Predicting the success of vaginal birth after caesarean delivery: a retrospective cohort study in China

Yun-Xiu Li,1 Zhi Bai,2 Da-Jian Long,2 Hai-Bo Wang,3 Yang-Feng Wu,3 Kathleen H Reilly,4,5 Su-Ran Huang,6 Yan-Jie Ji2

ABSTRACT

Objectives To develop a nomogram to predict the likelihood of vaginal birth after caesarean section (VBAC) among women after a previous caesarean section (CS).

Design A retrospective cohort study.

Setting Two secondary hospitals in Guangdong Province, China.

Participants Inclusion criteria were as follows: pregnant women with singleton fetus, age ≥ 18 years, had a history of previous CS and scheduled for trial of labour after caesarean delivery (TOLAC). Patients with any of the following were excluded from the study: preterm labour (gestational age < 37 weeks), two or more CSs, contraindications for vaginal birth, history of other uterine incision such as myomectomy, and incomplete medical records.

Primary outcome measure The primary outcome was VBAC, which was retrospectively abstracted from computerised medical records by clinical staff.

Results Of the women who planned for TOLAC, 84.0% (1686/2006) had VBAC. Gestational age, history of vaginal delivery, estimated birth weight, body mass index, spontaneous onset of labour, cervix Bishop score and rupture of membranes were independently associated with VBAC. An area under the receiver operating characteristic curve (AUC) in the prediction model was 0.77 (95% CI 0.73 to 0.81) in the training cohort. The validation set showed good discrimination with an AUC of 0.70 (95% CI 0.60 to 0.79).

Conclusions TOLAC may be a potential strategy for decreasing the CS rate in China. The validated nomogram to predict success of VBAC could be a potential tool for VBAC counselling.

INTRODUCTION

The rates of caesarean section (CS) have increased steadily all over the world in the past two decades.1 Women undergoing CS may face health risks, including haemorrhage, blood transfusion, anaesthesia-associated complications and surgical risks.2 The WHO has reported that China has one of the highest CS rates in the world,3 especially in the northeastern province of Jilin (62% in 2014) and Shanghai (60% in 2010).4,5 To reduce CS rates, the Chinese government has introduced various policies and programmes at the national, provincial, district, county and hospital levels, including education of pregnant women, physician training, supervision of non-medically indicated CS (inspection and monitoring periodically conducted by national and provincial health authorities to identify any unnecessary CS, which was interpreted as an indicator of the quality of obstetric care), setting targets for CS rates and establishing incentives for lowering CS rates.6,7 China has made significant progress in achieving milestone goals, CS rates declined steadily between 2012 and 2016 (from 45.3% to 41.1%).8 CS rates declined from 60% in 2009 to 43% in 2014.4

The policy for allowing women to have a second child established in China in November 2015 has resulted in new challenges for controlling CS rates considering the increasing number of repeat CS. In addition, repeat CS is associated with increased health risk, including placenta accreta, infection, vein thrombosis and uterine rupture.8-10 The increasing number of women with a previous CS is an urgent matter and should be given close attention by clinicians and policymakers. Trial of labour after caesarean delivery (TOLAC) is an alternative to repeat...
CS and vaginal birth after caesarean section (VBAC) is an accepted practice. Current evidence suggests that women who undergo repeated CS have significantly higher risk of maternal and perinatal morbidity compared with women who deliver vaginally after CS. Major complications associated with TOLAC include scar dehiscence, hysterectomy and uterine rupture, but successful TOLAC is associated with less blood loss, significantly lower risk of neonatal respiratory morbidities and placenta previa, and a shorter hospital stay with a more rapid recovery. TOLAC should be considered among women with a uterine scar if there are no contraindications, and successful TOLAC can be safely achieved for both mother and infant in most cases.

