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ORIGINAL RESEARCH

# Risk Factors for Postpartum Hemorrhage Following Vaginal Deliveries in China: A Case-Control Study of Second Births After IUD Removal

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**Objective:** This study aims to evaluate the predictive value of risk factors for postpartum hemorrhage (PPH) following vaginal delivery, with a special focus on the impact of intrauterine device (IUD) usage in the context of recent policy changes allowing more childbirths in China.

**Methods:** A total of 6879 women who underwent vaginal deliveries from January 2021 to December 2023 in the Lianyungang regional maternal care system and met the inclusion and exclusion criteria were enrolled. A case-control design was employed, comprising 524 women with PPH (blood loss ≥500 mL) 24h after giving birth and an equal number of controls (blood loss <500 mL) matched on a 1:1 ratio. Univariate and multivariate logistic regression analyses, alongside ROC curve analysis, were conducted to identify risk factors for PPH.

**Results:** Univariate analysis revealed significant differences in age (OR = 1.86, 95% CI: 1.35–2.57, $P < 0.01$), number of miscarriages (OR = 1.97, 95% CI: 1.46–2.65, $P < 0.001$), gestational week, number of fetuses, weight of the second child (OR = 10.78, 95% CI: 7.88–14.75, $P < 0.001$), placental adhesion, and uterine atony (OR = 2.40, 95% CI: 1.60–3.61, $P < 0.001$). No significant differences were observed regarding occupation, educational level, mode of first delivery, IUD use and duration, and presence of gestational diabetes or hypertension ($P > 0.05$). Multivariate logistic regression identified age, number of miscarriages, weight of the second child, and uterine atony as independent risk factors for PPH ($P < 0.05$). ROC curve analysis showed that the combined predictive value of these factors was superior, with an AUC of 0.805 for the combined predictive model.

**Conclusion:** PPH is influenced by advanced maternal age, multiple miscarriages, high birth weight, and uterine atony. IUD use may not independently impact the likelihood of PPH under the conditions studied.

**Keywords:** intrauterine device, postpartum hemorrhage, vaginal delivery, risk factors

## Introduction

Postpartum hemorrhage (PPH) is a serious complication of childbirth and the leading cause of maternal mortality in China.[1] Globally, PPH accounts for over 500,000 maternal deaths annually, representing more than a quarter of all such fatalities.[2] The incidence of PPH varies significantly across regions. In china, the incidence of PPH ranges from 2.88% to 15.4% depending on the region and health setting.[3] In other countries, such as Northern Africa, the PPH incidence can reach up to 32%.[4] Globally, PPH affects approximately 6% of all vaginal deliveries, but the rates vary widely by region, from 1.2% in high-income countries to 10.5% in low-income settings. Since the implementation of the two-child and three-child policies in China, the number of women at risk of PPH has increased, particularly among those with prior iUD use. This polish shift necessitates a reevaluation of PPH risk factors.

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The etiology of PPH is multifaceted, primarily involving factors related to the placenta, trauma to the birth canal, uterine atony, and coagulation disorders. Active management of the third stage of labor (AMTSL), including the use of uterotonic agents such as oxytocin, controlled cord traction, and uterine massage, remains the cornerstone of PPH prevention. Known risk factors for PPH include advanced maternal age, multiparity, multiple gestations, macrosomia, prolonged labor, and uterine atony.[5] In China, due to historical conditions and birth control policies, the use of intrauterine devices (IUDs) has been a prevalent contraceptive method among women of childbearing age. IUDs, recognized for their efficacy, longevity, and reversibility, account for approximately 49.79% of all contraceptive measures utilized in the country.[6] However, with recent adjustments to fertility policies, a significant number of women who had previously used IUDs been now opting to have them removed to conceive again. Second births are particularly relevant in the context of China's recent birth policy changes, which have led to increased IUD removals. Understanding how these demographic changes influence PPH risk is crucial for developing targeted preventive strategies.

IUDs, particularly those containing copper, can induce local inflammatory responses in the endometrium, potentially affecting placental implantation and increasing the risk of placental adhesion or uterine atony, both of which are risk factors for PPH.[7] The inflammatory response induced by IUDs may alter endometrial receptivity and vascularization, potentially impairing uterine contractility and increasing the likelihood of PPH.[8] It's reported that the usage of IUDs would cause some complications in women such as inflammation.[9] Moreover, inflammatory markers were detected in the animal studies.[10] These findings implicate that the inflammatory response induced by IUDs could contribute to complications in the postpartum period.

While numerous studies have identified general risk factors for PPH, few have focused on the Chinese population, particularly second births after IUD removal. This study addresses this gap by examining whether previous IUD use influences PPH risk in multiparous women. The focus on second births after IUD removal is particularly relevant in the context of China's changing birth policies. The case-control design was chosen to compare women with and without PPH effectively, controlling for confounding variables. This design is particularly suitable for studying multiple risk factors and is efficient for rare outcomes like PPH. Additionally, there is a need for localized data in China, where PPH incidence may differ from global statistics due to unique reproductive health policies.

This study employs a case-control approach to delve deeper into the risk factors associated with PPH, aiming to provide scientific guidance for women wishing to conceive after IUD removal and to prevent postpartum hemorrhage. By investigating the causes of PPH, this research seeks to contribute to the safety and health of expectant mothers, thereby enhancing maternal health outcomes.

## Methodology

This longitudinal cohort study was conducted in the Lianyungang region from January 2021 to December 2023, evaluating the risk factors for PPH among women undergoing vaginal delivery of their second child. Ethical Review Committee of Lianyungang Maternal and Child Health Hospital approved the study under the protocol number LYG-MEP2021001, and informed consent was obtained from all participants before data collection, ensuring compliance with ethical standards. This study aimed to explore the impact of IUD removal on PPH risk, within the context of China's changing birth policies.

