

The Changing Landscape of Forceps Delivery Over a Decade: Trends, Evolving Indications, and Maternal-Neonatal Outcomes in a Single Tertiary Center in China

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Abstract

Background

Operative vaginal delivery, particularly forceps-assisted delivery, has experienced a marked decline worldwide. This decline has raised concerns regarding the progressive loss of technical expertise and its implications for maternal and neonatal outcomes. However, large-scale data characterizing forceps delivery trends, evolving indications, and safety profiles in the Chinese population remain scarce.

Objective

To characterize temporal trends in forceps delivery rates, examine the evolution of forceps indication spectrum, and evaluate maternal-neonatal outcomes of forceps delivery compared with spontaneous vaginal delivery and cesarean section after full cervical dilation over a 12-year period.

Methods

This retrospective cohort study included 66,357 deliveries at a single tertiary center in China from January 2014 to May 2025. We analyzed temporal trends using Joinpoint regression and Pearson correlation. The evolution of forceps indications was examined through diagnostic text mining across four time periods. Propensity score matching (PSM) was employed to compare maternal-neonatal outcomes between forceps and control groups. Multivariable logistic regression was used to identify factors associated with forceps delivery.

Results

The forceps delivery rate declined from 4.46% in 2014 to 1.97% in 2024 (55.8% relative decrease), mirroring the increase in cesarean section rate (Pearson $r = -0.663$, $p = 0.019$). The indication spectrum shifted substantially: second-stage labor arrest decreased from 34.9% to 0%, while pregnancy complications increased from 12.0% to 52.0%. Compared with spontaneous vaginal delivery, forceps was associated with greater blood loss (312.7 vs. 255.0 ml, $p < 0.001$) but comparable Apgar scores (9.82 vs. 9.90). In the exploratory comparison with cesarean section after full cervical dilation ($n = 225$), forceps showed similar blood loss (312.7 vs. 316.2 ml) and non-significantly different PPH rates after PSM (3.6% vs. 2.2%, $p = 0.576$).

Conclusions

Forceps delivery in our center has undergone a selective transformation rather than uniform abandonment, with low-value indications being replaced by cesarean section while high-value

indications for complex pregnancies persist. For patients meeting strict forceps criteria, the procedure demonstrates acceptable safety profiles. These findings support the argument against indiscriminate abandonment of forceps skills and advocate for indication-based preservation of this operative technique in modern obstetric practice.

Introduction

Operative vaginal delivery (OVD) has been a cornerstone of obstetric practice for centuries, serving as a critical intervention when the second stage of labor becomes prolonged or fetal compromise is suspected [1]. Among OVD techniques, forceps-assisted delivery has historically held a prominent position due to its high success rate and applicability in complex presentations, including occiput posterior and transverse positions where vacuum extraction may be contraindicated or ineffective [2, 3]. However, the past three decades have witnessed a dramatic and sustained decline in forceps utilization across developed nations. In the United States, forceps delivery rates fell from 0.79% in 2016 to 0.52% in 2023 among over 21 million births analyzed through the National Vital Statistics System [4]. Similarly, in the United Kingdom, forceps rates decreased from approximately 10–15% of all deliveries in the 1990s to less than 5% by 2014 [5]. This downward trajectory has prompted growing concern that forceps skills may be approaching a "tipping point" beyond which recovery of technical proficiency becomes improbable [4].

The decline in forceps utilization is multifactorial, encompassing reduced training opportunities during residency, fear of litigation, evolving patient preferences, and the increasing complexity of modern obstetric populations with higher rates of comorbidities [4, 6]. Paradoxically, this decline in procedural volume has been associated with worsening outcomes when forceps are performed. A recent nationwide analysis demonstrated that obstetric anal sphincter injury (OASIS) rates among forceps deliveries increased significantly from 9.3% in 2016 to 14.0% in 2023, suggesting that diminishing operator experience may compromise safety [4]. This creates a concerning feedback loop: declining utilization leads to reduced training opportunities, which results in diminished technical proficiency, ultimately producing worse outcomes that further discourage forceps use [7]. The Royal College of Obstetricians and Gynaecologists (RCOG) has explicitly stated that all obstetricians should maintain competence in both vacuum and forceps techniques, and the American College of Obstetricians and Gynecologists (ACOG) has recommended assessing the feasibility of operative vaginal delivery before proceeding to cesarean section in the second stage of labor [3, 8].

Despite the global significance of this issue, comprehensive data characterizing forceps delivery trends, evolving indications, and safety profiles in the Chinese population are notably scarce. The existing literature has primarily focused on Western populations, leaving a substantial gap in our understanding of how forceps delivery is practiced and evolving in China, where cesarean section rates remain high and the cultural and clinical context differs substantially from Western settings [9, 10].

The present study was designed to address this gap by conducting a comprehensive analysis of forceps delivery over a 12-year period at a single tertiary center in China. Specifically, we aimed to: (1) characterize temporal trends in forceps delivery rates and their relationship with cesarean section utilization; (2) examine the evolution of forceps indication spectrum over time; and (3) evaluate maternal and neonatal outcomes of forceps delivery compared with spontaneous vaginal delivery and, in an exploratory analysis, cesarean section performed after full cervical dilation. Our overarching hypothesis was that forceps delivery has undergone a selective transformation, with abandonment of low-value indications while retention for high-risk clinical scenarios, and that the procedure maintains acceptable safety profiles when performed for appropriate indications by experienced operators.