Globally, TOLAC is considered a reasonable and safe option. However, in China, repeat CS rates remain high among women with a history of previous CS. Therefore, TOLAC would be highly effective at decreasing the overall CS rates considering the primary CS rates in China. Although relatively few women with TOLAC experience serious complications, there is still concern among patients and their clinicians. Few prediction models have been developed to forecast the probability of successful TOLAC in China, although multiple screening tools have been developed in other countries. The aim of the present study was to determine the factors associated with successful TOLAC in Chinese hospitals and to develop a nomogram based on the selected variables to predict the likelihood of successful TOLAC among women after a previous CS.

**MATERIALS AND METHODS**

**Study population**

This was a retrospective cohort study conducted between January 2011 and December 2017 in two secondary hospitals (Tangxia Hospital in Dongguan city and Longhua District Central Hospital in Shenzhen city) in Guangdong Province, China. Hospitals in China are classified as primary, secondary or tertiary institutions according to the ability to provide medical care, medical education and conduct medical research. TOLAC has been practiced in the two centres for decades. Inclusion criteria were as follows: pregnant women with singleton fetus, age ≥18 years, had a history of a previous CS and scheduled for TOLAC. Patients with any of the following were excluded from the study: preterm labour (gestational age <37 weeks), two or more previous CS, contradictions for vaginal birth, congenital fetal anomalies, history of other uterine incision such as myomectomy, and incomplete medical records. This study received approval from institutional review boards of the two participating hospitals. Informed consent was not obtained as this was a retrospective cohort study.

**Data collection**

Data on demographic and obstetric characteristics, as well as, data on delivery outcomes and delivery complications were retrospectively abstracted from computerised medical records by clinical staff. The data collected at baseline included maternal age, education level, prepregnancy body mass index (BMI), gestational age, parity, history of abortion, history of vaginal delivery, time from previous delivery, medical history (diabetes or pregestational diabetes, hypertension), estimated birth weight, recurrence of previous caesarean indications and onset of labour. In addition, information from childbirth was also collected, including oxytocin augmentation, analgesic administration, rupture of membranes and cervix Bishop score. Common ultrasound biometric measurements, including biparietal diameter, head circumference, abdominal circumference, femur length and humerus length, were used to estimate fetal birth weight based on WHO fetal growth charts. Those pregnant women with delayed pregnancy, prolonged pregnancy, gestational diabetes mellitus, gestational hypertension, premature rupture of membrane or women who made a request for labour induction were in consideration for receiving oxytocin augmentation. Women with a cervix Bishop score ≥5 or having premature rupture of membrane were directly induced with oxytocin, otherwise a single or double balloon catheter was used to promote cervical ripening followed by induction of labour with oxytocin.

The primary outcome was success rate of TOLAC (vaginal birth). Secondary outcomes were maternal and neonatal adverse events, including uterine rupture, maternal infection, blood transfusion, maternal death, Apgar score <7, neonatal intensive care unit (NICU) admission and neonatal death.

**Statistical analysis**

Analyses were carried out using SAS software V.9.4. Of the eligible participants, 80% were randomly assigned to the training set, while the remaining 20% were assigned to the external validation set. Categorical variables were reported as frequency (percentage) and the differences between groups were compared using the χ² test or Fisher’s exact test, as appropriate.

In the training cohort, univariate and multivariate logistic regression models were used to determine the factors associated with successful TOLAC, and the associations between related factors and successful TOLAC were presented as ORs with corresponding 95% CIs. Variables found to be significant in univariate analysis were included in a stepwise multivariate logistic regression model with entry criteria of p<0.20 and exit criteria of p>0.05. A nomogram was constructed based on the results of the multivariate logistic regression analysis and the selected variables were incorporated in the nomogram to predict the probability of successful TOLAC. The model performance was evaluated using the C statistic, which is equivalent to the receiver operating characteristic curve (ROC) area under the receiver operating characteristic curve (AUC). The calibration performance (agreement between observed outcome frequencies and predicted...
probabilities of successful TOLAC) was assessed by Hosmer-Lemeshow $\chi^2$ statistics.

