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Trial of labor after cesarean section in risk pregnancies: A population-based cohort study

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Abstract

Introduction: In most pregnancies after a cesarean section, a trial of labor is an option. The objective of the study was to explore trial of labor and its failure in pregnancies with medical risk conditions, in a population with a high trial of labor rate.

Material and methods: In a cohort study (n = 57 109), using data from the Medical Birth Registry of Norway 1989-2014, women with a second delivery after a first pregnancy cesarean section were included. Preterm, multiple, and non-cephalic deliveries were excluded. The outcomes were trial of labor and failed trial of labor, assessed as rates and relative risk, using deliveries without risk conditions as reference. Temporal trends were assessed by 3-year periods. The exposures were selected medical risk conditions, ie previous offspring death, labor dystocia, diabetes, heart conditions, chronic hypertension, chronic kidney disease, rheumatoid arthritis, thyroid disease, asthma, prepregnancy psychiatric conditions, epilepsy, obesity, gestational diabetes, eclampsia and preeclampsia, gestational hypertension, major malformations, second-pregnancy psychiatric conditions, assisted reproduction, macrosomia, and small-for-gestational-age neonates. Induced onset of labor was compared with spontaneous onset of labor for each condition studied.

Results: In risk pregnancies (n = 31 994) the trial of labor rate was 64.9% and failure rate was 27.6%, compared with 74.6% and 16.4% in pregnancies without any of the risk conditions studied (n = 25 115). The lowest trial of labor rates were observed in diabetes type 1 (49.5%), diabetes type 2 (46.7%), maternal heart conditions (54.5%), and pregnancy-related psychiatric conditions (19.7%). The highest failure rates were observed in diabetes type 1 (43.1%), diabetes type 2 (40.3%), maternal obesity (36.9%), gestational diabetes (36.0%), and offspring macrosomia (43.0%). Induced labor was associated with failed trial of labor ($P < .05$), whereas after spontaneous labor, failure rates were less than 40% in all conditions studied.

Conclusions: In conditions with high rates of failed trial of labor, eg diabetes, macrosomia, and obesity, a planned cesarean section might be a better option than a trial of labor, particularly if induction of delivery might be needed.

KEYWORDS

cesarean section, cohort study, induction of labor, risk pregnancy, trial of labor

Abbreviations: CI, confidence interval; CS, cesarean section; MBRN, Medical Birth Registry of Norway; RR, relative risk; SGA, small-for-gestational-age; TOLAC, trial of labor after cesarean section.

1 | INTRODUCTION

In most pregnancies after a cesarean section (CS), trial of labor (TOLAC) is an option for consideration.[1-4] However, in TOLAC failure, involving an acute CS, excess risk of adverse outcome has been reported, compared with both vaginal delivery and planned CS.[1,5,6] Hence, factors that might predict TOLAC failure are of clinical interest, especially if known before the onset of the delivery. TOLAC failure has been associated with high maternal age, low level of education, some ethnic backgrounds, obesity, and previous labor dystocia.[7,8] Guidelines advise against TOLAC in extreme maternal obesity or fetal macrosomia.[2-4]

However, except for diabetic and hypertensive diseases,[9-12] the risk of TOLAC failure in specific medical conditions is sparsely studied.[1,5,9-12] Conditions with presumed high prevalence, eg asthma and psychiatric illnesses, are of particular interest.[14] Furthermore, a need for specialized services in certain diseases, eg maternal heart conditions[15] might affect the planning of mode of delivery. Finally, several medical conditions, eg diabetes and hypertensive disorders, might necessitate induction of labor, which has been associated with excess risk of TOLAC failure and adverse outcome of pregnancy.[16]

A high TOLAC rate, eg around 70% as observed in Norway, warrants close attention to the TOLAC failure rate, particularly in risk pregnancies.[17] The objective of the present study was to explore medical conditions as risk factors for TOLAC and TOLAC failure, in a population with a high TOLAC rate. Additionally, for each risk condition studied, the induction of labor rate was assessed, and TOLAC failure rates with and without induction were compared.

Key message

In trial of labor after a previous cesarean section, high failure rates were observed in some risk conditions, particularly diabetes, macrosomia, and obesity, and after induction of labor.

2 | MATERIAL AND METHODS

Based on compulsory notification, the Medical Birth Registry of Norway (MBRN) has, since 1967, received data on all births in the country, including data on maternal medical conditions registered before and during the pregnancy. With the introduction of electronic reporting in 2005, data on maternal weight and height were added. Shortly after delivery, data are reported by midwives and doctors with access to predelivery records, including the standardized pregnancy chart.[18] In vitro fertilization clinics, pediatric departments, and genetics laboratories also report data to the MBRN. Medical conditions are reported as plain text and by tick-boxes and recorded as International Classification of Diseases codes or categorical variables. Notification forms, instructions to reporting practitioners, as well as code manuals, are available online.[19]

In the present study, MBRN records from 1967 to 2014 were internally linked to identify the first and second delivery of the same woman, and externally linked to Statistics Norway with data on maternal country of origin and education. Term, cephalic, second deliveries for 1989-2014, after a first CS delivery (n = 57 109) were included. The risk conditions studied were selected based on their clinical importance, prevalence, and availability of data.

