

# Risk Scoring System for the Prediction of Postpartum Blood Loss over 300 mL at Chiang Rai Regional Hospital

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## ABSTRACT

**Objective:** To develop an assessment tool for the prediction of postpartum blood loss over 300 mL and 500 mL after vaginal delivery.

**Methods:** A retrospective case-control study of 504 (72 cases: 432 controls) pregnant women with gestational age of 28 weeks or above who underwent vaginal delivery at Chiang Rai Regional Hospital between 1<sup>st</sup> October 2015 and 30<sup>th</sup> September 2016 was conducted. The predictors were selected using “Sign OK” selection. The risk scoring system was developed according to the seven steps of clinical prediction model development of Steyerberg.

**Results:** This form included eight predictors: maternal age of 35 years old or above, gestational age over 40 weeks, being nulliparous, history of curettage in prior pregnancy, gestational hypertensive disorder, hemoglobin level equal to or less than 10 g/dL, fundal height of 38 centimeters or above, and the use of pethidine for pain relief in the 1st stage of labor. The sensitivity of predicting postpartum blood loss over 300 mL after vaginal delivery by the risk scoring system was 80.7%, specificity of 60.8%, and the ROC curve was equal to 0.71 at the optimal cut-off score of four points or above. To predict the postpartum blood loss of 500 mL or above after vaginal delivery, the sensitivity was 88.1%, specificity of 54.6%, and the ROC curve was equal to 0.71 at the optimal cut-off score of three points or above.

**Conclusion:** This form had an acceptable performance in predicting postpartum blood loss over 300 mL and 500 mL at the optimal cut-off scores of four points or above and three points or above, respectively.

**Keywords:** Risk score; postpartum blood loss; vaginal delivery; Chiang Rai Regional Hospital (Siriraj Med J 2019;71: 110-116)

## INTRODUCTION

In Thailand, the incidence of postpartum hemorrhage (PPH) was 2.30%, 2.37%, 2.44%, 2.40%, 2.39%, 2.54%, and 2.65%, from 2009 to 2015.<sup>1</sup> Similarly, in Chiang Rai province, the incidence of PPH increases by 1.12%, 1.15%, 1.34%, and 2.07%; the pregnant women who had PPH and hysterectomy were 3.05%, 4.58%, 1.82%, and

1.23%, from 2012 to 2015.<sup>2</sup> Moreover, in fiscal year 2014 and 2015, the pregnant women who died from PPH numbered 2 cases, and 1 case, respectively.<sup>2</sup>

For early diagnosis of PPH, the healthcare providers in Chiang Rai Regional Hospital used a collector bag to measure postpartum blood loss over 300 mL after vaginal delivery following the LABOR strategy. Similarly,

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many settings used collector bags as an effective tool for measuring postpartum blood loss after vaginal delivery in the third stage of labor.<sup>3-6</sup> However, the risk of PPH could be assessed in the antepartum or the first stage of labor as indicated in the study of Sittiparn and Siwadune that identified the risk factors associated with PPH and incorporated those risk factors into a risk score to predict PPH in normal labor. It could predict PPH in normal labor with sensitivity of 81.30% and specificity of 50.80% at the optimal cut-off score of four points or above.<sup>7</sup>

The purpose of this study was to set a tool for use in the first stage of labor for the early detection of postpartum blood loss over 300 mL after vaginal delivery compared with using a collector bag for measuring postpartum blood loss after vaginal delivery in the third stage of labor. This study was part of the risk prediction model development for postpartum hemorrhage at the hospitals in Chiang Rai province.

## MATERIALS AND METHODS

Before the investigation of the retrospective case-control study, twenty articles from PubMed, Science Direct, Pro Quest, and EBSCO host related to risk factors for PPH in studies from 2005 to 2017, in Thailand and globally, were analyzed by MedCalc Version 18.2.1 (Free Trial Version 15 days)<sup>12</sup> to create the data collection form. This study was approved by the Khon Kaen University Ethics Committee (HE601234) and the Chiang Rai Regional Hospital Ethics Committee on 21<sup>st</sup> July 2017.

### Study design and population

The retrospective case-control study included 2,957 pregnant women with gestational age of 28 weeks or above who underwent vaginal delivery between 1<sup>st</sup> October 2015 and 30<sup>th</sup> September 2016 at Chiang Rai Regional Hospital. Five hundred and four of them who had blood loss in the range of 50-3,000 ml were enrolled in this study. The case study included 72 pregnant women with PPH and the control was 432 women with no PPH. The control groups were selected on maternal age, gestational age, gravida, and parity similar to the cases. The ratio of case : control was 1 : 6.