For external validation, the nomogram was then applied to the validation cohort, and the discrimination and calibration performance of the model was also analysed. The optional cut-off point of the nomogram was determined

by the area under the ROC and Youden index. In addition, sensitivity, specificity, accuracy rate, positive predictive value (PPV), negative predictive value (NPV) and 95% CI for predicting successful TOLAC were calculated. All tests were two-sided and $p<0.05$ was considered statistically significant for all analyses.

Table 1  Women's characteristics of training and validation cohorts

| Characteristics                        | Training cohort (N=1491) | Validation cohort (N=373) | P value |
|---------------------------------------|--------------------------|---------------------------|---------|
| Research centre                       | Hospital in Shenzhen     | 898 (60.2)                | 220 (59.0) | 0.66 |
| Age (years)                           | <35                      | 1311 (87.9)               | 340 (91.1) | 0.08 |
| 35                                     | 180 (12.1)               | 33 (8.9)                  |         |
| Education (years)                     | <9                       | 847 (56.8)                | 219 (58.7) | 0.51 |
| 9                                     | 644 (43.2)               | 154 (41.3)                |         |
| Gestational age (weeks)               | ≥41                      | 209 (14.0)                | 55 (14.8) | 0.72 |
| <41                                   | 1282 (86.0)              | 318 (85.2)                |         |
| Parity                                | One previous delivery    | 1264 (84.8)               | 333 (89.3) | 0.03 |
| ≥2 previous deliveries                | 227 (15.2)               | 40 (10.7)                 |         |
| Number of abortions                   | <3                       | 1405 (94.2)               | 353 (94.6) | 0.76 |
| 3                                     | 86 (5.8)                 | 20 (5.4)                  |         |
| History of vaginal delivery           | No                       | 1266 (84.9)               | 334 (89.5) | 0.02 |
| Yes                                   | 225 (15.1)               | 39 (10.5)                 |         |
| Success of TOLAC                      | No                       | 142 (9.5)                 | 36 (9.7) | 0.94 |
| Yes                                   | 1349 (90.5)              | 337 (90.3)                |         |
| Time from previous delivery (years)   | ≤2                       | 61 (4.1)                  | 10 (2.7) | 0.20 |
| >2                                    | 1430 (95.9)              | 363 (97.3)                |         |
| BMI (kg/m²)                           | ≥30                      | 150 (10.1)                | 32 (8.6) | 0.39 |
| <30                                   | 1341 (89.9)              | 341 (91.4)                |         |
| Diabetes or pregestational diabetes   | Yes                      | 126 (8.5)                 | 30 (8.0) | 0.80 |
| No                                    | 1365 (91.5)              | 343 (92.0)                |         |
| Hypertension                          | Yes                      | 23 (1.5)                  | 7 (1.9) | 0.65 |
| No                                    | 1468 (98.5)              | 366 (98.1)                |         |
| Estimated birth weight (kg)           | ≥4                       | 46 (3.1)                  | 14 (3.7) | 0.51 |
| <4                                    | 1445 (96.9)              | 359 (96.3)                |         |
| Previous caesarean indications        | Recurrent                | 3 (0.2)                   | 1 (0.3) | 0.80 |
| Non-recurrent                         | 1488 (99.8)              | 372 (99.7)                |         |
| Onset of labour                       | Induced                  | 291 (19.5)                | 66 (17.7) | 0.42 |
| Spontaneous                           | 1200 (80.5)              | 307 (82.3)                |         |
| Oxytocin augmentation                 | Yes                      | 294 (19.7)                | 69 (18.5) | 0.59 |
| No                                    | 1197 (80.3)              | 304 (81.5)                |         |
| Analgesic                             | Yes                      | 4 (0.3)                   | 0 (0.0) | 0.32 |
| No                                    | 1487 (99.7)              | 373 (100.0)               |         |
| Cervix Bishop score                   | <5                       | 660 (44.3)                | 165 (44.2) | 0.99 |
| ≥5                                    | 831 (55.7)               | 208 (55.8)                |         |
| Ruptured of membranes                 | Yes                      | 297 (19.9)                | 72 (19.3) | 0.79 |
| No                                    | 1194 (80.1)              | 301 (80.7)                |         |

BMI, body mass index; TOLAC, trial of labour after caesarean delivery.
### Patient and public involvement

Patients were not involved in study design, recruitment or implementation. Major findings from the study will be disseminated through international conference posters and social media.