This study utilized a case-control design to compare women who experienced PPH with those who did not, effectively controlling for confounding variables. This design was chosen because it is particularly suitable for studying multiple risk factors and is efficient for rare outcomes like PPH.

A total of 6879 women who had vaginal deliveries of their second child were initially assessed for eligibility. The case selection was conducted based on Figure 1. PPH was defined as blood loss ≥500 mL within 24 hours post-delivery, following the guidelines from the Children's Hospital of Philadelphia, USA. The threshold is consistent with international standards for defining PPH severity. From the initial cohort, participants were excluded based on the following criteria: 1) presence of any coagulopathy or other bleeding disorders that could independently increase the risk of PPH; 2) Refusal to participate in the study. After these exclusions, the remaining eligible participants were included in the study. Among these, 524 women who experienced postpartum hemorrhage (PPH) (blood loss exceeding 500mL within 24h post delivery), were designated as the case group. The control group was then randomly selected from the

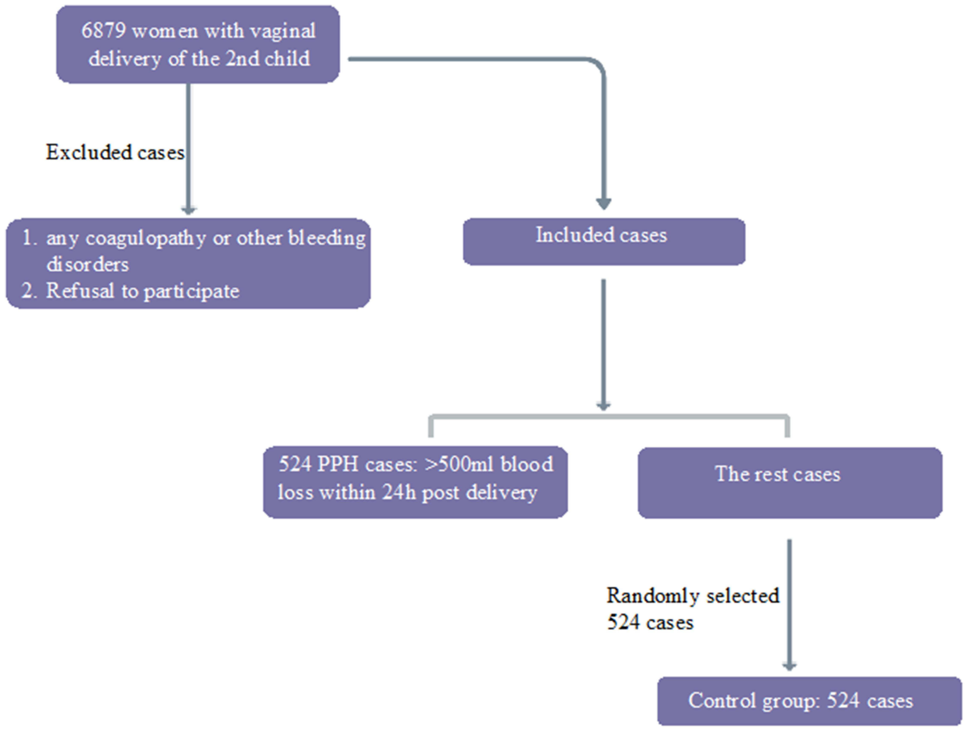


**Figure 1** The flowchart about the case selection of PPH group and control group from 6879 patients.

remaining participants who did not experience PPH. To reduce confounding effects and ensure comparability between groups, controls were matched to cases by age and delivery mode using a 1:1 ratio. This matching was conducted because age and delivery mode are known to influence PPH risk. The 1:1 ratio was chosen to maximize statistical power while maintaining balance between groups. The control group was randomly selected using a computer-generated sequence to minimize any selection bias. The approach ensured that each eligible non-PPH participant had an equal chance of being included in the. Control group, enhancing the validity of the comparison.

A power calculation was performed using G Power software to determine the appropriate sample size. Assuming a significance level (α) of 0.05, a power (1-β) of 0.80, and an expected odds ratio (OR) of 1.5 for key risk factors, a minimum of 500 cases and 500 controls were required. This calculation justifies the selection of 524 pairs, providing sufficient power to detect significant associations between risk factors and PPH.

Blood loss was measured using a gravimetric method, which involves weighing blood-soaked pads before and after delivery. The weight difference was converted to milliliters using the assumption that 1 gram equals 1 milliliter of blood. This method is considered more accurate than visual estimation and reduces measurement bias.

Comprehensive baseline data were gathered, covering demographics such as age, occupation, and education; obstetric history including number of miscarriages, birth weight, gestational age at delivery, mode of delivery, and amount of postpartum bleeding; contraceptive use, specifically the duration and reason for IUD removal; and complications during pregnancy such as gestational hypertension, diabetes, and placental adhesion. In the study, an intrauterine device (IUD) for at least two months between their first and second pregnancies was defined as IUD usage.

Quality control measures were rigorously applied to ensure the integrity of data collection. Collected data were double-checked by two independent researchers. Fifteen qualified health service personnel were trained to thoroughly understand the study design and master the survey methodology. Each questionnaire was meticulously checked for accuracy and completeness, with any issues promptly addressed. Periodic random checks of the questionnaires were performed to maintain high data quality. Data validation procedures included cross-checking with medical records to ensure consistency. Data were gathered at three critical points: prenatal visits, immediate postpartum period, and follow-up visits within 6 weeks postpartum.