### Identification of risk factors for postpartum blood loss after vaginal delivery

The following seven steps for development and an ABCD for validation of the clinical prediction model<sup>8,9</sup> include:

Step 1: problem definition and data inspection; step 2: coding of predictors, candidate risk factors for postpartum blood loss of 500 mL or above after vaginal

delivery were identified from the secondary analysis of twenty articles from PubMed, Science Direct, Pro Quest, and EBSCO host related to the risk factors for PPH in studies from 2005 to 2017, in Thailand and globally. They categorized that individual factors, obstetric factors, and placental factors followed the 4T's causes of PPH<sup>10,11</sup> to create the data collection form.

Step 3: model specification; step 4: model estimation, the data collection form created in steps 1-2 was used in the investigation of the retrospective case-control study of 72 pregnant women with PPH and 432 pregnant women with no PPH. They had gestational age of 28 weeks or above and underwent vaginal delivery between 1<sup>st</sup> October 2015 and 30<sup>th</sup> September 2016 at Chiang Rai Regional Hospital. First, the samples were categorized to 93 pregnant women with postpartum blood loss over 300 mL and 411 pregnant women with postpartum blood loss equal to or less than 300 mL. Second, the association between the factors and postpartum blood loss over 300 mL was determined by univariate logistic regression. Then, the factors associated with blood loss over 300 mL, statically significant at a p-value < 0.05, were selected for analysis by multiple logistic regression. There were eight predictors for postpartum blood loss over 300 mL after vaginal delivery. Lastly, these predictors were confirmed by experts' opinion agreement, namely two obstetricians, three registered nurses, and five nursing instructors. This predictor identification method is called "Sign OK" selection and included statistical analysis and experts' opinion agreement.

Step 5: model performance; step 6: model validity, eight predictors approved by "Sign OK" selection were incorporated into a risk scoring system for the prediction of postpartum blood loss over 300 mL and 500 mL after vaginal delivery, with calculation of sensitivity, specificity, and a receiver operating characteristic (ROC) curve by the bootstrap resampling technique. However, this step had only 415 samples for data analysis (missing data 89 records).

Step 7: model presentation; the model was presented in the Postpartum Hemorrhage Risk Score Record Form.

### Data analysis

Data were analyzed using MedCalc Version 18.2.1 (Free Trial Version 15 days)<sup>12</sup> in steps 1-3 and IBM SPSS software version 22 in steps 4-6. The variables that were significantly associated with postpartum blood loss over 300 mL after vaginal delivery according to the Chi-square test were entered into logistic regression model and used to calculate the index of item objective congruence (IOC). A risk scoring system was developed from the sum of

each significant adjusted odds ratio value. The ROC curve was calculated to determine the optimal score for the prediction of postpartum blood loss over 300 mL and 500 mL after vaginal delivery. Sensitivity and specificity with an associated 95% confidence interval (CI) of each cut-off point were presented. The statistically significant difference was set at a p-value < 0.05.

## RESULTS

In steps 1-2, candidate risk factors for postpartum blood loss of 500 mL or above after vaginal delivery from hospitalization at the labor room unit to the first stage of labor were as follows: individual factors as teenage pregnancy, advanced age pregnancy, body mass index (OR > 1.0-1.5), and hemoglobin level equal to or less than 10 g/dL (OR > 2.0); obstetric factors as nulliparous, primiparous, grand-multiparous, pre-term gestational age, gestational diabetes meatus (OR > 1.0-1.5), post-term gestation age, gestational hypertensive disorder, abnormal presentation (OR > 1.5-2.0), prior PPH, previous abortion, and large gestational age / multiple pregnancy / fibroid / hydramnios (OR > 2.0); placental factors as placenta previa, placenta abruption, and placenta accrete (OR > 2.0); complications and procedures of the first stage of labor as induction or augmentation of labor, use of anesthetic drugs (OR > 1.0-1.5), and chorioamnionitis (OR > 1.5-2.0) (data not shown).

