour for planned VBAC. Additionally, data originating from Ireland, Italy and Germany enabled comparison between countries. However, the sample sizes for the individual countries might have been too small to detect differences for some factors, e.g. cervical dilation ≥4 cm on admission and oxytocin augmentation in Ireland and Italy. An innovative strength of the OptiBIRTH trial was the documentation of events and interventions to the nearest minute, enabling precise computations of durations and intervals. Although different intrapartum interventions were investigated in detail, no data about induction methods were collected. This limitation was a result of the considerable variation in types of induction between sites due to insufficient evidence about the best method of induction for women with a previous c-section (West et al., 2017). A further strength of the OptiBIRTH trial was that the study was designed for women with planned VBAC, enabling the relatively large sample size. However, study participants eager to consent to participate in the OptiBIRTH trial may have been more motivated to achieve a VBAC, leading to potential selection bias.

This study has revealed new knowledge about the labour process for successful VBAC in three European countries. Shorter labour duration and lower intervention rates resulting in successful VBAC could indicate that labour progress should be accelerated by fostering endogenous uterine contractions. When labour progresses slowly, performing an ARM might increase the chance for a successful VBAC.

List of abbreviations

ARM	Artificial rupture of the membranes
BMI	Body mass index
CI	Confidence interval
c-section	Caesarean section
IQR	Interquartile range
md	Median
OR	Odds ratio
ROM	Rupture of the membranes
SROM	Spontaneous rupture of the membranes
VBAC	Vaginal birth after caesarean section

Acknowledgements Labour for VBAC in three European countries

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Tables Labour for VBAC in three European countries

Table 1: Comparison of baseline characteristics between countries

Variable	Whole study group n=790	Ireland n=258	Italy n=145	Germany n=387
Sociodemographic data				
Age > 35 years, n (%)	288 (36.5)	77 (29.8)	68 (46.9)	143 (37.0)**
BMI in kg/m^2, md (IQR)	24.7 (22.2-27.8)	24.8 (22.7-27.7)	24.8 (22.5-28.3)	24.4 (21.8-27.7)
Married/living partner[b], n (%)	657 (95.5)	194 (93.7)	137 (97.9)	326 (95.6)
Private or supplementary insurance[b], n (%)	176 (25.5)	74 (35.9)	15 (10.7)	87 (25.4)***
Bachelor qualification or higher[b], n (%)	347 (50.2)	91 (44.0)	62 (44.3)	194 (56.4)**
Perinatal data				
Previous vaginal birth, n (%)	177 (22.5)	82 (31.8)	35 (24.1)	60 (15.6)***
Gestational weeks, md (IQR)	40 (39-41)	40 (39-41)	40 (39-40)	40 (39-41)**
Labour induction, n (%)	122 (15.4)	31 (12.0)	5 (3.5)	86 (22.2)***
Cervical dilatation on admission ≥ 4cm[a], n (%)	189 (26.3)	66 (26.5)	49 (38.0)	74 (21.6)**
ROM*:*				
Prelabour SROM, n (%)	209 (28.1)	62 (26.5)	39 (28.9)	108 (28.9)
Intrapartum SROM, n (%)	314 (42.3)	89 (38.0)	55 (40.7)	170 (45.5)
Intrapartum ARM, n (%)	220 (29.6)	83 (35.5)	41 (30.4)	96 (25.7)*
Oxytocin augmentation, n (%)	249 (31.5)	32 (12.4)	27 (18.6)	190 (49.1)***
Epidural analgesia, n (%)	324 (41.0)	134 (51.9)	46 (31.7)	144 (37.2)***
Opioid analgesia, n (%)	106 (13.4)	20 (7.8)	0 (0.0)	86 (22.2)***
Neither ARM, oxytocin, epidural nor opioids, n (%)	221 (28.9)	66 (26.8)	59 (42.5)	96 (25.3)***
Mode of birth:				
Spontaneous birth, n (%)	460 (58.2)	116 (45.0)	104 (71.7)	240 (62.0)***
Ventouse, n (%)	124 (15.7)	60 (23.3)	13 (9.0)	51 (13.2)***
Forceps, n (%)	6 (0.8)	6 (2.3)	0 (0.0)	0 (0.0)**
Unplanned CS, n (%)	200 (25.3)	76 (29.5)	28 (19.3)	96 (24.8)
CS during first stage, n (%)	158 (79.0)	73 (96.1)	20 (71.4)	65 (67.7)***
CS during second stage, n (%)	42 (21.0)	3 (4.0)	8 (28.6)	31 (32.3)***
Infant birthweight in kg,	3.48 (3.18-3.80)	3.54 (3.23-3.90)	3.34 (3.05-3.66)	3.49 (3.19-3.81)***