From the first pregnancy record, we included offspring death (prelabor, intrapartum, and first 28 days), and labor dystocia (defined by a recoded clinical diagnosis of fetal-pelvic disproportion, prolonged delivery, or ineffective labor). From the second-pregnancy record, we included diabetes type 1, diabetes type 2, heart conditions (of any nature, as indicated by tick-box), chronic hypertension, chronic kidney disease, rheumatoid arthritis, thyroid disease, asthma, prepregnancy psychiatric disease (recorded before the current pregnancy, or with International Classification of Diseases codes indicating chronic conditions), epilepsy, obesity (body mass index ≥30 kg/m^2 before or in the first trimester of the second pregnancy), gestational diabetes, eclampsia and preeclampsia, gestational hypertension, major malformations,[20] second-pregnancy psychiatric conditions, assisted reproduction (in vitro fertilization, intracytoplasmic sperm injection, other, or unspecified), offspring macrosomia (birthweight ≥4500 g), and small-for-gestational-age (SGA) (birthweight ≤ sex and gestational age-specific 10th centile).

The outcomes studied were TOLAC and TOLAC failure. As TOLAC is not reported as a separate variable to the MBRN, the outcomes were identified by sets of variables that indicate a planned or actual attempt at vaginal delivery (Figure 1), aiming to capture the intended mode of delivery at admission to the delivery unit. TOLAC failure was defined as an acute or unspecified CS in a TOLAC delivery. A similar approach was validated in a separate study, and found to have an acceptable predictive value.[21] In 2.3% of the deliveries (n = 1303), data were insufficient for classification.

2.1 | Statistical analyses

Temporal trends were calculated as rates (%) of TOLAC and TOLAC failure in all and high-risk pregnancies by 3-year period. The statistical significance of the temporal trends was tested by calculating relative risks (RR) for each 3-year period with a 95% confidence interval (CI), using 1989-1991 as reference, adjusting for maternal age, maternal education, country of origin, and size of the maternity unit.

For each condition studied, the rates (%) and RRs of TOLAC and TOLAC failure were calculated with a 95% CI, using low-risk pregnancies as reference. Adjusted RRs were estimated, including maternal age, maternal education, country of origin, 3-year period of delivery, and size of maternity unit in the models. In a supplemental analysis we assessed TOLAC and TOLAC failure in settings of

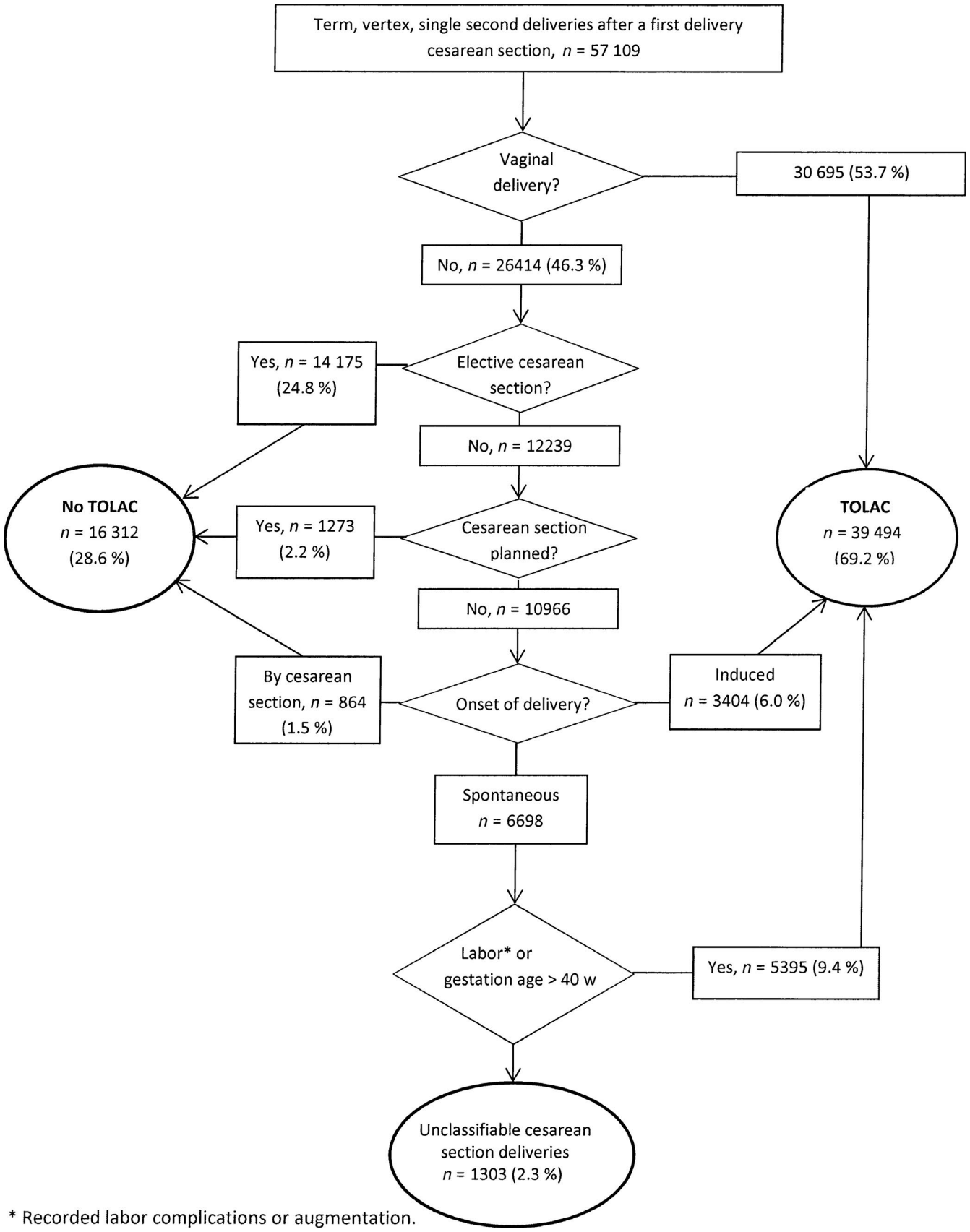

FIGURE 1 Flow chart indicating the study population and identification of outcome categories: Trial of labor after cesarean section (TOLAC), no TOLAC, and unclassifiable deliveries, based on data from the Medical Birth Registry of Norway, 1989-2014