In steps 3 – 4, eight predictors for postpartum blood

loss over 300 mL after vaginal delivery were selected using “Sign OK” selection as being maternal age of 35 years old or above, hemoglobin level equal to or less than 10 g/dL, being nulliparous, gestational age over 40 weeks, curettage in prior pregnancy, gestational hypertensive disorder, fundal height of 38 centimeters or above, and having received pethidine for pain relief in the first stage of labor. In addition, their adjusted odds ratio was transformed to a score that is presented in Table 1.

In steps 5-6, the total of the risk score ranged from 0 to 30. The sensitivity and specificity with an associated 95% CI for the risk score at different cut-off values are presented in Tables 2 and 3. The ROC curve of a risk score for the prediction of postpartum blood loss over 300 mL after vaginal delivery demonstrated overall an area under the curve (AUC) of 0.71 (95% CI 0.65 to 0.77) (Table 2; Fig 1). The cut-off score was three points or greater, which had a sensitivity of 85.5% and specificity of 56.0%. In addition, the cut-off score of four points or greater had a sensitivity of 80.7% and specificity of 60.8%. On the other hand, the ROC curve of the risk score for the prediction of postpartum blood loss of 500 mL or above after vaginal delivery demonstrated overall an AUC of 0.71 (95% CI 0.65 to 0.77) (Table 3; Fig 2). The cut-off score was three points or greater, which had a sensitivity of 88.1% and specificity of 54.6%.

In step 7, the model was presented in the Postpartum Hemorrhage Risk Score Record Form (Fig 3).

**TABLE 1.** Risk factors associated with postpartum blood loss over 300 mL after vaginal delivery were identified by “Sign OK” selection.

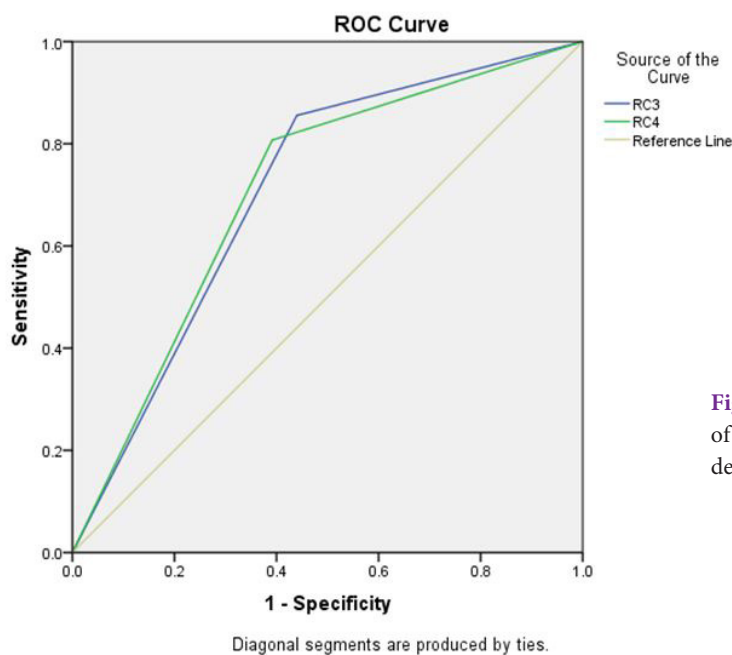
| Risk factors                                                                 | Statistical analysis<br>(multiple logistic regression) | Expert’s opinion<br>agreement | Score |
|------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------|-------|
|                                                                              | Adjusted odds ratio<br>[95% CI], P-value               | Item objective<br>congruence  |       |
| Maternal age ≥ 35 years old                                                  | 3.33 [1.44 – 7.67], .005                               | 0.60                          | 3     |
| Hemoglobin ≤ 10 gram per deciliters                                          | 8.19 [3.05 – 22.00], <.001                             | 0.90                          | 8     |
| Nulliparous                                                                  | 2.42 [1.26 – 4.63], .008                               | 0.60                          | 2     |
| Gestational age >40 weeks                                                    | 2.25 [1.19 – 4.24], .012                               | 1.00                          | 2     |
| Curettage in prior pregnancy                                                 | 3.81 [1.58 – 9.22], .003                               | 1.00                          | 4     |
| Gestational hypertensive disorder                                            | 7.59 [2.49 – 23.08], <.001                             | 0.90                          | 7     |
| Fundal high ≥ 38 centimeters                                                 | 2.67 [1.29 – 5.35], .008                               | 0.80                          | 2     |
| Having received pethidine for relief pain<br>in the 1 <sup>st</sup> of labor | 2.11 [1.16 – 3.82], .014                               | 0.60                          | 2     |