md (IQR)				
Arterial pH[c], md (IQR)	7.25 (7.18-7.30)	7.22 (7.15-7.30)	7.29 (7.20-7.34)	7.25 (7.19-7.30)*
Labour intervals				
Overall labour duration in hrs, md (IQR)	8.20 (4.67-17.17)	13.67 (5.67-28.60)	5.83 (3.50-8.42)	7.90 (4.78-16.10)***
First stage of labour duration in hrs, md (IQR)	5.83 (3.42-11.53)	7.67 (4.00-14.17)	4.58 (2.67-7.00)	5.75 (3.42-10.42)***
Second stage of labour duration in hrs, md (IQR)	1.00 (0.38-2.08)	0.97 (0.27-2.43)	0.83 (0.37-1.50)	1.10 (0.45-2.38)**
Timing of SROM in hrs[e], md (IQR)	2.67 (0.67-5.00)	1.17 (0.02-5.00)	1.50 (0.58-3.50)	3.08 (1.00-5.35)**
Timing of ARM in hrs[e], md (IQR)	4.33 (2.00-8.58)	3.50 (1.33-7.72)	2.67 (1.08-4.50)	5.87 (2.83-10.17)***
Timing of oxytocin infusion in hrs[e], md (IQR)	5.43 (3.17-8.28)	2.83 (0.83-6.75)	4.00 (3.00-6.00)	5.70 (3.60-8.50)**
Timing of epidural analgesia in hrs, md (IQR)	3.58 (1.83-6.50)	4.00 (1.75-8.33)	1.83 (0.75-2.67)	3.75 (2.42-6.20)***
Timing of opioids analgesia in hrs, md (IQR)	2.92 (1.25-5.00)	3.75 (0.67-7.00)	-	2.33 (1.25-4.98)
Timing of first of ARM, Oxytocin, epidural or opioids in hrs, md (IQR)	4.22 (1.95-8.25)	4.15 (1.58-9.65)	4.42 (1.67-9.33)	4.25 (2.25-7.77)

md = median; IQR = interquartile range; ROM = rupture of the membranes; SROM = spontaneous rupture of the membranes; ARM = artificial rupture of the membranes; CS = caesarean section

[a] 5-10% missing values; [b] 10-15% missing values, [c] > 15% ,missing values; [d] Mann-Whitney-U test, [e] Wilcoxon test

*p<0.05; **p<0.01; ***p<0.001

Table 2: Comparison between successful VBAC and unplanned c-section

Variable	Whole study group n=790		Ireland n=258		Italy n=145		Germany n=387	
	VBAC n=590	**C-section** n=200	**VBAC** n=182	**C-section** n=76	**VBAC** n=117	**C-section** n=28	**VBAC** n=291	**C-section** n=96
Socio-demographic								
Age > 35 years, n (%)	218 (37.0)	70 (35.0)	60 (33.0)	17 (22.4)	54 (46.2)	14 (50.0)	104 (35.7)	39 (40.6)
BMI in kg/m^2, md (IQR)	24.4 (22.0-27.5)	25.1 (22.9-28.6)*	24.8 (22.6-27.0)	24.8 (22.8-28.5)	24.5 (22.1-28.2)	25.3 (24.0-29.0)	24.2 (21.5-27.6)	25.2 (22.6-28.7)*
Married/living partner[b]	494 (96.1)	163 (93.7)	141 (97.2)	53 (85.5)**	109 (97.3)	28 (100.0)	244 (94.9)	82 (97.6)
Private or supplementary insurance[b], n (%)	126 (24.5)	50 (28.6)	54 (37.5)	20 (32.3)	12 (10.7)	3 (10.7)	60 (23.3)	27(31.8)
Bachelor qualification or higher[b], n (%)	262 (50.8)	85 (48.6)	65 (44.8)	26 (41.9)	52 (46.4)	10 (35.7)	145 (56.0)	49 (57.7)
Perinatal data								
Previous vaginal birth, n (%)	158 (26.9)	19 (9.5)***	73 (40.1)	9 (11.8)***	30 (25.6)	5 (17.9)	55 (19.0)	5 (5.2)**
Gestational weeks, md (IQR)	40.0 (39.0-41.0)	40.0 (40.0-41.0)***	40.0 (39.0-41.0)	41.0 (40.0-41.0)***	40.0 (39.0-40.0)	40.0 (39.5-40.5)	40.0 (39.0-41.0)	40.0 (40.0-41.0)**
Labour induction, n (%)	88 (14.9)	34 (17.0)	21 (11.5)	10 (13.2)	5 (4.3)	0 (0.0)	62 (21.3)	24 (25.0)
Cervical dilatation on admission ≥ 4cm[a], n (%)	156 (28.8)	33 (18.4)**	54 (30.5)	12 (16.7)*	42 (39.3)	7 (31.8)	60 (23.4)	14 (16.5)
ROM:								
Prelabour SROM, n (%)	160 (29.5)	49 (24.5)	39 (24.7)	23 (30.3)	33 (30.8)	6 (21.4)	88 (31.7)	20 (20.8)*
Intrapartum SROM, n (%)	259 (47.7)	55 (27.5)***	72 (45.6)	17 (22.4)**	49 (45.8)	6 (21.4)*	138 (49.6)	32 (33.3)**
Intrapartum ARM, n (%)	124 (22.8)	96 (48.0)***	47 (29.8)	36 (47.4)**	25 (23.4)	16 (57.1)**	52 (18.7)	44 (45.8)***