Statistical analyses were conducted using SPSS 19.0. Demographic and clinical characteristics were summarized using means ± standard deviations for continuous variables and frequencies (percentages) for categorical variables. The relationship between various factors and the risk of PPH was initially examined using chi-square tests, with significant factors ($P < 0.05$) subsequently analyzed through binary logistic regression to calculate odds ratios (ORs) and 95% confidence intervals (CIs). Multiple imputation techniques were used to handle missing values, with sensitivity analyses confirming the robustness of results. The predictive value of individual and combined risk factors was assessed using ROC curves, considering an area under the curve (AUC) greater than 0.5 as indicative of predictive relevance, with P-values less than 0.05 considered statistically significant.

## Results

Our study investigated various risk factors for postpartum hemorrhage (PPH) among 1048 participants who underwent natural childbirth. The data analyzed was grouped into two main categories: those who developed PPH (n=524) and those who did not (n=524), providing a balanced case-control scenario.

Age, occupation and educational level in each group were investigated (Table 1) and visualized in Figure 2. There was no statistically significant difference in age (Figure 2a), occupation (Figure 2b) and educational level (Figure 2c) between the two groups. Thus, it revealed that the incidence of PPH was not significantly associated with these demographic variables.

The detailed parameters and data in each group were displayed in Table 2 and visualized in Figure 3, including the number of miscarriages, presence of gestational diabetes, intrauterine device (IUD) use, mode of first delivery, gestational hypertension, duration of IUD use, and the type of IUD utilized. Only 34.54% of women in the PPH group had no previous miscarriages compared to 49.24% in the control group (Figure 3a). Higher percentages of one to two miscarriages (53.82%) and three or more miscarriages (11.64%) in the PPH group compared to the control group (44.66% and 6.10%, respectively). A statistically significant association was found between the number of prior miscarriages and the incidence of PPH. Women with two or more miscarriages had a 35% higher risk of developing PPH compared to those with fewer or no prior miscarriages ($p<0.05$). This signified a strong association between the number of miscarriages a woman has had and the occurrence of PPH in this study population. Women with a history of miscarriages, especially those with three or more, are at a higher risk of developing PPH compared to those with fewer or no previous miscarriages. Among the participants, 7.06% of the control group (n=37) and 9.73% of the PPH group (n=51) were diagnosed with gestational diabetes (Figure 3b). The chi-square test yielded a value of 2.431, with a p-value of 0.119, indicating that there was no statistically significant association between gestational diabetes and the occurrence of PPH in this sample. IUD usage was reported by 53.05% of the control group (n=278) and 48.47% of the PPH group (n=254) (Figure 3c). The chi-square statistic for this comparison was 3.081, with a p-value of 0.079. This result suggested a lack of statistically significant association between IUD use and the risk of developing PPH, though a trend toward lower incidence in the PPH group was observed. Furthermore, the analysis of the mode of first delivery revealed varied practices, with the most common being vaginal delivery, reported by 57.63% of the control group (n=302) and 61.83% of the PPH group (n=324) (Figure 3d). Other methods included forceps delivery, breech delivery,

**Table 1** Demographic and Clinical Characteristics Among the Study Population. Statistical Significance Was Set at a p-value < 0.05. All Statistical Analyses Were Performed Using SPSS

| Risk Factors | | Control (n=524) | PPH (n=524) | $\chi^2$ | P |
|---|---|---|---|---|---|
| Age | <35 | 195 (37.21) | 133 (25.38) | 17.058 | 0 |
| | ≥35 | 329 (62.79) | 391 (74.62) | | |
| Occupation | Unemployed | 402 (76.72) | 421 (80.34) | 2.043 | 0.153 |
| | Employed | 122 (23.28) | 103 (19.66) | | |
| Educational level | Junior high school/Below | 289 (55.15) | 273 (52.10) | 3.164 | 0.206 |
| | High school/ vocational school | 142 (27.10) | 135 (25.76) | | |
| | College degree/higher | 93 (17.75) | 116 (22.14) | | |

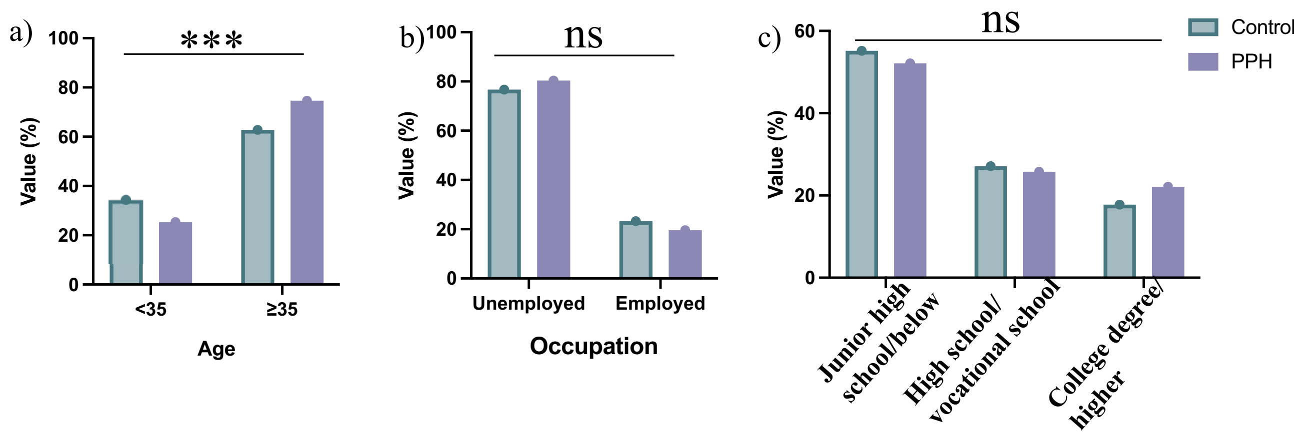


**Figure 2** Bar plots of the (**a**) age, (**b**) occupation (unemployed, employed) and (**c**) educational level (junior high school, high school, college) of cases in control group and PPH group. In all number of miscarriages (0, 1/2, ≥3), there were statistically significant differences between the control and PPH groups, with p-values < 0.01. p-values < 0.01 was displayed as ***. ns stands for not significant.

lower segment cesarean section (LSCS), and episiotomy. Notably, forceps deliveries were slightly more prevalent in the PPH group (0.95% vs 0.38% in the control group). However, the overall chi-square test for the mode of delivery produced a value of 4.533 with a p-value of 0.339, indicating no significant differences in the mode of delivery between groups that could be linked statistically to the incidence of PPH.