comorbidity, including diabetes (all subgroups), hypertensive conditions (all subgroups), and morbid obesity (BMI ≥35 kg/m^2), calculating rates, and RR adjusted for maternal age.

Induction of labor is recorded by the MBRN as four variables; "prostaglandin", "oxytocin", "amniotomy", and "other". In the present study this was combined to a single variable identifying any form of induction. For each condition studied, TOLAC failure rates and RR after induction of labor were compared with spontaneous onset, using spontaneous delivery start as reference. We also assessed RR adjusted for gestational age (<41 weeks and ≥41 weeks) and maternal age (<30 years and ≥30 years). As prelabor fetal death might affect the decision and clinical course of induction, these deliveries (n = 80, of which 74 were TOLAC) were excluded from this analysis.

In the log binominal models, unclassified deliveries were excluded, and missing model data were handled by restriction. The adjustment variables were selected based on previous review studies of medical and nonmedical factors affecting TOLAC and TOLAC failure.[1,17] We used IBM SPSS software version 20.0. Characteristics of the study population are provided in Table 1.

2.2 | Ethical approval

The Regional Committee for Medical and Health Research Ethics approved the study (permit no. 2015/1728).

3 | RESULTS

In risk pregnancies, the TOLAC rate was 64.9% compared with 74.6% in low-risk pregnancies (Table 2). TOLAC rates in risk pregnancies

TABLE 1 Population characteristics and prevalence of the conditions studied, Norway 1989-2014. Cephalic, single deliveries, ≥37 weeks, after a first delivery cesarean section

Population characteristics	n	%	Conditions	n	%
Maternal country of origin			First pregnancy		
Western[a]	49 879	87.3	Offspring death[c]	501	0.9
Other	7235	12.7	Labor dystocia[d]	16 918	29.6
Hospital size			Prepregnancy		
1-499	5712	10.0	Diabetes 1	422	0.7
500-1499	13 431	23.5	Diabetes 2	165	0.3
1500-2999	17 413	30.5	Heart conditions[e]	354	0.6
≥3000	20 481	35.9	Hypertension	520	0.9
Not hospital	71	0.1	Chronic kidney disease	511	0.9
Missing	1	0.0	Rheumatoid arthritis	261	0.5
Education (y)			Thyroid disease	1039	1.8
≤12	29 449	51.6	Asthma	2308	4.0
>12	26 833	47.0	Psychiatric condition[f]	1542	2.7
Missing	827	1.4	Epilepsy	477	0.8
Maternal age			Obesity (BMI ≥ 35)[b]	673	1.2
<25	5684	10.0	Second pregnancy		
25-29	18 421	32.3	Gestational diabetes	1119	2.0
30-34	21 829	38.2	Eclampsia/preeclampsia	2091	3.7
35-39	9489	16.6	Gestational hypertension	1015	1.8
≥40	1686	2.9	Major malformation	2163	3.8
			Psychiatric condition	1077	1.9
Risk conditions			Assisted reproduction	937	1.6
One or more	31 994	56.0	LGA (≥4500 g)	3039	5.3
None	25 115	44.0	SGA (≤10%)	5620	9.8
Total	57 109		Total	57 109	

ICD, International Classification of Diseases; LGA, large-for-gestational-age; SGA, small-for-gestational-age.
[a]Europe, North America, Australia.
[b]Data available 2005-2014.
[c]Prelabor, intrapartum, and first 28 days of life.
[d]Recorded clinical diagnosis of fetal-pelvic disproportion prolonged delivery, or ineffective labor;
[e]Any heart condition.
[f]Recorded before the current pregnancy, or with ICD codes indicating chronic conditions.

TABLE 2 Trial of labor after cesarean section (TOLAC) in various risk conditions; Rates, relative risk (RR) and adjusted relative risk (ARR). Cephalic, single deliveries, ≥37 weeks, Norway 1989-2014

