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ORIGINAL ARTICLE

# Assessing the accuracy of visual blood loss estimation in postpartum hemorrhage in Shanghai hospitals: A web-based survey for nurses and midwives

**Ying Liu MSN, RN, Clinical Nurse Midwife**[1,2,3] | **Wei Zhu MSN, RN, Associate Chief Nurse Officer**[1,2,3] | **Ying Shen BSN, RN, Head Midwife**[1,2,3] | **Jingbo Qiu MSN, RN, Clinical Nurse Midwife**[1,2,3] | **Lin Rao PhD, RN, Associate Chief Nurse Officer**[1,2,3] | **Hong Li MSc, RN, Chief Nurse Officer**[1,2,3]

[1]International Peace Maternity and Child Health Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

[2]Shanghai Key Laboratory of Embryo Original Diseases, Shanghai, China

[3]Institute of Embryo-Fetal Original Adult Disease Affiliated to Shanghai, Shanghai Jiao Tong University School of Medicine, Shanghai, China

**Correspondence**
Lin Rao and Hong Li, International Peace Maternity and Child Health Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China.
Emails: ireenrao@163.com (LR); 2750074682@qq.com (HL)

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## Abstract

**Aims and objectives:** This study aimed at evaluating the accuracy of visual estimated blood loss in postpartum haemorrhage by midwives and nurses, as well as exploring its influencing factors.

**Background:** Timely recognition of postpartum haemorrhage is critical in saving maternal lives. Yet midwives and nurses can barely distinguish whether the blood loss has reached a life-threatening amount without precise measurement. Understanding their ability to accurately estimate the amount of blood loss and the influencing factors can help improve this ability with effective measures.

**Design:** This research was a multicenter cross-sectional survey with convenient sampling.

**Material and Methods:** Using a modified online visual estimation questionnaire of blood loss, the QR code of this survey was sent to midwives and obstetrical nurses engaged in clinical practice in secondary and tertiary hospitals in Shanghai. A descriptive analysis was performed with demographics and the responses of visual estimated blood loss of each volume. The difference and consistency of the responses of each volume were evaluated. The relationship between each demographic characteristic and accuracy was explored. STROBE statement checklist was chosen for reporting the study process.

**Results:** A total of 361 midwives and nurses participated in the survey. The finding showed an overall accuracy of 30.52% (1763/5776), with 25.3% and 18.0% subjects distinguishing postpartum haemorrhage (500 ml) and severe postpartum haemorrhage (1000 ml), respectively. The Kappa coefficients were slight to moderate (0.037–0.590). There were no differences among the categories of gender, age, academic degree, position, title, working experience in years, working department and reported

Ying Liu, Wei Zhu, and Ying Shen contributed equally in this study.

methods of blood loss estimation with regard to accuracy. However, having institutional guidance for blood loss calculation showed a significant relationship with higher accuracy.

**Relevance to clinical practice:** While representing a relatively well-developed area in China, the accuracy of visual estimated blood loss was not satisfactory, as suggested in other developed countries around the world. Training and institutional guidance on blood loss quantification should be provided in midwifery settings, regardless of how the level of medical development is advanced.

**Conclusions:** The accuracy of VEBL was low even with a visual aid, especially when the volume exceeds 500 ml. To improve accuracy, institutions should make standardadized assessment guidance and provide regular training for blood loss quantification.

**KEYWORDS**
estimation of blood loss, nurse midwives, nurses, postpartum haemorrhage

## 1 | INTRODUCTION

Postpartum haemorrhage (PPH) is considered to be the leading cause of maternal death, especially in developing countries (Say et al., 2014). The key actions to successful management of PPH are early recognition and prompt treatment (Knight et al., 2018). But analysis demonstrated that patients undergoing PPH might have no clinical signs of haemorrhage despite a blood loss of over 500 ml (Habak et al., 2016; Pacagnella et al., 2013). Research employing quantitative methods of blood loss estimation revealed a higher incidence of PPH compared to visual estimation (Habak et al., 2016). Therefore, using quantitative estimation methods in a timely manner is important for the diagnosis of PPH (ACOG, 2019). Although highly recommended, these methods could not be performed case by case precisely due to inconvenience. In fact, visual estimation of blood loss (VEBL) was described as the most common and practical way (Diaz et al., 2018).

While subjects in the research showed a significant overestimation of the volume (Yoong et al., 2010), other practitioners tended to overestimate blood loss at low volumes and underestimate blood loss at high volumes (Parayre et al., 2015; Stafford et al., 2008). In a study conducted by Parayre et al., (2015) in France, student midwives in their fifth year were offered an online questionnaire with photographs of different volumes of simulated blood. The result showed an accuracy of only 35.34% of the responses, with regional difference across the country.