### RESULTS

During the study period, 2006 women with a history of previous CS who planned for TOLAC were included in the study: 1175 in Shenzhen Longhua District Central Hospital (58.6%) and 831 in Dongguan Tangxia Hospital (41.4%). The majority of participants were <35 years of age (88.7%) and had one previous delivery (86.5%). More than one-tenth (N=267, 13.3%) of participants reported a history of vaginal delivery. Less than one-tenth (N=171, 8.5%) women had diabetes or pregestational diabetes, while 35 (1.7%) had hypertension. The demographic and clinical characteristics of women in training

| Characteristics                               | Failure of TOLAC (N=142) | Success of TOLAC (N=1349) | OR (95% CI) |
|-----------------------------------------------|--------------------------|----------------------------|-------------|
| **Age (years)**                               |                          |                            |             |
| <35                                           | 125 (9.5)                | 1186 (90.5)                | 1.0         |
| ³5                                            | 17 (9.4)                 | 163 (90.6)                 | 1.01 (0.59 to 1.72) |
| **Education (years)**                         |                          |                            |             |
| <9                                            | 73 (8.6)                 | 775 (91.4)                 | 1.0         |
| ³9                                            | 69 (10.7)                | 574 (89.3)                 | 0.78 (0.55 to 1.11) |
| **Gestational age (weeks)**                   |                          |                            |             |
| ≥41                                           | 30 (14.4)                | 179 (86.6)                 | 1.0         |
| <41                                           | 112 (8.7)                | 1170 (91.3)                | 1.75 (1.14 to 2.70) |
| **Parity**                                    |                          |                            |             |
| One previous delivery                         | 130 (10.3)               | 1134 (89.7)                | 1.0         |
| ≥2 previous deliveries                        | 12 (5.3)                 | 215 (94.7)                 | 2.05 (1.12 to 3.78) |
| **Number of abortions**                       |                          |                            |             |
| <3                                            | 133 (9.5)                | 1272 (90.5)                | 1.0         |
| ³3                                            | 9 (10.5)                 | 77 (89.5)                  | 0.90 (0.44 to 1.83) |
| **History of vaginal delivery**               |                          |                            |             |
| No                                            | 130 (10.3)               | 1136 (89.7)                | 1.0         |
| Yes                                           | 12 (5.3)                 | 213 (94.7)                 | 2.03 (1.11 to 3.74) |
| **Time from previous delivery (years)**       |                          |                            |             |
| ≤2                                            | 4 (6.6)                  | 57 (93.4)                  | 1.0         |
| >2                                            | 138 (9.6)                | 1292 (90.4)                | 0.66 (0.24 to 1.84) |
| **BMI (kg/m²)**                               |                          |                            |             |
| ≥30                                           | 25 (16.7)                | 125 (83.3)                 | 1.0         |
| <30                                           | 117 (8.7)                | 1224 (91.3)                | 2.09 (1.31 to 3.35) |
| **Diabetes or pregestational diabetes**       |                          |                            |             |
| Yes                                           | 12 (9.5)                 | 114 (90.5)                 | 1.0         |
| No                                            | 130 (9.5)                | 1235 (90.5)                | 1.00 (0.54 to 1.86) |
| **Hypertension**                              |                          |                            |             |
| Yes                                           | 2 (8.7)                  | 21 (91.3)                  | 1.0         |
| No                                            | 140 (9.5)                | 1328 (90.5)                | 0.90 (0.21 to 3.89) |
| **Estimated birth weight (kg)**               |                          |                            |             |
| ≥4                                            | 17 (37.0)                | 29 (63.0)                  | 1.0         |
| <4                                            | 125 (8.6)                | 1320 (91.4)                | 6.19 (3.31 to 11.58) |
| **Previous caesarean indications**            |                          |                            |             |
| Recurrent                                     | 1 (33.3)                 | 2 (66.7)                   | 1.0         |
| Non-recurrent                                 | 141 (9.5)                | 1347 (90.5)                | 4.78 (0.43 to 53.02) |
| **Onset of labour**                           |                          |                            |             |
| Induced                                       | 65 (22.3)                | 226 (77.7)                 | 1.0         |
| Spontaneous                                   | 77 (6.4)                 | 1123 (93.6)                | 4.20 (2.93 to 6.01) |
| **Oxytocin augmentation**                     |                          |                            |             |
| Yes                                           | 68 (23.1)                | 226 (76.9)                 | 1.0         |
| No                                            | 74 (6.2)                 | 1123 (93.8)                | 4.57 (3.19 to 6.54) |
| **Analgesic**                                 |                          |                            |             |
| Yes                                           | 0 (0.0)                  | 4 (100.0)                  | 1.0         |
| No                                            | 142 (9.6)                | 1345 (90.5)                | <0.01 (<0.01 to >99.9) |
| **Cervix Bishop score**                       |                          |                            |             |
| <5                                            | 105 (15.9)               | 555 (84.1)                 | 1.0         |
| ≥5                                            | 37 (4.5)                 | 794 (95.5)                 | 4.06 (2.75 to 6.00) |
| **Rupture of membranes**                      |                          |                            |             |
| Yes                                           | 44 (14.8)                | 253 (85.2)                 | 1.0         |
| No                                            | 98 (8.2)                 | 1096 (91.8)                | 1.95 (1.33 to 2.85) |