		TOLAC							
Risk condition	**N**	**n**	**%**	**RR**	**[95% CI]**		**ARR[a]**	**[95% CI]**	
None	25 115	18 743	74.6	Reference = 1					
One or more	31 994	20 751	64.9	0.88	0.87	0.89	0.88	0.87	0.89
First pregnancy									
Perinatal death	501	306	61.1	0.82	0.77	0.88	0.80	0.75	0.86
Prolonged delivery	16 918	10 542	62.3	0.84	0.83	0.85	0.84	0.83	0.85
Pre- pregnancy maternal conditions									
Diabetes 1	422	209	49.5	0.68	0.62	0.75	0.67	0.61	0.74
Diabetes 2	165	77	46.7	0.65	0.55	0.76	0.72	0.61	0.84
Heart conditions	354	193	54.5	0.73	0.67	0.81	0.75	0.68	0.83
Hypertension	520	344	66.2	0.90	0.85	0.95	0.94	0.88	0.99
Chronic kidney disease	511	321	62.8	0.85	0.80	0.91	0.86	0.80	0.91
Rheumatoid arthritis	261	152	58.2	0.79	0.71	0.87	0.82	0.74	0.91
Thyroid disease	1039	646	62.2	0.84	0.80	0.88	0.87	0.83	0.92
Asthma	2308	1464	63.4	0.86	0.83	0.88	0.86	0.83	0.89
Psychiatric condition	1542	893	57.9	0.78	0.74	0.81	0.81	0.77	0.84
Epilepsy	477	295	61.8	0.83	0.78	0.89	0.84	0.79	0.90
Obesity (BMI ≥ 30)[b]	1899	1223	64.4	0.89	0.86	0.92	0.93	0.90	0.95
Second pregnancy									
Gestational diabetes	1119	686	61.3	0.83	0.79	0.87	0.86	0.82	0.90
Eclampsia/pre-eclampsia	2091	1442	69.0	0.96	0.93	0.98	0.95	0.92	0.97
Gestational hypertension	1015	732	72.1	0.98	0.94	1.01	0.99	0.95	1.03
Major malformation	2163	1441	66.6	0.90	0.87	0.92	0.90	0.87	0.93
Current psychiatric condition	1077	212	19.7	0.26	0.23	0.30	0.27	0.24	0.30
Assisted reproduction	937	572	61.0	0.83	0.79	0.87	0.91	0.87	0.96
Birthweight ≥4500 g	3039	1985	65.3	0.87	0.85	0.89	0.86	0.84	0.88
SGA (≤10%)	56 20	4202	74.8	1.02	1.01	1.04	1.02	1.00	1.03
Total	57 109	39 494	69.2						

BMI, body mass index; SGA, small-for-gestational age.
[a]Adjusted for maternal age, maternal education, country of origin, year of delivery, size of maternity unit.
[b]BMI: Data 2005-2014.

initially increased from 67% in 1989-1991 to 73% in 1998-2000, then declined to 62% in 2009-2011, and finally increased again to 68% in the last 2 years of the period studied (Figure 2, data not shown). In risk pregnancies, the TOLAC failure rate was 27.6% compared with 16.4% in low-risk pregnancies (Table 3). TOLAC failure rates in risk pregnancies decreased from 27% in 1989-1991 to 23% in 1992-1994, with a subsequent increase, leveling out at 31% in the last 5 years of the period studied (data not shown). The temporal trends observed (Figure 2) were statistically significant ($P < .05$), both crude and adjusted.

In all conditions studied, except for gestational hypertension and SGA, we found lower TOLAC rates than the reference. The lowest TOLAC rates were observed in diabetes type 1 (49.5%), diabetes type 2 (46.7%), maternal heart conditions (54.5%), and second-pregnancy psychiatric conditions (19.7%) (Table 2). In women with obesity, the TOLAC rate was 64.4% (Table 2, Figure 3). In offspring macrosomia, the TOLAC rate was 65.3% (Table 2, Figure 4). In all conditions studied, except for previous offspring death, we found higher TOLAC failure rates than the reference. The highest TOLAC failure rates were observed in diabetes type 1 (43.1%), diabetes type 2 (40.3%), women with obesity (36.9%), gestational diabetes (36.0%), and offspring macrosomia (43.0%) (Table 3, Figure 3, Figure 4). In combinations of diabetes, hypertensive conditions and morbid obesity, TOLAC rates were still >50%, with TOLAC failure rates from 38.4% to 48.6% (Table 4).

The induction rates (Table 4) were highest in previous perinatal death (43.3%), diabetes type 1 (66.7%), diabetes type 2 (62.3%), hypertension (46.1%), gestational diabetes (49.0%), eclampsia and preeclampsia (63.2%), gestational hypertension (42.7%), and second-pregnancy psychiatric conditions (40.8%). In all conditions

studied, higher TOLAC failure risks were observed after induction of labor than after spontaneous onset of delivery (Table 5).

4 | DISCUSSION

In risk pregnancies, the TOLAC rate was 64.9%, compared with 74.6% in low-risk pregnancies. The lowest TOLAC rates were observed in diabetes types 1 and 2, heart conditions, and psychiatric conditions related to the current pregnancy. In risk pregnancies, the TOLAC failure rate was 27.6%, compared with 16.4% in low-risk pregnancies. The main finding of the study was the generally high TOLAC rates in risk pregnancies, combined with high TOLAC failure rates in diabetic conditions, obesity, and offspring macrosomia, especially after induced labor. The study benefited from a large study population, adjustment for confounders, and TOLAC was identified by a validated approach, based on data derived from a national registry with near complete coverage.[21] Studies of MBRN of data on clinically important medical conditions against hospital records have shown acceptable quality for epidemiological studies.[22-27] Still, incomplete ascertainment of some medical conditions cannot be ruled out, especially if these are considered by the reporting midwife or physician to be of limited importance in management of the pregnancy and delivery.

In non-TOLAC deliveries, requiring a sufficient indication and preoperative assessment, registration of conditions might differ from TOLAC deliveries. Some conditions might be of special interest in this regard, eg asthma, and so be more meticulously reported, to the extent that this might cause an underestimation of TOLAC rates in such conditions, and an underestimation of excess TOLAC failure rates.