Our analysis did not reveal significant associations between gestational hypertension and PPH, with chi-square tests yielding a value of 0.954 and a p-value of 0.329, despite mild preeclampsia being more prevalent in the PPH group (15.65%) compared to the control group (12.79%), and severe preeclampsia observed in 8.97% of the PPH group versus 5.53% of the control group (Figure 3e). Similarly, the duration of IUD use showed no significant impact on PPH risk,

**Table 2** Pregnancy-Related Historical Data in Control and PPH Group

| Risk Factors | Categories | Control Cases (%) (n=524) | PPH Cases (%) (n=524) | $\chi^2$ | P |
|---|---|---|---|---|---|
| **Number of Miscarriages** | 0 | 258 (49.24) | 181 (34.54) | 27.014 | 0.000 |
| | 1–2 | 234 (44.66) | 282 (53.82) | | |
| | ≥3 | 32 (6.10) | 61 (11.64) | | |
| Gestational diabetes | | 37 (7.06) | 51 (9.73) | 2.431 | 0.119 |
| IUD use | Yes | 278 (53.05) | 254 (48.47) | 3.081 | 0.079 |
| | No | 246 (46.95) | 270 (51.53) | | |
| Mode of first delivery | Forceps Delivery | 2 (0.38) | 5 (0.95) | 4.533 | 0.339 |
| | Breech Delivery | 1 (0.19) | 0 | | |
| | Lower Segment Cesarean Section (LSCS) | 184 (35.12) | 157 (29.97) | | |
| | Episiotomy | 35 (6.68) | 38 (7.25) | | |
| | Vaginal Delivery | 302 (57.63) | 324 (61.83) | | |
| Gestational hypertension | Mild Preeclampsia | 67 (12.79) | 82 (15.65) | 0.954 | 0.329 |
| | Severe Preeclampsia | 29 (5.53) | 47 (8.97) | | |
| Duration of IUD Use | <60 month | 120 (22.90) | 100 (19.08) | 1.075 | 0.584 |
| | 60–120 month | 143 (27.29) | 142 (27.10) | | |
| | >120 month | 15 (2.86) | 12 (2.29) | | |
| Type of IUD | TCu-IUD | 49 (9.35) | 63 (12.02) | 6.891 | 0.142 |
| | GCu-IUD | 63 (12.02) | 47 (8.97) | | |
| | γCu-IUD | 89 (16.98) | 87 (16.60) | | |
| | MCu-IUD | 42 (8.02) | 27 (5.15) | | |
| | OCu-IUD | 23 (4.39) | 25 (4.77) | | |