Oxytocin augmentation, n (%)	185 (31.4)	64 (32.0)	20 (11.0)	12 (15.8)	24 (20.5)	3 (10.7)	141 (48.5)	49 (51.0)
Epidural analgesia, n (%)	222 (37.6)	102 (51.0)**	90 (49.5)	44 (57.9)	36 (30.8)	10 (35.7)	96 (33.0)	48 (50.0)**
Opioids analgesia, n (%)	81 (13.7)	25 (12.5)	17 (9.3)	3 (4.0)	0 (0.0)	0 (0.0)	64 (22.0)	22 (22.9)
Neither ARM, oxytocin, epidural nor opioids, n (%)	194 (34.3)	27 (13.5)***	54 (31.8)	12 (15.8)**	54 (48.7)	5 (17.9)**	86 (30.3)	10 (10.4)***
Infant birthweight in kg, md (IQR)	3.43 (3.12-3.74)	3.66 (3.33-3.98)***	3.47 (3.17-3.77)	3.72 (3.41-4.01)***	3.35 (3.01-3.62)	3.33 (3.11-3.70)	3.42 (3.16-3.74)	3.69 (3.35-3.92)***
Arterial pH[c,d], md (IQR)	7.24 (7.18-7.30)	7.27 (7.21-7.31)**	7.19 (7.11-7.28)	7.26 (7.18-7.30)	7.30 (7.21-7.34)	7.27 (7.20-7.34)	7.25 (7.18-7.29)	7.28 (7.22-7.31)**
Labour intervals								
Overall labour duration[d] in hrs, md	5.71 (3.58-8.65)	8.28 (5.27-12.61)***	6.18 (3.58-10.45)	8.19 (5.24-12.70)*	4.65 (2.92-6.75)	5.31 (4.18-7.16)	5.77 (3.90-8.53)	9.24 (5.94-12.95)***
First stage of labour duration[d] in hrs, md	4.68 (2.92-7.42)	7.83 (4.78-11.72)***	5.38 (3.25-9.67)	8.19 (4.83-12.70)**	4.00 (2.00-5.75)	4.88 (3.00-6.71)	4.67 (3.00-7.17)	8.50 (5.81-12.21)***
Second stage of labour duration[d] in hrs, md	0.70 (0.28-1.42)	2.13 (1.23-2.93)***	0.50 (0.20-1.25)	2.47 (1.95-3.08)**	0.65 (0.27-1.10)	1.26 (0.69-2.23)*	0.85 (0.37-1.70)	2.20 (1.30-3.15)***
Timing of SROM in hrs, md (IQR)	2.50 (0.67-4.83)	3.00 (0.02-6.75)	1.83 (0.02-5.00)	0.02 (0.02-3.00)	1.50 (0.33-3.00)	3.33 (3.00-10.00)*	3.00 (1.00-5.10)	3.25 (0.75-7.17)
Timing of ARM, hrs, md (IQR)	3.50 (1.75-6.67)	6.08 (2.42-10.53)**	2.50 (0.75-6.17)	6.08 (2.25-8.58)*	2.33 (1.00-4.33)	3.00 (1.42-4.65)	5.25 (3.00-8.22)	8.28 (2.83-11.98)
Timing of oxytocin infusion in hrs, md (IQR)	5.33 (3.17-8.10)	5.67 (3.10-8.67)	2.50 (1.92-6.67)	3.00 (0.02-6.75)	4.42 (3.00-6.00)	0.78 (0.78-3.00)*,[e]	5.50 (3.50-8.50)	6.17 (4.33-8.67)
Timing of epidural analgesia in hrs, md (IQR)	3.42 (1.83-6.33)	3.75 (1.75-6.67)	4.03 (1.83-9.67)	3.75 (1.18-7.92)	1.67 (0.67-2.67)	2.00 (1.00-4.00)	3.72 (2.50-6.50)	3.87 (2.13-6.20)