A small number of deliveries classified as TOLAC in the study (n = 74) took place after a prelabor fetal death. Some of these might have been true non-TOLAC with insufficient data on planned mode, delivered vaginally because of the fetal death. This might cause some overestimation of TOLAC, and underestimation of TOLAC failure. However, because of the small numbers involved, the effect of such misclassification is probably very small.

The MBRN data items used to identify induction of labor in this study have not been specifically validated against hospital records. However, a study of variables regarding onset of delivery has reported a positive predictive value of 57% and a negative predictive value of 98% for induction as delivery start.[21] Misclassification of labor augmentation as induction is a possibility. If present, this might cause overestimation of induction rates, and possibly of TOLAC failure rates after induced onset of delivery.

In Norway, since before the start of the study period, a low transverse incision has been the preferred procedure for third-trimester CS deliveries. However, a small number of CS are still performed by vertical incision, eg in extreme prematurity. Since incision type could not be identified by the MBRN records used, some non-transverse CS are probably included in this study, but most likely the number is very limited, and without any bearing on the results.

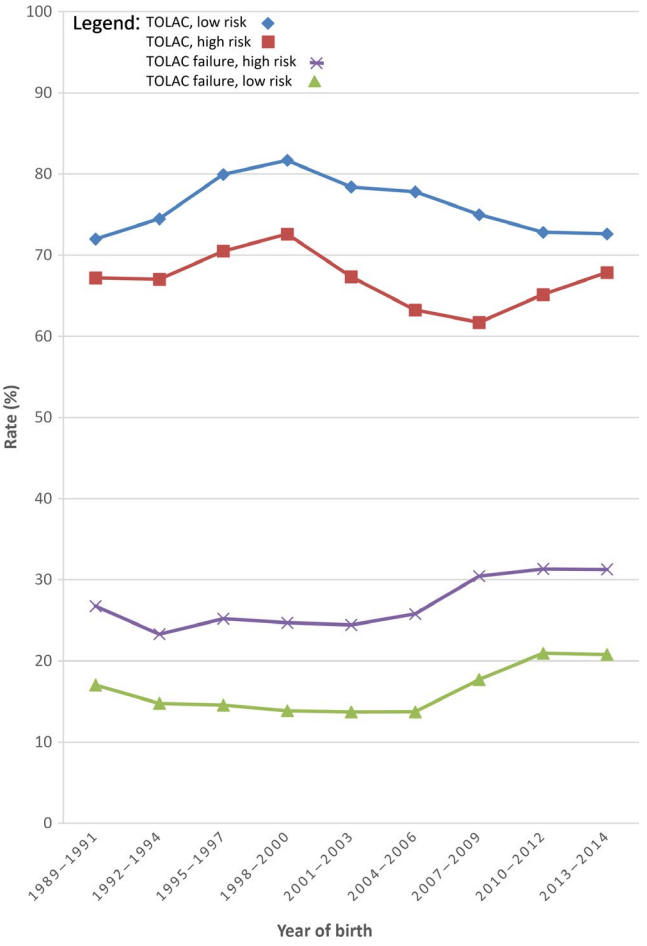

FIGURE 2 Temporal trends in rates (%) of trial of labor after cesarean section (TOLAC) and TOLAC failure, all pregnancies and high-risk pregnancies. Cephalic, single deliveries, ≥37 weeks' gestational age, Norway 1989-2014. [Color figure can be viewed at wileyonlinelibrary.com]

Gestational age and cervical ripening might affect the decision to induce delivery, as well as induction success or failure. Some conditions, eg diabetes, might provide stronger indication for medically initiated delivery, so gestational age and cervical ripening at induction start might differ between the conditions studied. However, adjustment for gestational age had little effect on the observed RRs of TOLAC failure after induction (Table 4). Data on cervical ripening were not available, so it cannot be ruled out that some of the observed differences between conditions in TOLAC failure rates after induction might be connected to cervical status.

In most studies of TOLAC, the TOLAC rates have been far lower than in the present study. In a US registry-based study (n = 41 450, of which 12 320 with risk conditions), several of the conditions included in the present study were explored.[13] The overall TOLAC rates were considerably lower, 26% in risk pregnancies and 29% in low-risk pregnancies. The lowest TOLAC rate was observed in heart conditions, and the highest in intrauterine growth restriction, which agrees with our findings.

In the US study mentioned above,[13] the TOLAC failure rate was 50% in risk pregnancies, considerably higher, regardless of condition,

TABLE 3 Trial of labor after cesarean section (TOLAC) failure in various risk conditions; Rates, relative risk (RR) and adjusted relative risk (ARR). Cephalic, single deliveries, ≥37 weeks, Norway 1989-2014