BMI, body mass index; TOLAC, trial of labour after caesarean delivery.
cohort (N=1604, 80%) and the validation cohort (N=402, 20%) are shown in Table 1. Comparison of the baseline data indicated that the training and validation groups showed no significant differences.

Of the women who planned for TOLAC, 1686 (84.0%) had a successful TOLAC, while 320 (16.0%) had a repeated CS. The reasons for failed TOLAC were request of repeated CS by patients or their family members (142, 44.4%), followed by fetal distress (63, 19.7%), abnormal stage of labour (59, 18.4%), failed induction of labour (35, 10.9%) and others (21, 6.6%). There were six (0.3%) women with uterine rupture, six (0.3%) with blood transfusion, seven (0.3%) with maternal infection and one (0.05%) with hysterectomy, but fortunately no maternal deaths were reported during the study period. Five-minute Apgar scores were 10 in most newborns (N=1987, 99.1%), but <7 in three newborns (2 with 0 score and 1 with 2 score). There were 21 (1.0%) cases of neonatal asphyxia (7 cases with repeat CS), 128 (6.4%) cases of NICU admission and 2 (0.1%) neonatal deaths (1 case with repeat CS) recorded.

Participants with repeated CS requested by themselves or their family members rather than medical indications were excluded when developing the prediction model. The demographic and clinical characteristics of women in the training cohort (N=1491, 80%) and the validation cohort (N=373, 20%) are shown in Table 1. Comparison of the baseline data indicated that the training and validation groups showed no significant differences, with the exception of parity (p=0.03) and history of vaginal delivery (p=0.02).

Table 2 presents the univariate relationships between successful TOLAC and demographic and clinical characteristics of women in the training cohort. Women with <41 weeks of gestational age, ≥2 previous deliveries, with a history of vaginal delivery, lower BMI (<30 kg/m²), lower estimated birth weight and women with spontaneous onset of labour were significantly more likely to achieve success of TOLAC. In addition, in the delivery process, women with a cervix Bishop score ≥5 had a higher probability of successful TOLAC, whereas women with rupture

![Figure 1](http://bmjopen.bmj.com/)  Nomogram for predicting success rate of TOLAC. BMI, body mass index; TOLAC, trial of labour after caesarean delivery.
of membranes and women using oxytocin augmentation were significantly less likely to achieve success of TOLAC.