Timing of opioids analgesia in hrs, md (IQR)	2.62 (1.25-4.50)	5.00 (1.00-10.00)*,[e]	3.75 (0.67-7.00)	5.00 (0.02-10.00)	-	-	2.30 (1.27-4.20)	3.83 (1.00-10.00)*,[e]
Timing of first of ARM, Oxytocin, epidural or opioids in hrs, md (IQR)	4.15 (2.00-8.53)	4.42 (1.67-8.00)	4.00 (1.80-9.87)	4.82 (1.17-8.58)	4.58 (1.67-17.00)	3.00 (1.00-6.33)*,[e]	4.07 (2.30-7.52)	4.48 (2.00-8.08)

md = median; IQR = interquartile range; ROM = rupture of the membranes; SROM = spontaneous rupture of the membranes, ARM = artificial rupture of the membranes

[a] 5-10% missing values; [b] 10-15% missing values, [c] > 15% ,missing values; [d] Mann-Whitney-U test; [e] log rank test

*p<0.05; **p<0.01; ***p<0.001

Table 3: Predictors for successful VBAC in the mixed effect logistic regression

Predictors	Whole study group n=784 OR [95% CI]	Ireland n=258 OR [95% CI]	Italy n=143 OR [95% CI]	Germany n=383 OR [95% CI]
Age > 35 years	0.86 [0.59, 1.24]	1.13 [0.55, 2.33]	0.69 [0.27, 1.76]	0.72 [0.42, 1.24]
Married/living partner	1.50 [0.67, 3.38]	4.25 [1.07, 16.84]*	-[b]	0.66 [0.08, 5.14]
Previous vaginal birth	3.73 [2.17, 6.44]***	6.13 [2.59, 14.50]***	1.42 [0.45, 4.48]	4.51 [1.62, 12.55]**
Birthweight (in kg)	0.34 [0.23, 0.50]***	0.24 [0.13, 0.46]***	0.72 [0.27, 1.95]	0.38 [0.21, 0.69]**
ARM	0.20 [0.11, 0.37]***	0.46 [0.16, 1.30]	0.09 [0.02, 0.44]**	0.10 [0.03, 0.27]***
Reference SROM[a]	1	1	1	1
Labour duration (in hrs)	0.93 [0.90, 0.97]***	0.98 [0.94, 1.03]	0.95 [0.85, 1.05]	0.88 [0.83, 0.94]***
Interaction ARM/ labour duration (in hrs)	1.06 [1.004, 1.12]*	1.00 [0.93, 1.08]	1.17 [0.94, 1.45]	1.13 [1.03, 1.24]**

SROM = spontaneous rupture of the membranes; ARM = artificial rupture of the membranes,

[a] Prelabour and intrapartum SROM; [b] could not be computed, because all women with successful VBAC were married/lived with a partner

*p<0.05; **p<0.01; ***p<0.001

Table 4: Sensitivity analysis for mixed effect logistic regression modelling without the variable labour duration

Predictors	**Whole study group** n=784 OR [95% CI]	**Ireland** n=258 OR [95% CI]	**Italy** n=143 OR 95% CI]	**Germany** n=383 OR [95% CI]
Age > 35 years	0.87 [0.60, 1.25]	1.18 [0.58, 2.41]	0.72 [0.29, 1.81]	0.67 [0.40, 1.12]
Married/living partner	1.59 [0.71, 3.57]	4.39 [1.11, 17.37]*	-[b]	0.68 [0.10, 4.64]
Previous vaginal birth	4.12 [2.40, 7.06]***	6.50 [2.77, 15.27]***	1.49 [0.48, 4.63]	5.62 [2.07, 15.25]**
Birthweight (in kg)	0.35 [0.23, 0.51]***	0.24 [0.13, 0.46]***	0.76 [0.29, 2.00]	0.38 [0.21, 0.69]**
ARM	0.32 [0.22, 0.46]***	0.45 [0.23, 0.86]*	0.23 [0.09, 0.56]**	0.26 [0.15, 0.46]***
Reference SROM[a]	1	1	1	1

SROM = spontaneous rupture of the membranes; ARM = artificial rupture of the membranes,

[a] Prelabour and intrapartum SROM; [b] could not be computed, because all women with successful VBAC were married/lived with a partner

*p<0.05; **p<0.01; ***p<0.001