		TOLAC failure							
Risk condition	**N**	**n**	**%**	**RR**	**[95% CI]**		**ARR[a]**	**[95% CI]**	
None	18 743	3080	16.4	Reference = 1					
One or more	20 751	5719	27.6	1.68	1.61	1.75	1.66	1.60	1.73
First pregnancy									
Perinatal death	306	56	18.3	1.11	0.88	1.41	1.14	0.90	1.44
Prolonged delivery	10 542	3279	31.1	1.89	1.81	1.98	1.85	1.77	1.93
Pre- pregnancy maternal conditions									
Diabetes 1	209	90	43.1	2.62	2.24	3.07	2.45	2.10	2.86
Diabetes 2	77	31	40.3	2.45	1.86	3.22	1.91	1.45	2.51
Heart conditions	193	65	33.7	2.05	1.68	2.51	1.80	1.47	2.20
Hypertension	344	110	32.0	1.95	1.66	2.28	1.75	1.50	2.00
Chronic kidney disease	321	73	22.7	1.38	1.13	1.70	1.42	1.16	1.74
Rheumatoid arthritis	152	44	28.9	1.76	1.37	2.26	1.62	1.27	2.07
Thyroid disease	646	164	25.4	1.55	1.35	1.77	1.35	1.18	1.55
Asthma	1464	373	25.5	1.55	1.41	1.70	1.49	1.35	1.63
Psychiatric condition	893	248	27.8	1.69	1.51	1.89	1.42	1.27	1.59
Epilepsy	295	73	24.7	1.51	1.23	1.84	1.41	1.15	1.71
Obesity (BMI ≥ 30)[b]	1223	451	36.9	1.96	1.76	2.18	1.83	1.69	1.99
Second pregnancy									
Gestational diabetes	686	247	36.0	2.19	1.97	2.43	1.70	1.53	1.91
Eclampsia/ pre-eclampsia	1442	461	32.0	1.95	1.79	2.11	1.94	1.76	2.10
Gestational hypertension	732	199	27.2	1.65	1.46	1.87	1.63	1.44	1.84
Major malformation	1441	337	23.4	1.42	1.29	1.57	1.36	1.23	1.50
Current psychiatric condition	212	66	31.1	1.90	1.55	2.32	1.85	1.51	2.25
Assisted reproduction	572	147	25.7	1.56	1.36	1.80	1.27	1.10	1.47
Birthweight ≥4500 g	1985	853	43.0	2.62	2.46	2.78	2.61	2.46	2.77
SGA (≤10%)	4202	862	20.5	1.25	1.17	1.34	1.21	1.13	1.52
Total	39 494	8799	22.3						

BMI, body mass index; SGA, small-for-gestational age.
[a]Adjusted for maternal age, maternal education, country of origin, year of delivery, size of maternity unit.
[b]BMI: Data 2005-2014.

than in the present. The failure rate was highest in offspring macrosomia, which agrees with our findings. However, contrary to our observation, a high TOLAC failure rate (57%) was reported in SGA. Induction rates were not reported, which hampers further comparison.

Another US study,[10] including 17 delivery units with a total TOLAC rate of 55%, reported an RR for TOLAC in gestational hypertension of 0.54 (95% CI 0.49-0.60) with an RR for TOLAC failure of 1.26 (95% CI 1.07-1.50), compared with normotensive women. In preeclampsia the RR for TOLAC was 0.89 (95% CI 0.83-0.96), with an RR for TOLAC failure of 1.53 (95% CI 1.33-1.76), compared with normotensive women. With induction rates in the same range as the present study, 40% in gestational hypertension and 55% in preeclampsia, this agrees well with our observations.

In a study of women with diabetes attempting vaginal delivery (n = 215), the TOLAC failure rate was 36%; 63% after induction, and 19% after spontaneous labor.[11] With a TOLAC rate of 46% in women with diabetes, Cormier et al. also reported a TOLAC failure rate of 36%.[12] A study of women with pregestational diabetes reported a TOLAC rate of 37% and a TOLAC failure rate of 38%.[9] Hence, our findings regarding diabetic conditions also agree with previous research, though with somewhat higher TOLAC and TOLAC failure rates. High TOLAC failure risk was observed after induction of labor

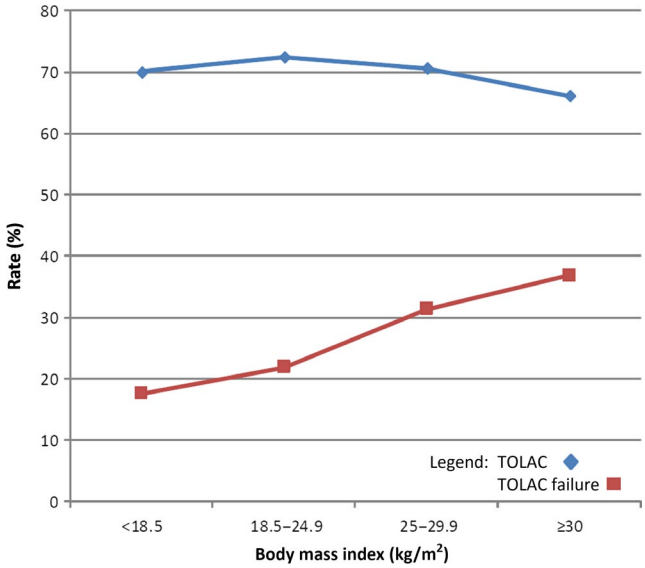

FIGURE 3 Trial of labor after cesarean section (TOLAC) and TOLAC failure rates (%) by body mass index at pregnancy start. Cephalic, single deliveries, ≥37 weeks' gestational age, Norway 2005-2014. [Color figure can be viewed at wileyonlinelibrary.com]