The following variables remained statistically significant in the multivariate logistic regression model for the training cohort (table 3): gestational age <41 (OR=1.69), history of vaginal delivery (OR=1.72), estimated birth weight (OR=5.33), BMI (OR=1.81), spontaneous onset of labour (OR=2.50), cervix Bishop score ≥5 (OR=3.39) and rupture of membranes (OR=2.50). The nomogram prediction model of successful TOLAC, which included these independent variables, was developed based on multivariate logistic regression analysis (figure 1).

AUC in the prediction model was 0.77 (95% CI 0.73 to 0.81), and the Hosmer-Lemeshow test result was not significant (p=0.82). The AUC in the external validation model is 0.70 (95% CI 0.60 to 0.79) and the Brier score is 0.08, suggesting that the nomogram prediction model has moderate discrimination (figures 2 and 3).

Table 4 shows the success rate of TOLAC in the validation cohort according to the nomogram prediction model. According to the distribution at each probability of TOLAC success, two groups were identified: a high-probability TOLAC success group (TOLAC success probability ≥0.85, 78.6% of the validation cohort and TOLAC success rate 92.8%) and low-probability TOLAC success group (TOLAC success probability <0.85, 21.4% of the validation cohort and TOLAC success rate 81.3%). With a cut-off of 0.85, a sensitivity of 80.7% (95% CI 76.5% to 84.9%), specificity of 41.7% (95% CI 25.6% to 57.8%), PPV 92.8% (95% CI 89.9% to 95.8%), NPV 18.8% (95% CI 10.2% to 27.3%) and a correctly classified proportion of 76.9% (95% CI 72.7% to 81.2%) were found.

**DISCUSSION**

There are few studies reporting the rate of TOLAC in China due to the former one-child policy. The results from the current study indicate that the success rate of TOLAC (84.0%) was relatively high with relatively low incidence of serious complications (0.3% uterine rupture), which implies the potential benefit of TOLAC among women with a uterine scar in China. We have developed and validated a simple nomogram prediction model based on common antenatal predictors, which are independently associated with successful TOLAC, including gestational age, history of vaginal delivery, estimated birth weight, BMI, spontaneous onset of labour, cervix Bishop score and rupture of membranes.

Success rates of TOLAC reached up to 84% in the current study. However, repeat CSs are the preferred mode of delivery for women with a previous history of CS in China. Negative attitudes regarding TOLAC from clinical staffs are rare but serious complications from TOLAC (especially potential uterine rupture) and women’s fear are the main obstacles for conducting TOLAC in China. Realising the high chance of VBAC success, some women who planned a repeat CS may instead decide to pursue...
TOLAC as their first choice, which can result in a significant reduction in the number of CS deliveries. Considering both the high CS rates and newly adopted two-child policy in 2015, TOLAC is an important public health strategy in China and TOLAC should be widely recommended for the appropriately selected pregnant women with previous CS.

As far as we know, this is the largest study to date to develop a nomogram model for predicting successful TOLAC among women with a uterine scar in China. The model has best performance at the high estimated probability of successful TOLAC for about 95% of women with an estimated ≥90% having a vaginal birth. The proposed prediction model could be a clinically important tool as it can be used to identify women with greater chance of a successful TOLAC. Those women with an estimated high probability of successful TOLAC could be counselled and informed that pursuing a TOLAC is worthwhile since a successful TOLAC is associated with a shorter postpartum recovery time with fewer complications.