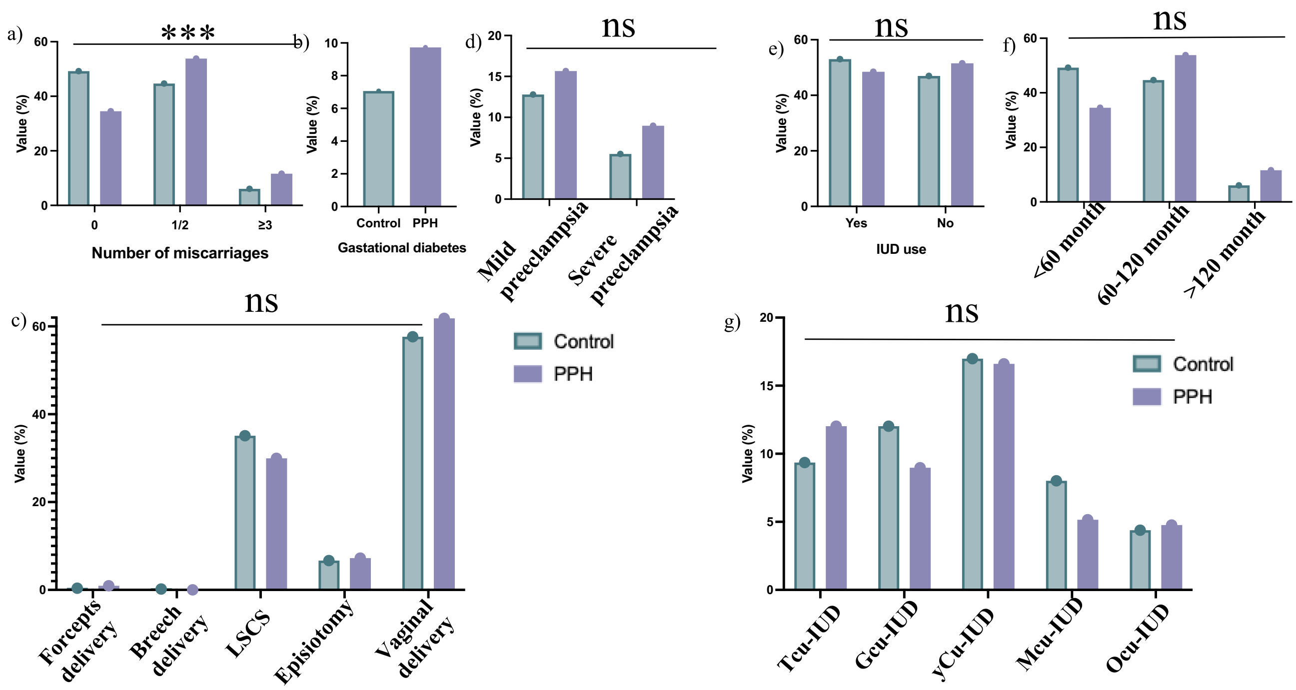


**Figure 3** Bar plots of pregnancy-related historical data in control and PPH group. (**a**) number of miscarriages, (**b**) gestational diabetes, (**c**) gestational hypertension, (**d**) IUD use, (**e**) duration of IUD, (**f**) mode of first delivery and (**g**) type of IUD percentage in control and PPH group. Statistically significant differences were observed between the control and PPH groups in all birth weight categories (<2500g, 2500–4000g, and ≥4000g), as well as in placental adhesion and uterine atony (p < 0.01). Significant differences were also found in gestational age at delivery (>37w, 37–41w+6D, and ≥42w) and pregnancy type (singleton vs multiple) (p < 0.05). Significance levels are indicated as * for p < 0.05 and *** for p < 0.01.

with chi-square values of 1.075 and p-values of 0.584 across categories of less than 60 months, 60–120 months, and more than 120 months (Figure 3f). Lastly, the type of IUD—whether TCu-IUD, GCu-IUD, γCu-IUD, MCu-IUD, or OCu-IUD—also did not significantly affect PPH outcomes, evidenced by a chi-square value of 6.891 and a p-value of 0.142 (Figure 3g). These findings suggested that in our study cohort, neither gestational hypertension, the duration of IUD use, nor the specific type of IUD significantly influenced the occurrence of PPH, indicating the need for further research to identify more definitive risk factors.

Significant findings emerged from the analysis of birth weight of the second child, gestational age at delivery, number of fetuses, placental adhesion, and uterine atony. A pronounced variance was observed in the birth weights between the control and PPH groups (Figure 4a). The chi-square test revealed a highly significant association ($\chi^2 = 245.168$, $p = 0$). Specifically, 83.04% of the control group had birth weight between 2500–4000g, compared to only 37.21% in the PPH group. Conversely, a substantial 61.61% of women in the PPH group had macrosomia weighing ≥4000g, significantly higher than 14.26% in the control group. Gestational age also showed significant differences, with a chi-square value of 7.012 and a p-value of 0.03 (Figure 4b). Most notably, 93.89% of the control group delivered between 37 weeks and 41 weeks + 6 days, slightly lower than 96.95% in the PPH group. Extremely prolonged gestations (≥42 weeks) were rare but slightly more common in the PPH group (0.38%) compared to the control group (0.19%). The number of fetuses showed a statistically significant difference between the groups ($\chi^2 = 5.88$, $p = 0.015$), with multiple pregnancies occurring in 0.95% of the control group and 3.05% of the PPH group, indicating a higher incidence of PPH in multiple pregnancies (Figure 4c). Placental adhesion, though relatively rare, was more prevalent in the PPH group (3.63%) than in the control group (1.53%), with a significant chi-square value of 6.925 and a p-value of 0.008 (Figure 4d). Uterine atony was notably more frequent in the PPH group (19.66%) compared to the control group (9.92%), with a chi-square value of 19.693 and a p-value of 0, suggesting a strong association with the occurrence of PPH (Table 3 and Figure 4e).

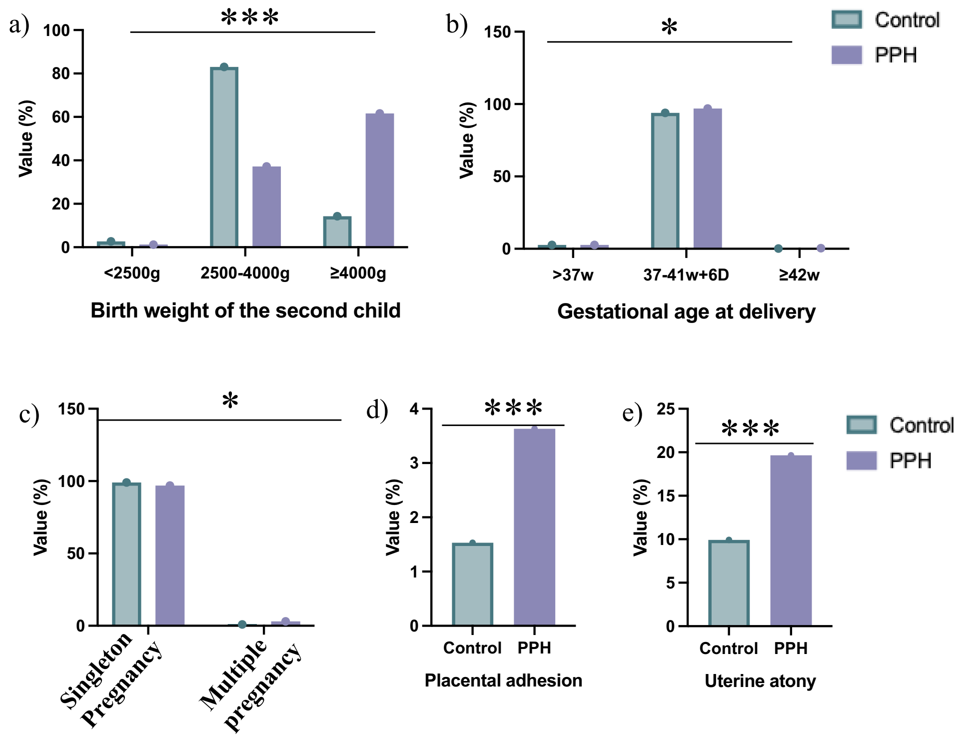


**Figure 4** Bar plot of labor and delivery-related details in control and PPH group. (**a**) birth weight of second child, (**b**) gestational age at delivery, (**c**) number of fetuses, (**d**) placental adhesion and (**e**) uterine atony percentage in control and PPH group. Statistical significance was set at a p-value < 0.05. ns stands, and mean not significant, p<0.05, p<0.01, respectively.