In order to improve the ability of accurate visual estimation, researchers have reported different approaches to staff training and modified measurement tools. In Thailand, Cheerranichanunth employed a simple self-developed pictogram tool for initial evaluation of blood loss in cesareans and found that subjects improved the accuracy significantly in seven clinical stations after viewing pictures printed on paper (2012). However, this study also indicated that subjects had poor accuracy on VEBL when they were tested again 9 months later. Currently, analysis is somewhat inadequate to determine factors that can help midwives better predict the PPH.

In China, although midwives are under the supervision of obstetricians, they have the call on noticing the obstetricians during emergencies like PPH. Thus, understanding their ability of PPH recognition has a profound impact on maternal prognosis. Considering the prominent unavailability of midwives in the country in terms of both quantity and quality (Wang, 2015), as well as lacking an advanced national midwifery training system, we had concerns regarding their performance on PPH recognition. Yet on the other hand, while a large portion of clinical midwives was transferred from nurses who worked in the obstetrical unit (Huang et al., 2010) in Shanghai, the overall obstetrical healthcare level is internationally competitive (WHO, 2019) with a maternal mortality of 1.15 per 100,000 in 2019. With few relevant reports, this research aimed to evaluate the ability of VEBL in midwives and obstetrical nurses and to explore the relationship of demographical characteristics and accurate estimations.

## 2 | METHODS

### 2.1 | Study design

This research was a cross-sectional multicenter study, with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (von Elm et al., 2007) chosen for a report (See Appendix S1).

### 2.2 | Participants

Midwives and obstetrical nurses in secondary and tertiary hospitals in Shanghai participated in this survey voluntarily. The inclusion criteria were working or once worked in the delivery room, or working in the obstetrical ward. Midwifery or nursing students , and nurses working in other units rather than obstetrics were excluded from this research.

### 2.3 | Data collection

Hospital ranks in China were stratified into the tertiary, secondary and primary according to the scale of the hospital (beds), technical level, management level, equipment conditions, scientific research capacity, etc. The higher the rank, the higher level of speciality and advanced care. Of the 79 institutions licensed for midwifery services in Shanghai, four institutions were selected randomly according to each stratification by drawing lots for each rank. Chief Nursing Officers in hospitals involved were contacted for agreement before sending the QR code of the web survey (https://www.wjx.cn/jq/24600621.aspx), and the code was then forwarded to two units.

The web-based cross-sectional questionnaire was open from 20 October 2019–20 June 2020, which included two sections: (1) demographics and (2) visual assessment questions. The title was divided into junior, intermediate and senior according to professional and technical accomplishment. For further information, we queried if the hospitals had institutional guidance for blood amount calculation (e.g. the mean weight of dry and wet gauges) in demographical characteristic. Visual assessment questions contained 16 photographs of 8 different blood volumes with each image presented twice, and photographs were labelled in serial numbers for comparison. The original graphic questionnaire was developed by Parayre et al., (2015), surveyed among student midwives in France to assess the accuracy of visual estimation of blood loss. Prior to conducting this research, permission was obtained from the corresponding author of that study so that pictures in the questionnaire could be adopted in our study. Each one of the visual assessment questions included a 50-ml reference photograph accompanied for calibration, with only one answer to be chosen among 7 choices.

Before starting the survey, informed consent was shown to each subject. According to instructions, they should finish the questionnaire independently and submit only once. No time limitation was set for the subjects during their response. Each record would only be saved after all questions were completed. Ethical approval was granted by the institutional ethical committee.

### 2.4 | Statistical analysis

Statistical analysis was performed using SPSS version 24.0. The primary endpoint was the rate of accurate responses for each visual assessment question, as well as overestimated and underestimated responses. Categorical variables were reported as frequency counts (*n*) and proportions (%), including demographic characteristics and VEBL responses. Comparison of VEBL responses was conducted with McNemar's $X^2$ test. The intra-rater agreement for the identical photograph was performed with the kappa coefficient. Mann–Whitney *U* test and Kruskal–Wallis test were used to compare the means of accurate VEBL responses (16 in total) with regard to demographic characteristics. Any test yielding a *p* value smaller than .05 was considered significant.

## 3 | RESULTS

A total number of 361 midwives and nurses participated in this survey. Gender, age, academic degree, position, title, working experience in years, working department, reported methods of blood loss estimation and availability of institutional guidance for blood loss quantification were shown in Table 1.