Similar factors associated with a successful TOLAC have also been found by other studies. Women with <41 weeks of gestational age were more likely to have successful TOLAC. A cohort study conducted in Thailand also showed that late gestational age was significantly associated with a higher failure rate.20 Consistent with previous reports,20 21 BMI is another predictor incorporated into our prediction model. Previous studies have identified high maternal BMI to be significantly associated with a higher risk of failed TOLAC.20 21 van der Merwe et al found that obese patients were almost 50% less likely to have a successful VBAC (OR 0.47, 95% CI 0.24 to 0.91).22 Women with prior vaginal birth were three times more likely to achieve success of TOLAC. Similar findings regarding a history of vaginal births have been reported by numerous studies.20 25 As was also concluded in the study by Haumont et al, Bishop’s score was an important predictor of successful VBAC.16 24 Kalok et al demonstrated that a modified Bishop score ≥6 was independently associated with successful VBAC after adjusting for confounding variables.23 Various studies have been conducted to evaluate the influence of neonatal birth weight on the success of TOLAC, and have found consistent results that lower estimated birth weight have a greater chance of having a successful VBAC than their counterparts.20 As was seen in studies conducted by Krut et al, women with spontaneous onset of labour were more likely to have successful VBAC.25 The rate of repeat CS was higher in women undergoing induction of labour (38% vs 20.2%; p<0.001).25

This study was subject to several limitations. First, a high percentage of women (44.4%, 142/320) made a request of repeated CS by themselves or their family members among all participants with repeated CS. Although those participants were excluded when developing the prediction model, the potential impact on the model cannot be neglected; however, this is a subject, which could provide an important direction for future research by exploring related factors and establishing new measures to encourage persistent TOLAC. Second, missing data are unavoidable due to the retrospective nature of the study; however, the nursing staff were trained in abstracting data from high-quality electronic medical records. Third, our obstetric population is from two secondary hospitals in Guangdong Province, which may not represent the population in China and limit the generalisability to more heterogeneous populations. The sample size is too limited to estimate maternal and neonatal adverse events which are the secondary outcomes in our study. In addition, the development of the prediction model was based on a cohort of women who attempted TOLAC, while some women who were good candidates for TOLAC chose an elective repeat caesarean delivery.

CONCLUSIONS
A relatively high success rate of TOLAC (84.0%) was established in women with a previous history of CS, which implies that TOLAC is a potential important strategy for decreasing CS rates in China. The nomogram predicting success of TOLAC generated in the study could be a potential tool for more directed TOLAC counselling for women with a primary caesarean delivery. Further prospective validation studies with larger sample sizes and in the general population should be undertaken to confirm efficacy before pervasive application among Chinese women and to estimate maternal and neonatal adverse events of TOLAC.

Acknowledgements We wish to thank the project staffs for their efforts in the study. We also wish to thank the subjects for their participation.

Contributors YXL, ZB, D-JL, H-BW, Y-FW, S-RH and Y-JJ contributed to the development of the study protocol. YXL, ZB, S-RH and Y-JJ were the principal investigators and managed the protocol. H-BW and KHR were responsible for data management and statistical analysis. YXL, H-BW, KHR and Y-FW were involved in reviewing the manuscript. All authors read and approved the final manuscript.

Funding This research was funded by Science and Technology Planning Project of Guangdong Province in 2017 (2017A020214007) and Society Technology Development Project of Dongguan City in 2016 (2016108101004).

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Original data are available on request by emailing the corresponding author who will delete the personal identification information.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

REFERENCES
1. Betran AP, Ye J, Moller AB, et al. The Increasing Trend in Caesarean Section Rates: Global, Regional and National Estimates: 1990-2014. PLoS One 2016;11:e0148343.
2. Villar J, Carroli G, Zavaleta N, et al. Maternal and neonatal individual risks and benefits associated with caesarean delivery: multicentre prospective study. *BMJ* 2007;335:1025.

3. Lumbiganon P, Laopaiboon M, Gülmezoglu AM, et al. Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007-08. *Lancet* 2010;375:490–9.

4. Li HT, Luo S, Trasande L, et al. Geographic Variations and Temporal Trends in Cesarean Delivery Rates in China, 2008-2014. *JAMA* 2017;317:69–76.

5. Hellenstein S, Feldman R, Duan T. China’s 50% caesarean delivery rate: is it too high? *BJOG* 2015;122:160–4.

6. Liu X, Lynch CD, Cheng WW, et al. Lowering the high rate of caesarean delivery in China: an experience from Shanghai. *BJOG* 2016;123:1620–8.