## Logistic Regression Analysis of Risk Factors for Postpartum Hemorrhage

This study employed binary logistic regression to evaluate the impact of several key factors on the risk of postpartum hemorrhage (PPH). The analysis focused on age, history of miscarriages, birth weight of the second child, and the presence of uterine atony as potential predictors. Each factor was subjected to a rigorous statistical analysis to determine its individual contribution to the risk of PPH. Initial univariate analysis identified a set of high-risk factors including age, history of miscarriages, gestational age, birth weight of the second child, number of fetuses, placental adhesion, and uterine atony. These variables were coded as independent variables and entered into a logistic regression model. The criteria for entry and removal from the model were set at α_entry=0.05 and α_exit=0.01, respectively. Through a structured four-step selection process, the final equation derived in the fourth step included age, number of

**Table 3** Labor and Delivery-Related Details in Control and PPH Group

| Risk Factors | Categories | Control (n=524) | PPH (n=524) | $\chi^2$ | P |
|---|---|---|---|---|---|
| **Birth weight of the second Child** | <2500g | 14 (2.70) | 6 (1.18) | 245.168 | 0 |
| | 2500–4000g | 431 (83.04) | 189 (37.21) | | |
| | ≥4000g | 74 (14.26) | 313 (61.61) | | |
| **Gestational age at delivery** | <37w | 14 (2.67) | 14 (2.67) | 7.012 | 0.03 |
| | 37–41w+6D | 492 (93.89) | 508 (96.95) | | |
| | ≥42W | 1 (0.19) | 2 (0.38) | | |
| **Number of fetuses** | Singleton Pregnancy | 519 (99.05) | 508 (96.95) | 5.88 | 0.015 |
| | Multiple Pregnancy | 5 (0.95) | 16 (3.05) | | |
| **Placental adhesion** | | 8 (1.53) | 19 (3.63) | 6.925 | 0.008 |
| **Uterine atony** | | 52 (9.92) | 103 (19.66) | 19.693 | 0 |

**Table 4** Logistic Regression Analysis of Risk Factors for Postpartum Hemorrhage

| Risk Factor (X) | Regression Coefficient (B) | Standard Error (SE) | $\chi^2$ | *P* value | OR | OR value 95% CI |
|---|---|---|---|---|---|---|
| Age | 0.62 | 0.16 | 14.557 | 0.00 | 1.86 | 1.35~2.57 |
| Number of miscarriages | 0.68 | 0.15 | 19.972 | 0.00 | 1.97 | 1.46~2.65 |
| Birth weight of the second child | 2.38 | 0.16 | 220.74 | 0.00 | 10.78 | 7.88~14.75 |
| Uterine atony | 0.88 | 0.21 | 17.659 | 0.00 | 2.40 | 1.60~3.61 |
| Constant | −1.83 | 0.18 | 104.573 | 0.00 | 0.16 | ND |

miscarriages, birth weight of the second child, and uterine atony as significant predictors of PPH, all achieving statistical significance with p-values less than 0.05.

In Table 4, the odds of experiencing PPH increased by 86% with each additional year of age (OR = 1.86, 95% CI: 1.35 to 2.57). 95% CI means we are 95% confident that the true OR lies between 1.35–2.57. The regression coefficient for age was 0.62 (SE = 0.16), which was statistically significant (Chi-square = 4.557, $p < 0.01$). Women with a greater number of miscarriages faced nearly double the risk of PPH (OR = 1.97, 95% CI: 1.46 to 2.65). The associated regression coefficient was 0.68 (SE = 0.15), reflecting a strong link (Chi-square = 19.972, $p < 0.001$). As the birth weight of the second child increased, particularly exceeding 2500 grams, the risk of PPH escalated dramatically to an OR of 10.78 (95% CI: 7.88 to 14.75), indicating women giving birth to infants with high birth weight are approximately 10.78 times more likely to experience PPH compared to those with lower birth weight infants. The very high OR indicates a strong positive association between birth weight and PPH risk. We are 95% confident that the true OR lies between 7.88 and 14.75. This finding was supported by the highest regression coefficient in the model (B = 2.38) and a significant chi-square value of 220.74 ($p < 0.001$). The presence of uterine atony was associated with a 140% increase in the risk of PPH (OR = 2.40, 95% CI: 1.60 to 3.61), with a regression coefficient of 0.88 (SE = 0.21) and marked significance (Chi-square = 17.659, $p < 0.001$). The constant of the model was −1.83 (SE = 0.18), indicating a strong baseline effect, underscored by a significant chi-square value of 104.573 ($p < 0.001$). In short summary, the logistic regression model effectively highlighted the independent influence of age, previous miscarriages, birth weight of the second child, and uterine atony on the risk of PPH. These results suggest targeted monitoring and intervention strategies could be beneficial for women exhibiting these risk factors, thereby potentially mitigating the incidence of PPH in clinical practice.