Statistically significant at p-value <.05

**TABLE 2.** Performances of a risk score at different cut-off values for the prediction of postpartum blood loss over 300 mL after vaginal delivery.

| Cut-off value | Number of women with score at cut-off level | ROC curve | % sensitivity | % specificity | 95% CI      | P-value |
|---------------|---------------------------------------------|-----------|---------------|---------------|-------------|---------|
| 0             | 415                                         | 0.50      | 100.00        | NA            | 0.43 – 0.57 | 1.000   |
| 1             | 336                                         | 0.61      | 98.80         | 23.50         | 0.55 – 0.67 | .002    |
| 2             | 336                                         | 0.61      | 98.80         | 23.50         | 0.55 – 0.67 | .002    |
| 3             | 217                                         | 0.71      | 85.50         | 56.00         | 0.65 – 0.77 | <.001   |
| 4             | 197                                         | 0.71      | 80.70         | 60.80         | 0.65 – 0.77 | <.001   |
| 5             | 96                                          | 0.68      | 51.80         | 84.00         | 0.60 – 0.75 | <.001   |
| 6             | 85                                          | 0.67      | 47.00         | 86.10         | 0.60 – 0.74 | <.001   |
| 7             | 60                                          | 0.63      | 34.90         | 90.70         | 0.56 – 0.70 | <.001   |
| 8             | 50                                          | 0.64      | 33.70         | 93.40         | 0.56 – 0.71 | <.001   |
| 9             | 35                                          | 0.61      | 26.50         | 96.10         | 0.54 – 0.69 | .001    |
| 10            | 28                                          | 0.59      | 21.70         | 97.00         | 0.52 – 0.67 | .008    |
| 11            | 19                                          | 0.58      | 16.90         | 98.50         | 0.50 – 0.65 | .030    |
| 12            | 14                                          | 0.55      | 12.00         | 98.80         | 0.48 – 0.63 | .126    |
| 13            | 5                                           | 0.52      | 4.80          | 99.70         | 0.45 – 0.59 | .524    |
| 14            | 5                                           | 0.52      | 4.80          | 99.70         | 0.45 – 0.59 | .524    |
| 15            | 3                                           | 0.52      | 3.60          | 100.00        | 0.45 – 0.59 | .610    |
| 16            | 3                                           | 0.52      | 3.60          | 100.00        | 0.45 – 0.59 | .610    |
| 17            | 1                                           | 0.51      | 1.20          | 100.00        | 0.44 – 0.58 | .865    |
| 18            | 0                                           | 0.50      | NA            | 100.00        | 0.43 – 0.57 | 1.000   |

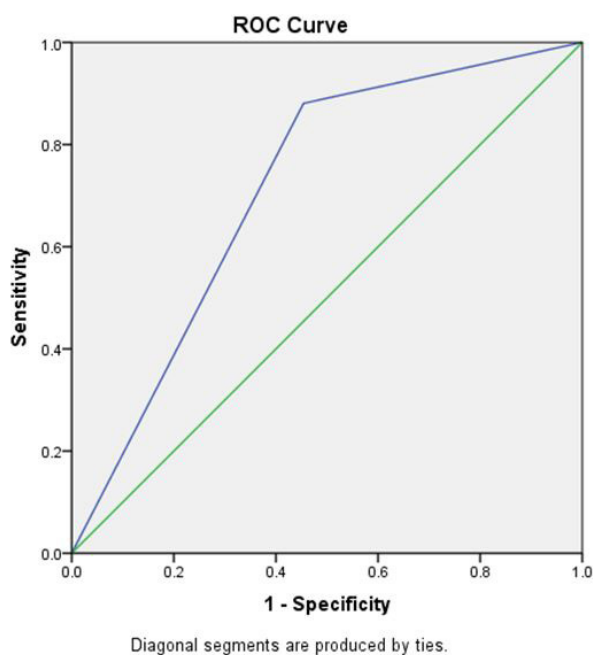
Abbreviations: ROC = receiver operating characteristic, NA = not analysis

**Fig 1.** The ROC curve of a risk score for the prediction of postpartum blood loss over 300 mL after vaginal delivery.

**TABLE 3.** Performances of a risk score at different cut-off values for the prediction of postpartum blood loss of 500 ml or above after vaginal delivery.