The accuracy of responses for the different amounts of blood is shown in Table 2. Of the 5776 responses in total, 1763 (30.52%) were accurate, whereas 1573 (27.73%) were overestimated and 2440 (42.24%) underestimated. Generally, the accuracy fell below 30% with a blood loss of 500 ml, and below 20% with 1000 ml. The accumulated percentage of accuracy in volumes below 500 ml was significantly higher than those 500 ml and above (1197/1763, 67.9% versus 566/1763, 32.1%, $p < .001$). There were significant differences in accuracy between two identical photographs for the volumes of 150 ml, 300 ml and 850 ml. The volumes were more likely to be underestimated than overestimated (2440/5776, 42.24% versus 1573/5776, 27.23%). When exceeding 500 ml, approximately 60%–80% responses were underestimated.

The intra-rater agreement of accurate responses in two identical photographs of each volume was shown in Table 3. The Kappa coefficients were moderate in the volumes of 100 ml, 300 ml and 850 ml, with the lowest 0.037 of 200 ml. When the blood loss amount was greater than 1000 ml, the Kappa coefficients were fair with low accuracy.

Table 4 showed the relationship between demographical characteristics and the overall accuracy per person. The result yielded a higher accuracy with the availability of institutions guidance for blood loss calculation (5.00 ± 2.54 versus 3.95 ± 2.06, $p = .016$). However, disparities of age, academic degree, position, title, department, working experience, reported methods of blood loss estimation and hospital rank did not indicate significant difference.

## 4 | DISCUSSION

### 4.1 | Principle results

Conducted as a multicentered study, this research surveyed both midwives and obstetrical nurses. These institutions typically included all types of midwifery facilities in Shanghai, allowing for the reduction of potential bias in single-centred research. Since this research utilized an online questionnaire, it offered much convenience for data collection and analysis. Based on the findings, the accuracy of VEBL, which hasn't been reported in China regarding the obliquity with a virtual pictorial method, was dissatisfactory with the help of visual aid.

To the best of our knowledge, the incidences of PPH saw great distinctions regarding the methods of blood loss estimation, generally somewhere between 2%–5% across the mainland without claiming estimation approaches. However, the PPH rate could be surprisingly high when blood loss was precisely evaluated by the

**TABLE 1** Demographical characteristics of respondents

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 1 | 0.3 |
| Female | 360 | 99.7 |
| Age | | |
| 20–29 | 151 | 41.8 |
| 30–39 | 137 | 38.0 |
| 40–49 | 60 | 16.6 |
| 50–59 | 13 | 0.4 |
| Academic degree | | |
| Vocational degree | 15 | 4.2 |
| Associate degree | 159 | 44.0 |
| Bachelor's degree | 179 | 49.6 |
| Master's degree | 8 | 2.2 |
| Position | | |
| Nurse | 187 | 51.8 |
| Midwife | 156 | 43.2 |
| Nursing administration | 18 | 5.0 |
| Title | | |
| Junior | 257 | 71.2 |
| Intermediate | 100 | 27.7 |
| Senior | 4 | 1.4 |
| Department | | |
| Obstetrical ward | 212 | 58.7 |
| Delivery room | 145 | 40.2 |
| Nursing administration department | 4 | 1.1 |
| Working experience in years | | |
| 0–9 | 187 | 51.8 |
| 10–19 | 93 | 25.8 |
| 20–29 | 59 | 16.3 |
| 30–39 | 22 | 0.6 |
| Reported methods of blood loss estimation | | |
| Visual estimation | 38 | 10.5 |
| Weight | 274 | 75.9 |
| Volume | 49 | 13.6 |
| Availability of institutional routines for blood loss calculation | | |
| Yes | 321 | 88.9 |
| No | 40 | 11.1 |
| Hospital rank | | |
| Tertiary general hospital | 88 | 24.4 |
| Tertiary specialized hospital | 109 | 30.2 |
| Secondary general hospital | 128 | 35.5 |
| Secondary specialized hospital | 36 | 10.0 |