## ROC Curve Analysis for Predicting Postpartum Hemorrhage

The diagnostic performance of individual risk factors and their combination for predicting postpartum hemorrhage (PPH) was assessed using Receiver Operating Characteristic (ROC) curve analysis. The Area Under the Curve (AUC), p-values, and 95% confidence intervals (CIs) were calculated to evaluate the predictive accuracy of each factor (Table 5 and Figure 5). The ROC analysis for age showed an AUC of 0.559, indicating limited predictive power. This model was statistically significant (p = 0.001, 95% CI: 0.524–0.594). The narrow CIs are due to the large sample size and rigorous matching strategy, which reduced variability. This predictor number of miscarriages had an AUC of 0.594, suggesting moderate predictive ability, with statistical significance ($p < 0.001$, 95% CI: 0.56–0.628). Demonstrating a higher AUC of 0.74, this factor birth weight of the second child significantly predicts PPH, ($p < 0.001$, 95% CI: 0.709–0.77). This

**Table 5** ROC Curve Analysis for Predicting Postpartum Hemorrhage

| Variables | AUC | *P* | 95% CI |
|---|---|---|---|
| Age | 0.559 | 0.001 | 0.524–0.594 |
| Number of miscarriages | 0.594 | 0.000 | 0.56–0.628 |
| Birth weight of the second child | 0.74 | 0.000 | 0.709–0.77 |
| Uterine atony | 0.549 | 0.006 | 0.514–0.583 |
| Combined Predictive Probability | 0.805 | 0.000 | 0.778–0.831 |

 https://doi.org/10.2147/IJWH.S516263 

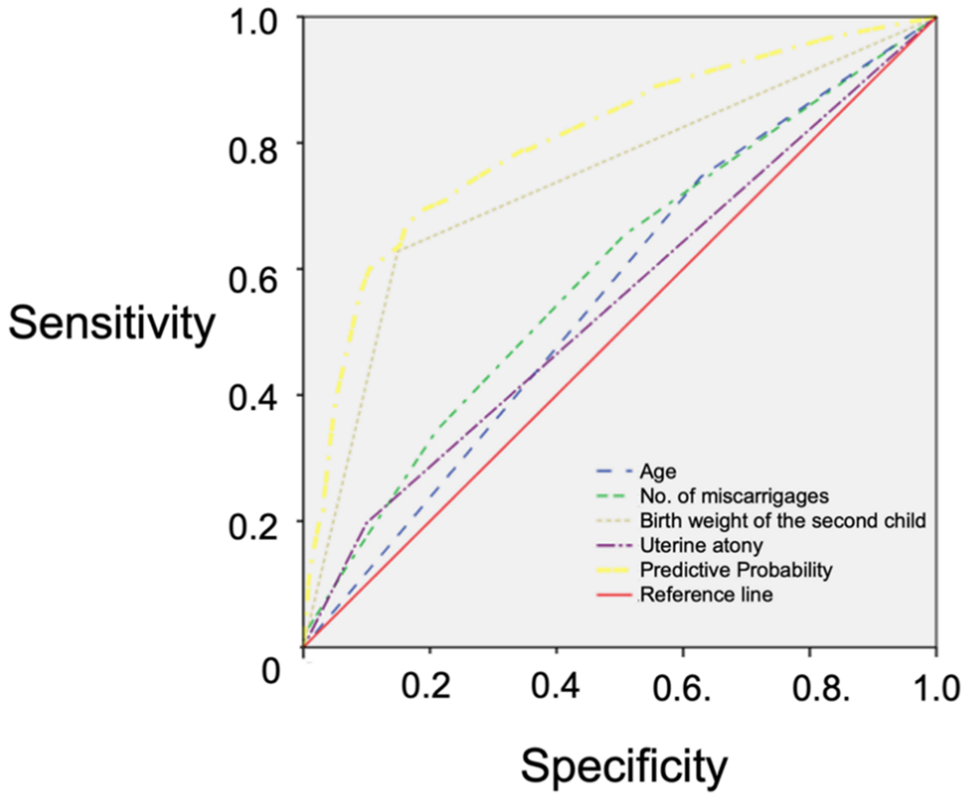


**Figure 5** ROC Curve Analysis for Predicting Postpartum Hemorrhage. This figure illustrates the Receiver Operating Characteristic (ROC) curves for various independent and combined predictors of postpartum hemorrhage (PPH). Each curve represented the trade-off between sensitivity (true positive rate) and specificity (true negative rate) for the respective predictor: Blue Dashed Line: Age; Green Dash-Dot Line: Number of Miscarriages; Purple Dotted Line: Birth Weight of the Second Child; Yellow Long Dash Line: Uterine Atony; Magenta Solid Line: Combined Predictive Probability.

factor uterine atony showed an AUC of 0.549, reflecting limited efficacy in predicting PPH ($p = 0.006$, 95% CI: 0.514–0.583). When combining all predictors, the ROC curve analysis yielded a much-improved AUC of 0.805, indicating excellent predictive accuracy. This combined model was highly significant ($p < 0.001$, 95% CI: 0.778–0.831), underscoring the enhanced diagnostic capability when multiple factors are considered together.

## Discussion

The successive shifts from a "two-child" policy in 2016 to a "three-child" policy in 2021 in China have notably influenced reproductive intentions among the population, increasing the number of women seeking to conceive after IUD removal. However, the policy raised concerns about the safety of childbirth, specifically regarding the risk of PPH. This study comprehensively investigates the multifaceted risk factors contributing to postpartum hemorrhage (PPH), a major complication and leading cause of maternal mortality. Special emphasis is placed on the use of IUDs within the framework of China's changing birth policies.