| Cut-off value | Number of women with score at cut-off level | ROC curve | % sensitivity | % specificity | 95% CI      | P-value |
|---------------|---------------------------------------------|-----------|---------------|---------------|-------------|---------|
| 0             | 415                                         | 0.50      | 100.00        | NA            | 0.42 – 0.58 | 1.000   |
| 1             | 336                                         | 0.61      | 98.50         | 22.40         | 0.54 – 0.67 | .007    |
| 2             | 336                                         | 0.61      | 98.50         | 22.40         | 0.54 – 0.67 | .007    |
| 3             | 217                                         | 0.71      | 88.10         | 54.60         | 0.65 – 0.77 | <.001   |
| 4             | 197                                         | 0.71      | 82.10         | 59.20         | 0.64 – 0.77 | <.001   |
| 5             | 96                                          | 0.69      | 55.20         | 83.00         | 0.62 – 0.77 | <.001   |
| 6             | 85                                          | 0.67      | 49.30         | 85.10         | 0.59 – 0.75 | <.001   |
| 7             | 60                                          | 0.64      | 37.30         | 89.90         | 0.56 – 0.72 | <.001   |
| 8             | 50                                          | 0.64      | 35.80         | 92.50         | 0.56 – 0.72 | <.001   |
| 9             | 35                                          | 0.63      | 29.90         | 95.70         | 0.55 – 0.71 | .001    |
| 10            | 28                                          | 0.60      | 23.90         | 96.60         | 0.52 – 0.68 | .008    |
| 11            | 19                                          | 0.58      | 17.90         | 98.00         | 0.50 – 0.66 | .039    |
| 12            | 14                                          | 0.55      | 11.90         | 98.30         | 0.47 – 0.63 | .185    |
| 13            | 5                                           | 0.53      | 6.00          | 99.70         | 0.45 – 0.61 | .461    |
| 14            | 5                                           | 0.53      | 6.00          | 99.70         | 0.45 – 0.61 | .461    |
| 15            | 3                                           | 0.52      | 4.50          | 100.00        | 0.45 – 0.60 | .562    |
| 16            | 3                                           | 0.52      | 4.50          | 100.00        | 0.45 – 0.60 | .562    |
| 17            | 1                                           | 0.51      | 1.50          | 100.00        | 0.43 – 0.58 | .847    |
| 18            | 0                                           | 0.50      | NA            | 100.00        | 0.42 – 0.58 | 1.000   |

**Abbreviations:** ROC = receiver operating characteristic, NA = not analysis

**Fig 2.** The ROC curve of a risk score for the prediction of postpartum blood loss of 500 mL or above after vaginal delivery.

| Postpartum Hemorrhage Risk Score Record Form                                 |       |           |                                                   |
|------------------------------------------------------------------------------|-------|-----------|---------------------------------------------------|
| Predictors                                                                   | Score | Pt. Score | Criteria                                          |
| 1. Age $\geq 35$ years old                                                   | 3     |           | [ ] Low risk<br>Score < 4<br>(EBL $\leq 300$ mL)  |
| 2. Gestational age > 40 weeks                                                | 2     |           |                                                   |
| 3. Nulliparous                                                               | 2     |           |                                                   |
| 4. Curettage in prior pregnancy                                              | 4     |           |                                                   |
| 5. Gestational hypertensive disorder                                         | 7     |           |                                                   |
| 6. Hemoglobin $\leq 10$ gram per deciliters                                  | 8     |           | [ ] High risk<br>Score $\geq 4$<br>(EBL > 300 mL) |
| 7. Fundal height $\geq 38$ centimeters                                       | 2     |           |                                                   |
| 8. Having received pethidine for pain relief in the 1 <sup>st</sup> of labor | 2     |           |                                                   |
| Total score                                                                  | 30    |           |                                                   |
| Type of delivery [ ] ND [ ] V/E [ ] F/E [ ] BA [ ] VBAC                      |       |           |                                                   |
| Total blood loss from collector bag _____ ml                                 |       |           |                                                   |
| Others medication for prevent or treat PPH _____.                            |       |           |                                                   |
| _____.                                                                       |       |           |                                                   |
| _____.                                                                       |       |           |                                                   |
| _____.                                                                       |       |           |                                                   |

**Fig 3.** The Postpartum Hemorrhage Risk Score Record Form for prediction of postpartum blood loss over 300 mL after vaginal delivery.