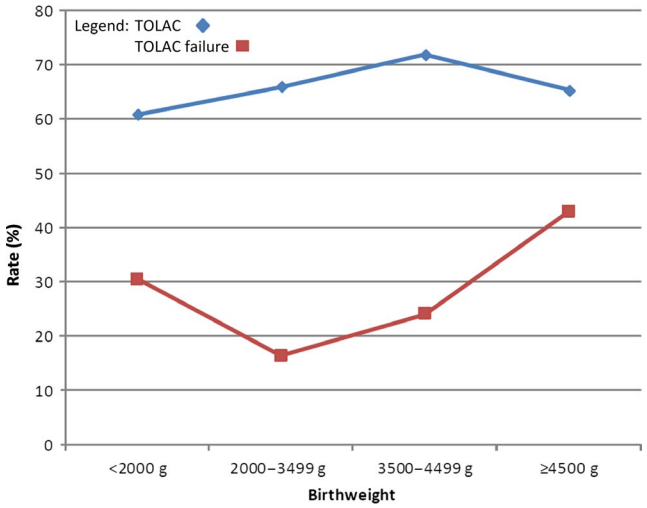

FIGURE 4 Trial of labor after cesarean section (TOLAC) and TOLAC failure rates (%) by offspring birthweight. Cephalic, single deliveries, ≥37 weeks' gestational age, Norway, 1989-2014. [Color figure can be viewed at wileyonlinelibrary.com]

in all conditions studied. This agrees with previous research,[16] but has not previously been assessed in such a wide range of specific risk conditions.

In addition to medical risk, organizational and nonmedical factors might affect TOLAC rates.[1] The high TOLAC rates observed in the present study might be connected to high TOLAC availability during the study period.[21] Additionally, the attitudes and perceptions of risk in Norwegian women and obstetricians might differ from those found in populations with lower rates. Finally, the high TOLAC rates might in part be explained by national guidelines placing the final decision with the obstetrician, requiring a medical indication for a CS.

Most conditions studied, eg maternal medical diseases, are known before admission to the delivery unit. However, SGA, macrosomia, and fetal malformations might be difficult to recognize before delivery. Nevertheless, with evolving precision in diagnostic ultrasound, it is reasonable to assume that an increasing proportion of such conditions might be suspected or recognized before the onset of delivery, and so considered when deciding on delivery mode.

The conditions studied do not seem to have been considered as strong indications for a planned CS. Even in conditions where more maternal requests for a planned CS might be expected, ie

TABLE 4 Trial of labor after cesarean section (TOLAC) and TOLAC failure in combinations of diabetic conditions, hypertensive conditions, and obesity. Cephalic, single deliveries, ≥37 wk gestational age, Norway 2005-2014 (n = 23 509). Diabetic: diabetes mellitus type 1 or 2 and gestational diabetes. Hypertensive: chronic hypertension, preeclampsia, eclampsia, and gestational hypertension. Obese: Prepregnancy BMI ≥ 35 kg/m^2

Condition				TOLAC					TOLAC failure				
Diabetic	Hyper-tensive	Obese[a]	N	n	%	ARR[b]	95% CI		n	%	ARR[a]	95% CI	
–	–	–	7454	5285	70.9	Reference=1.00			1267	24.0	Reference=1.00		
+	–	–	174	108	62.0	0.93	0.83	1.04	46	42.6	1.72	1.38	2.15
–	+	–	289	202	69.8	1.03	0.96	1.11	63	31.2	1.30	1.06	1.60
–	–	+	1475	946	64.1	0.91	0.88	0.95	330	34.9	1.47	1.33	1.62
+	+	–	24	12	50.0	0.77	0.53	1.13	5	41.6	1.77	0.90	3.45
+	–	+	102	52	50.9	0.73	0.61	0.89	20	38.4	1.58	1.12	2.23
–	+	+	173	121	69.9	1.01	0.92	1.10	49	40.5	1.68	1.35	2.10
+	+	+	49	35	71.4	1.05	0.88	1.24	17	48.6	1.96	1.40	2.76
Total			9740										
Missing			13 769										

[a]BMI ≥ 35 kg/m^2
[b]ARR: RR adjusted for maternal age.

TABLE 5 Trial of labor after cesarean section (TOLAC): Induction in risk conditions, and TOLAC failure with spontaneous and induced labor (any method). Cephalic, single deliveries, ≥37 weeks, Norway 1989-2014