Our findings indicate that the rate of PPH following vaginal delivery was 7.6%, which is consistent with previous report ranging from 2.88% to 15.4 in China, depending on regional health care practices and population characteristics.[3] The rate reflects the ongoing need for effective risk assessment and management strategies to reduce PPH incidence. Univariate analysis identified age, history of miscarriages, gestational week, number of fetuses, birth weight, placental adhesion, and uterine atony as significant risk factors.[11–13] Notably, advanced maternal age correlated with an increased bleeding risk, approximately 1.9 times higher,[14] likely due to physiological declines associated with aging. Our finding showed a 1.86 times higher risk of PPH with each additional year of maternal age. The association between advanced maternal age and PPH risk is consistent with other studies, which report ORs ranging 2.2 (for women with age 35–39.9) to 1.98 (for women with age≥40).[4] As maternal age increases, the risk of PPH also increases. This may be due to age-related physiological changes, such as reduced uterine muscle tone or increased likelihood of pregnancy complications. This finding suggests that older women carrying larger babies should be closely monitored for PPH risk.

Women with a history of miscarriages faced nearly twice the risk of PPH compared to those without, possibly due to endometrial and myometrial damage from repeated miscarriages.[15,16] This emphasizes the importance of comprehensive obstetric history assessments during prenatal visits to identify high-risk patients. Overdue pregnancies, which comprise between 1% and 10% of all pregnancies, present increased risks due to placental overgrowth, basal thickening, and decreased placental function, potentially leading to heightened rates of cesarean sections, prolonged labor, and notably, PPH.[17,18] Interestingly, our study reported a lower incidence rate of overdue pregnancies than typically noted, which may be attributed to standardized prenatal care and proactive interventions for pregnancies beyond 41 weeks.

Conditions such as multiple pregnancies and macrosomia were closely linked to PPH due to excessive uterine stretching, potentially impeding effective uterine contractions.[19] Our data also indicated that high birth weight is a major risk factor (OR: 10.78, 95% CI: 7.88 to 14.75) for PPH, likely due to increased uterine distension, which can impair effective uterine contractions (uterine atony) after delivery. The high OR for birth weight (10.78) observed in this study is notably higher than global averages, potentially reflecting regional dietary patterns and increasing gestational diabetes rates in China. This aligns with other studies reporting high macrosomia rates in East Asian populations.[20] The high prevalence of macrosomia is consistent with increasing obesity rates and gestational diabetes in China, possibly influenced by dietary and lifestyle changes.[21]

While studies have suggested that hypertension and diabetes are related to PPH, our research did not find significant associations between gestational diabetes, hypertension, and PPH.[22] The lack of significant associations may be attributed to proactive prenatal management in the study population, potentially mitigating these risks. Regarding the contraceptive mechanism of IUDs, they function by mechanically compressing the endometrium and disrupting sperm activity through copper ions.[22,23] It's reported that IUD use may induce some side effects like abdominal pain and menstrual irregularities.[24–27] Furthermore, research by Hu et al[28] has observed that high concentrations of copper ions post-IUD placement could cause cytotoxic effects. Microscopic examinations have revealed disorganized endometrial cell structures and partial cell death, while raise concerns about potential long-term impacts on subsequent pregnancies, including the risk of PPH. Nonetheless, other studies have found no increased risk of secondary infertility or ectopic pregnancy associated with IUD use.[14,29] Our study showed no significant associations between IUD usage, type, duration, and PPH. This suggests that the local inflammatory responses and side effects triggered by IUDs might not cause enduring endometrial damage or affect placental implantation adversely. Although no significant association was found between IUD use and PPH, this finding contributes to the ongoing debate about the long-term effects of IUDs on reproductive health. Our results support the continued use of IUDs as a safe contraceptive method in multiparous women planning second births.

Multivariate logistic regression confirmed age, number of miscarriages, birth weight, and uterine atony as independent risk factors for PPH. The combined predictive model (AUC 0.805) demonstrates excellent predictive accuracy, highlighting the importance of targeted monitoring for high-risk groups, particularly older mothers and those with macrosomic infants. Although stratification by PPH severity and interaction analysis were not conducted, the primary objective was to identify overall risk factors. Future multicenter studies could explore severity-specific risk patterns and potential interactions. The matched design and rigorous inclusion criteria minimized bias, supporting the robustness of the findings.

Based on these findings, targeted prenatal risk assessments are recommended for women with advanced maternal age, multiple miscarriages, high birth weight, and uterine atony. Enhance monitoring and proactive management, including early administration of uterotonic agents and careful labor management, could reduce the incidence of PPH in these high-risk groups.

This study, while comprehensive in its analysis of various risk factors for postpartum hemorrhage (PPH), has several limitations. Firstly, 1048 participants were involved in this study. They may not fully capture the wider variability in PPH risk factors across different populations or geographic regions, although they are sufficient for statistical analysis. Impact of COVID-19 on care delivery, addressing potential practice changes and seasonal variations during the 2021–2023 study period, as well as hospital-level clustering effects, may have influenced the findings. Consequently, the findings might not be universally generalizable. Future studies should validate these findings in diverse populations. Additionally, some potentially significant risk factors were not considered in this study. For instance, detailed socioeconomic factors, lifestyle behaviors, BMI and genetic predispositions were not included, which might also influence the risk of PPH. The matched design in this study minimized selection bias.

In conclusion, advanced maternal age, multiple miscarriages, high birth weight, and uterine atony are significant risk factors for PPH. No significant association was found between IUD use and PPH. Targeted monitoring and proactive management are recommended for high-risk groups.

## Data Sharing Statement

The datasets used and analysed during the current study available from the corresponding author on reasonable request.

## Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Lianyungang Maternal and Child Health Hospital (Protocol Number LYG-MEP2021001). All methods were carried out in accordance with Declaration of Helsinki.

## Consent for Publication

Informed consent was obtained from all the participants.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declared that they have no conflicts of interest regarding this work.

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