**TABLE 2** Analysis of accurate responses for different volumes of blood loss (5776 estimates by 361 respondents)

| Volume (ml) | Question number | Accurate responses | | |
|---|---|---|---|---|
| | | *N* | % | *p* value[a] |
| 100 | 10 | 142 | 39.3 | .403 |
| | 16 | 134 | 37.12 | |
| 150 | 3 | 233 | 64.5 | .000 |
| | 6 | 181 | 50.14 | |
| 200 | 1 | 153 | 42.4 | .052 |
| | 13 | 127 | 35.18 | |
| 300 | 4 | 98 | 27.1 | .001 |
| | 8 | 129 | 35.73 | |
| 500 | 11 | 84 | 23.3 | .151 |
| | 14 | 99 | 27.42 | |
| 850 | 2 | 41 | 11.4 | .010 |
| | 7 | 60 | 16.62 | |
| 1000 | 5 | 68 | 18.8 | .538 |
| | 12 | 62 | 17.17 | |
| 1500 | 9 | 71 | 19.7 | .295 |
| | 15 | 81 | 22.44 | |
| Total | | 1763 | 30.52 | |

aMcNemar's test was used to compare the accurate responses of each identical photographs.

gravimetric and the volume method, so much as 24.2% compared to 2.5% with visual estimation (Zhuang et al., 2010). The pictures adopted provided the subjects with a visual aid of 50 ml volume, which might to some extent add to accuracy. In a study conducted without such visual aid, the accuracy rate of 100 ml blood loss was as minimal as 17.22% (Zuckerwise et al., 2013). Therefore, offering such visual aid enables midwives to estimate blood loss more accurately, which provides insight for further clinical practice.

Similar to the results of research by Al Kadri et al., (2011), the volumes of blood loss were often overestimated when less than 500 ml, whereas underestimated over that point. The accuracy of over 50% for 150 ml blood loss might be linked to a common medical record between 100–200 ml. Yet the accuracy of 100 ml was no higher than that of 150 ml, which might due to the fewer record of 100 ml blood loss in clinical practice. As the amount exceeded over 500 ml, the accuracy dropped promptly, which indicated the urgency to weigh blood loss at an early stage once the midwife suspected PPH. Considering 500 ml as the standard of diagnosis, those who can recognize PPH timely before weighing the blood accounted for only a quarter in our study, which might possibly delay the diagnosis. Interestingly, the group reported to employ VEBL in their practice showed slightly higher accuracy than those employed weight and volume methods.

Compared to the research using the original pictorial questionnaire in France (2015), this survey yielded a lower overall accuracy

TABLE 3 The intrarater agreement of each volume of blood loss

| Volume (ml) | Average accuracy of identical photographs (%) | Agreement of estimation (Kappa coefficient) | *p* value |
|---|---|---|---|
| 100 | 38.2 | 0.590 (0.501–0.671) | <.001 |
| 150 | 57.3 | 0.324 (0.226–0.415) | <.001 |
| 200 | 38.8 | 0.037 (0.051–0.141) | .479 |
| 300 | 31.4 | 0.458 (0.356–0.549) | <.001 |
| 500 | 25.3 | 0.306 (0.195–0.417) | <.001 |
| 850 | 14.0 | 0.439 (0.302–0.564) | <.001 |
| 1000 | 18.0 | 0.381 (0.261–0.485) | <.001 |
| 1500 | 21.0 | 0.384 (0.262–0.489) | <.001 |

(30.52% versus 35.34%). In addition, an average percentage of 74.7% (76.7% and 72.6% for each picture) missed the diagnosis of PPH for visual estimation. The relatively higher accuracy in the French study might be caused by differences in professional training, which was inadequate for nurses who were assigned to shift their positions into understaffed midwives, with only months of hand-in-hand apprentice in China.

Further, midwives and nurses in hospitals which had institutional guidance for blood loss estimations in this study demonstrated better abilities to perform VEBL, suggesting the efficacy in the training of blood loss estimation and the necessity for establishing an institutional guidance for blood loss calculation. Under circumstances where midwives or nurses only consider to weigh the blood as necessary for further intervention, they need training lest they miss the best time for calling. While the availability of institutional guidance contributed to a better performance on accuracy, the difference was somehow moderate. This might be caused by poor mastery of the guidance, which needs to be reviewed on a regular basis. According to Al Kadri et al., (2011), the seniority of health care providers did not affect the accuracy of estimation, which is consistent in this study. Particularly, the result was an original finding that the demographical characteristics of the respondents, namely age, academic degree, position and department showed no significant relationship with accuracy. Consequently, all relevant staffs, regardless of their positions and titles, should accept certain training in blood loss quantification.

Studies showed an increase in accuracy after subjects were trained on visual estimation (Dunleavy et al., 2019; Toledo et al., 2010). Cheerranichanunth and Poolnoi (2012) set up six stations for subjects of different professions and found that the accuracy increased from 30.9%–61.8% with previous pictogram drills, meanwhile the error in estimation decreased from 69.1%–38.2%. Some researchers noted that in spite of the relative accuracy of the weighing method, it could not prevent the process of severe postpartum haemorrhage. Thus, when suspecting the diagnosis of postpartum haemorrhage, midwives can not only depend on the amount of bleeding, but also on the speed and characteristics of bleeding (2010).