		Induced				Spontaneous				Induced: RR of TOLAC failure					
		Total		Failed		Total		Failed		Spontaneous onset = 1.00					
Risk condition	N[a]	n	%	n	%	n	%	n	%	RR	95% CI		ARR[b]	95% CI	
First pregnancy															
Perinatal death	305	132	43.3	45	34.1	173	56.7	11	6.4	5.36	2.89	9.96	5.34	2.75	10.39
Prolonged delivery	10 523	2190	20.8	995	45.4	8333	79.2	2282	27.4	1.66	1.57	1.76	1.62	1.52	1.71
Prepregnancy maternal conditions															
Diabetes 1	207	138	66.7	69	50.0	69	33.3	21	30.4	1.64	1.11	2.44	1.57	1.06	2.32
Diabetes 2	77	48	62.3	26	54.2	29	37.7	5	17.2	3.14	1.36	7.27	3.52	1.52	8.16
Heart conditions	193	47	24.4	30	63.8	146	75.6	35	24.0	2.66	1.86	3.82	2.53	1.76	3.62
Hypertension	343	158	46.1	66	41.8	185	53.9	43	23.2	1.80	1.31	2.48	1.78	1.29	2.46
Chronic kidney disease	321	95	29.6	29	30.5	226	70.4	44	19.5	1.57	1.05	2.35	1.54	1.03	2.31
Rheumatoid arthritis	152	40	26.3	18	45.0	112	73.7	26	23.2	1.94	1.20	3.13	2.01	1.22	3.30
Thyroid disease	645	191	29.6	67	35.1	454	70.4	96	21.1	1.66	1.28	2.16	1.55	1.16	2.07
Asthma	1462	388	26.5	155	39.9	1074	73.5	218	20.3	1.97	1.66	2.33	1.93	1.63	2.29
Psychiatric condition	891	222	24.9	101	45.5	669	75.1	147	22.0	2.07	1.69	2.54	1.97	1.60	2.43
Epilepsy	294	84	28.6	34	40.5	210	71.4	39	18.6	2.18	1.49	3.20	2.17	1.47	3.19
Obese (BMI ≥ 30)[c]	1223	422	34.5	208	49.3	801	65.5	243	30.3	1.63	1.41	1.87	1.56	1.35	1.80
Second pregnancy															
Gestational diabetes	683	335	49.0	164	49.0	348	51.0	83	23.9	2.05	1.65	2.55	2.02	1.62	2.51
Eclampsia/ preeclampsia	1441	910	63.2	361	39.7	531	36.8	100	18.8	2.11	1.74	2.56	2.09	1.72	2.54
Gestational hypertension	731	312	42.7	104	33.3	419	57.3	95	22.7	1.47	1.16	1.86	1.47	1.16	1.87
Major malformation	1440	378	26.3	153	40.5	1062	73.8	184	17.3	2.34	1.95	2.80	2.21	1.83	2.66
Psychiatric condition	211	86	40.8	34	39.5	125	59.2	32	25.6	1.54	1.04	2.30	1.41	0.93	2.14
Assisted reproduction	571	190	33.3	84	44.2	381	66.7	63	16.5	2.67	2.03	3.53	2.57	1.94	3.39
LGA (≥4500 g)	1980	654	33.0	353	54.0	1326	67.0	498	37.6	1.44	1.30	1.59	1.43	1.30	1.59
SGA (≤10%)	4178	1177	28.2	423	35.9	3001	71.8	435	14.5	2.48	2.21	2.78	2.43	2.15	2.74

ARR, adjusted relative risk; BMI, body mass index; LGA, large-for-gestational age; SGA, small-for-gestational age.

[a]Second-delivery intrauterine fetal death not included.

[b]Adjusted for maternal age and gestational age.

[c]Data 2005-2014.

assisted reproduction and previous fetal loss, high TOLAC rates (both 61%) and low TOLAC failure rates (18% and 26%, respectively) were observed. One exception, the very low TOLAC rate observed in second-pregnancy psychiatric conditions (19.7%), might to some extent represent CS in situations where the woman's mental state, eg anxiety connected to the delivery, makes a TOLAC infeasible.

Some authors have suggested that if the TOLAC failure rate exceeds 40%, adverse outcome outweighs the benefits.[2,28,29] In the present study, TOLAC failure rates from 20% to 43% were observed. TOLAC failure rates exceeding 40% were observed in diabetic conditions and macrosomia. In some conditions, eg offspring macrosomia and obesity, a combination of high TOLAC rates and high failure rates was observed, possibly necessitating a more rigorous selection (Figure 2 and 3).

On the other hand, in a setting with a high TOLAC rate, a high failure rate might result from close monitoring of the delivery and timely intervention. Additionally, in some medical conditions there could be less tolerance for any adverse development, eg signs of fetal stress in maternal diabetes. Hence, the threshold for discontinuing the TOLAC might be lower. Conversely, a low TOLAC failure rate might be related to a too high threshold for discontinuing a TOLAC, potentially exposing mother and child to unacceptable risk.

A suggested acceptable upper limit for TOLAC failure based on retrospective data does not necessarily apply across populations, or even across risk subgroups in the same population. Consequently, even though the high TOLAC failure rates observed in some conditions warrant caution, the appropriateness of the practice observed ultimately depends on maternal and offspring mortality and morbidity, which should be closely monitored.

Several models have been proposed to predict TOLAC failure from data known before the onset of delivery. The most widely used models do not consider specific medical risk conditions, except for offspring macrosomia, obesity, and previous arrested birth.[7,8] The potential need for induction of delivery appears to be a key element in the planning. In our opinion, this limits the usefulness of such models in risk conditions.

Around one-third of the deliveries included in this study were performed in units with <1500 yearly deliveries (Table 1). Higher TOLAC rates, but not higher TOLAC failure rates, have been observed in larger units compared with smaller.[17] Hence, in some of the conditions studied, referral to a larger, tertiary institution might be a possible strategy to maintain a high TOLAC rate without excessive failure risk.

Some medical conditions, eg diabetes type 1, are strong indications for delivery within 40 weeks of gestation,[30] whereas in other settings, the indication for initiation of delivery might depend on the severity of the condition, evaluation of the fetal condition, and maternal request. When induction of labor might be necessary, and the TOLAC failure risk is high, an elective CS might in our opinion be a better option. However, to further assess the effect of induction as such, a prospective study, including information on cervical ripening, might be required.

5 | CONCLUSION

In diabetic conditions, macrosomia, and obesity, high TOLAC failure rates were observed. In all conditions studied, induced labor was associated with TOLAC failure. In conditions with a high TOLAC failure rate, a planned CS could be a better option than a TOLAC, particularly if medically initiated delivery might be needed.

CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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