## DISCUSSION

Eight predictors incorporated into the Postpartum Hemorrhage Risk Score Record form are the risk factors of 4T's causing PPH. Being of maternal age of 35 years old or above, gestational age over 40 weeks, fundal height of 38 centimeters or above, and having received pethidine for pain relief in the first stage of labor may affect uterine atony, failure of contractions, and retraction of myometrial muscle fibers.<sup>10,11</sup> Curettage in prior pregnancy may affect retained placenta.<sup>10,11</sup> Being nulliparous may affect uterine atony and cause damage to the birth canal or the genital tract.<sup>10,11</sup> Hemoglobin level equal to or less than 10 g/dL may lead to dysfunction of the coagulation system.<sup>10,11</sup> All of these may lead to excessive bleeding and PPH. Prior studies found that being of maternal age of 35 years old or above,<sup>7</sup> hemoglobin level equal to or less than 10 d/dL,<sup>13</sup> and gestational hypertensive disorder<sup>7,14-18</sup> were risk factors associated with PPH. On the other hand, being nulliparous, gestational age over 40 weeks, curettage in prior pregnancy, and fundal height of 38 centimeters or above were predictors of PPH in this study which are different from those of the previous studies. These findings may result from demographic differences. However, they were similar to results in the secondary analysis of the twenty articles in steps 1 – 2.

For performance on the Postpartum Hemorrhage Risk Score Record Form, it had sensitivity (80.7%) lower

than the sensitivity (88.1%) of the tool of Sittiparn and Siwadune,<sup>7</sup> but it had specificity (60.8%) and the ROC curve (0.71) higher than the specificity (54.6%) and the ROC curve (0.66) of the tool of Sittiparn and Siwadune.<sup>7</sup> However, the Postpartum Hemorrhage Risk Score Record Form incorporated many predictors (eight predictors) and covered all of the causes of PPH (4T's), while the tool of Sittiparn and Siwadune<sup>7</sup> included only three risk factors, which are being of maternal age of 35 years old or above, gestational hypertensive disorder, and gestational diabetes meatus. These three factors cover only one of the four causes of PPH, specifically tone or uterine atony.

Although the cut-off scores were three points or greater and four points or greater to predict postpartum blood loss over 300 mL after vaginal delivery had the same ROC curve (0.71) and summation of sensitivity and specificity (Table 2), the cut-off score of four points or greater had higher accuracy (64.82%) and positive predictive value (PPV) (34.01%) than the cut-off score of three points or greater (61.93% and 32.72%, respectively). Therefore, the cut-off score of three points or greater had a high sensitivity (85.5%) and low specificity (56.0%) and maybe resulted in false positives leading to overtreatment. Early detection or diagnosis, theoretically, must have a high specificity and screening must have a high sensitivity.<sup>9</sup> The cut-off score of four points or greater, which had 80.7% sensitivity, 60.8% specificity, and 64.82% accuracy,

was appropriate for early detection or diagnosis in the first stage of labor of postpartum blood loss over 300 mL compared to the cut-off score of three points or greater.

In practice, early diagnosis of PPH in the third stage of labor used a collector bag to measure postpartum blood loss over 300 mL and the healthcare providers used a high dose uterotonic drug to prevent excessive bleeding to 500 mL when it occurred.<sup>1</sup> Due to the circumstances whereby some settings in Chiang Rai province are far from Chiang Rai Regional Hospital, it is hard to refer the pregnant women with PPH. Thus, the cut-off score of three points or greater to predict postpartum blood loss of 500 mL or above after vaginal delivery is inappropriate for patients who are far from Chiang Rai Regional Hospital but appropriate for those who are nearby. So, the cut-off score of four points or greater to predict postpartum blood loss over 300 mL after vaginal delivery is more appropriate for the early detection of PPH. The pregnant women with PPH are immediately referred from remote areas to Chiang Rai Regional Hospital.

To conclude, the Postpartum Hemorrhage Risk Score Record Form is the first useful clinical assessment tool for the early detection or diagnosis of PPH. It has high sensitivity and specificity for the prediction of postpartum blood loss over 300 mL after vaginal delivery according to the LABOR strategy for the early detection or diagnosis of PPH. However, it had the limitation that some factors had a high score. For application, the healthcare providers should take into consideration the setting and characteristics of the pregnant women. Moreover, there should be confirmation of the score of each predictor and the total score by a retrospective or prospective cohort study.

## ACKNOWLEDGMENTS

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