To our understanding, this research was the first study using a pictorial questionnaire on assessing the ability of VEBL of the midwives and obstetrical nurses in mainland China. The results urge us to develop a training platform that can be nationally available to enhance knowledge and performance. There were also reports on using artificial intelligence-enabled technology platforms for blood loss quantification in recent years (Andrikopoulou & D'Alton, 2019), which would be a promising perspective for clinical practice.

### 4.2 | Limitation

Since our questionnaire was designed in online format, the response rate cannot be calculated. This might somehow add to sample bias in our research. Also, the online questionnaire brought about difficulties on training intervention, which was why it could not be integrated into this particular research.

## 5 | CONCLUSIONS

The accuracy and intra-rater agreement of VEBL were low with the help of visual aid. Disparities of age, academic degree, position, title, department, working experience, reported methods of blood loss estimation and hospital rank did not influence the accuracy of VEBL. Institutional guidance on blood loss quantification should be developed and integrated into training to assist staffs for better accuracy.

## 6 | RELEVANCE TO CLINICAL PRACTICE

While representing a relatively well-developed area in China, the accuracy of visual estimated blood loss was not satisfactory, as suggested in other developed countries around the world. Training and institutional guidance on blood loss quantification should be provided in midwifery settings, regardless of how the level of medical development is advanced.

**TABLE 4** Relationship between demographical characteristics and accurate responses

| Characteristics | Accurate responses per person (*M* ± *SD*) | *Z* or *H* | *p* value |
|---|---|---|---|
| Gender | | 0.919[a] | .461 |
| Male | 3.00 | | |
| Female | 4.89 ± 2.51 | | |
| Age | | 3.035[b] | .386 |
| 20–29 | 5.11 ± 2.69 | | |
| 30–39 | 4.84 ± 2.40 | | |
| 40–49 | 4.37 ± 2.08 | | |
| 50–59 | 5.08 ± 3.17 | | |
| Academic degree | | 0.810[b] | .847 |
| Vocational degree | 5.07 ± 2.12 | | |
| Associate degree | 4.79 ± 2.48 | | |
| Bachelor's degree | 4.98 ± 2.61 | | |
| Master's degree | 4.38 ± 1.30 | | |
| Position | | 5.997[b] | .199 |
| Nurse | 4.78 ± 40 | | |
| Midwife | 5.14 ± 2.71 | | |
| Nursing administrator | 4.93 ± 2.25 | | |
| Title | | 5.969[b] | .051 |
| Junior | 5.07 ± 2.55 | | |
| Intermediate | 4.37 ± 2.26 | | |
| Senior | 5.50 ± 4.51 | | |
| Department | | 2.080[b] | .353 |
| Obstetrical ward | 4.75 ± 2.35 | | |
| Delivery room | 5.10 ± 2.75 | | |
| Nursing administration department | 3.75 ± 0.50 | | |
| Working experience in years | | 3.508[b] | .320 |
| 0–9 | 5.06 ± 2.61 | | |
| 10–19 | 4.91 ± 2.49 | | |
| 20–29 | 4.47 ± 2.17 | | |
| 30–39 | 4.32 ± 2.51 | | |
| Reported methods of blood loss estimation | | 0.163[b] | .922 |
| Visual estimation | 5.08 ± 2.48 | | |
| Weight | 4.83 ± 2.46 | | |
| Volume | 5.02 ± 2.83 | | |
| Have institutional routines for blood loss calculation | | −2.415[a] | .016 |
| Yes | 5.00 ± 2.54 | | |
| No | 3.95 ± 2.06 | | |
| Hospital rank | | 1.606[b] | .658 |
| Tertiary general hospital | 4.82 ± 2.47 | | |
| Tertiary specialized hospital | 4.91 ± 2.52 | | |
| Secondary general hospital | 5.03 ± 2.46 | | |
| Secondary specialized hospital | 4.44 ± 2.80 | | |

[a]Mann–Whitney *U* test value.

[b]Kruskal–Wallis test value.

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## CONFLICT OF INTEREST

None to declare.

## AUTHOR CONTRIBUTIONS

HL and LR designed the study and proofreading of the manuscript. YL, WZ and YS contributed to the questionnaire design and distribution and collection. YL, JQ and YS were responsible for the data analysis and statistical analysis. YL and WZ drafted the manuscript. It has been approved by all authors and has never been published.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## ORCID

*Ying Liu* https://orcid.org/0000-0003-0571-2253

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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