7. Runmel M, Terence T L, Yonghu S, et al. Practice audits to reduce caesareans in a tertiary referral hospital in south-western China. *Bull World Health Organ* 2012;90:488–94.

8. Liang J, Mu Y, Li X, et al. Relaxation of the one child policy and trends in caesarean section rates and birth outcomes in China between 2012 and 2016: observational study of nearly seven million health facility births. *BMJ* 2018;360:k817.

9. Dodd JM, Crowther CA, Huertas E, et al. Planned elective repeat caesarean section versus planned vaginal birth for women with a previous caesarean birth. *Cochrane Database Syst Rev* 2013;CD004224:47.

10. Marshall NE, Fu R, Guise JM. Impact of multiple cesarean deliveries on maternal morbidity: a systematic review. *Am J Obstet Gynecol* 2011;205:262.e1–262.e8.

11. Oboro V, Adewumi A, Ande A, et al. Morbidity associated with failed vaginal birth after cesarean section. *Acta Obstet Gynecol Scand* 2010;89:1229–32.

12. Quinlan JD, Murphy NJ. Cesarean delivery: counseling issues and complication management. *Am Fam Physician* 2015;91:178–84.

13. Patel RM, Jain L. Delivery after previous cesarean: short-term perinatal outcomes. *Semin Perinatol* 2010;34:272–80.

14. Senthines L, Vayssière C, Beucher G, et al. Delivery for women with a previous cesarean: guidelines for clinical practice from the French College of Gynecologists and Obstetricians (CNGOF). *Eur J Obstet Gynecol Reprod Biol* 2013;170:25–32.

15. Ma RM, Duan T, Lao TT. VBAC should be encouraged as a means to reduce the caesarean section rate in China: FOR: VBAC reduces not only the caesarean section rate but also other associated issues. *BJOG* 2016;123 Suppl 3(Suppl 3):10.

16. Haumonte JB, Raylet M, Christophe M, et al. French validation and adaptation of the Grobman nomogram for prediction of vaginal birth after cesarean delivery. *J Gynecol Obstet Hum Reprod* 2018;47:127–31.

17. Metz TD, Stoddard GJ, Henry E, et al. Simple, validated vaginal birth after cesarean delivery prediction model for use at the time of admission. *Obstet Gynecol* 2013;122:571–8.

18. Kiserud T, Piaggio G, Carroli G, et al. The World Health Organization Fetal Growth Charts: A Multinational Longitudinal Study of Ultrasound Biometric Measurements and Estimated Fetal Weight. *PLoS Med* 2017;14:e1002220.

19. Minsart AF, Liu H, Moffett S, et al. Vaginal birth after caesarean delivery in Chinese women and Western immigrants in Shanghai. *J Obstet Gynaecol Can* 2017;39:446–8.

20. Thapsamuthdechakorn A, Sekararitthi R, Tongsong T. Factors Associated with Successful Trial of Labor after Cesarean Section: A Retrospective Cohort Study. *J Pregnancy* 2018;2018:1–5.

21. Abdelazim IA, Elbiaa AA, Al-Kadi M, et al. Maternal and obstetrical factors associated with a successful trial of vaginal birth after cesarean section. *J Turk Ger Gynecol Assoc* 2014;15:245–9.

22. van der Merwe AM, Thompson JM, Ekeroma AJ. Factors affecting vaginal birth after cesarean section at Middlemore Hospital, Auckland, New Zealand. *N Z Med J* 2013;126:49–57.

23. Kalok A, Zabil SA, Jamil MA, et al. Antenatal scoring system in predicting the success of planned vaginal birth following one previous caesarean section. *J Obstet Gynaecol Can* 2018;38:339–43.

24. Rijal P. Identification of risk factors for cesarean delivery following induction of labour. *J Nepal Health Res Counc* 2014;12:73–7.

25. Kruit H, Wilkman H, Tekay A, et al. Induction of labor by Foley catheter compared with spontaneous onset of labor after previous cesarean section: a cohort study. *J Perinatol* 2017;37:787–92.