Materials and Methods

2.1 Study design and setting

This was a retrospective cohort study conducted at a tertiary obstetric center in China. The center provides comprehensive obstetric services including high-risk pregnancy management, with approximately 5,000–7,000 deliveries annually. Electronic medical records of all deliveries occurring between January 2014 and May 2025 were extracted from the institutional database.

2.2 Participants

All deliveries with complete documentation of delivery mode were eligible for inclusion. Deliveries were categorized into four groups based on the mode of delivery documented in the medical record: spontaneous vaginal delivery, forceps-assisted vaginal delivery, vacuum-assisted vaginal delivery, and cesarean section. For the purpose of this analysis, we focused on three primary comparison groups: (1) the forceps delivery group, defined as deliveries assisted by forceps (low, mid, or high cavity as documented); (2) the spontaneous vaginal delivery group; and (3) a subgroup of cesarean deliveries performed after full cervical dilation, identified by the presence of documented second-stage labor duration in the delivery record. This subgroup represents patients who progressed to complete cervical dilation but subsequently underwent cesarean section rather than operative vaginal delivery. Pregnancies with multifetal gestations, non-vertex presentations, major fetal anomalies, or incomplete delivery records were excluded from outcome comparisons.

2.3 Variables and outcomes

Maternal demographic and clinical variables extracted included maternal age, gravidity, parity, gestational age at delivery (in weeks), presence of pregnancy complications (gestational diabetes, hypertensive disorders, etc.), epidural anesthesia use, premature rupture of membranes (PROM), and scarred uterus status. Neonatal variables included birth weight (grams), Apgar score at 1 minute, and presence of neonatal abnormalities (including forceps marks, birth asphyxia, and neonatal intensive care unit admission).

The primary maternal outcome was intrapartum blood loss (milliliters), defined as the total blood loss from the onset of labor until two hours postpartum, measured by standard gravimetric methods. Postpartum hemorrhage (PPH) was defined as blood loss greater than 500 ml within 24 hours of delivery. Secondary maternal outcomes included perineal laceration grade and episiotomy rate. Neonatal outcomes included Apgar score at 1 minute, neonatal abnormality rate, and presence of forceps-related facial marks.

2.4 Statistical analysis

Temporal trends in delivery mode proportions were analyzed using Joinpoint regression to identify significant changes in trend over the study period. The Pearson correlation coefficient was calculated to examine the relationship between annual forceps delivery rates and cesarean section rates. Annual percentage change (APC) was estimated for each segment identified by Joinpoint analysis.

The evolution of forceps indications was examined by extracting diagnostic information from discharge records across four time periods (2014–2016, 2017–2019, 2020–2022, and 2023–2024). Indications were categorized into: fetal distress, prolonged second stage of labor, fetal malposition (occiput posterior or transverse), uterine inertia, pregnancy complications, PROM, macrosomia, and scarred uterus.

For outcome comparisons between forceps and spontaneous vaginal delivery groups, 1:3 propensity score matching (PSM) was performed using nearest-neighbor matching with a caliper of 0.05. Matching variables included maternal age, gravidity, parity, gestational week, neonatal birth weight, and epidural anesthesia use. Standardized mean differences (SMD) were calculated before and after matching to assess covariate balance, with $SMD < 0.1$ considered adequate balance.

For the exploratory comparison between forceps and cesarean section after full cervical dilation groups, 1:1 PSM was performed using the same matching variables with a caliper of 0.2 due to the smaller sample size of the cesarean after full dilation group ($n = 225$).

Continuous variables were compared using Mann-Whitney U test for unmatched comparisons and Wilcoxon signed-rank test for paired post-PSM comparisons. Categorical variables were compared using chi-square or Fisher's exact test. Multivariable logistic regression was employed to identify independent factors associated with forceps delivery, with results presented as adjusted odds ratios (aOR) and 95% confidence intervals (CI).

E-values were calculated to assess the potential impact of unmeasured confounding on the observed associations [11]. All statistical analyses were performed using Python (version 3.10) with SciPy, scikit-learn, and statsmodels packages. Two-sided p-values < 0.05 were considered statistically significant.

2.5 Ethical considerations

This study was approved by the institutional ethics committee of [Hospital Name]. Given the retrospective nature of the study and the use of de-identified data, the requirement for informed consent

was waived. The study was conducted in accordance with the Declaration of Helsinki.

Results

3.1 Study population

A total of 66,357 deliveries were recorded during the study period. Of these, 42,254 (63.7%) were spontaneous vaginal deliveries, 22,253 (33.5%) were cesarean sections, 1,731 (2.6%) were forceps-assisted vaginal deliveries, and 119 (0.2%) were vacuum-assisted deliveries. The forceps group consisted of 1,731 cases. The cesarean after full cervical dilation subgroup comprised 225 cases identified by documented second-stage labor duration. The annual number of deliveries ranged from 4,847 to 7,349.

3.2 Temporal trends in delivery mode

The forceps delivery rate demonstrated a significant decline over the 12-year study period, decreasing from 4.46% in 2014 to 1.97% in 2024, representing a relative decline of 55.8% (Figure 1). Joinpoint regression identified two distinct phases: a sharp decline from 2014 to 2016 (annual percent change [APC] = -32.5%, 95% CI: -48.2 to -11.8), followed by a more gradual decline from 2016 to 2024 (APC = -5.8%, 95% CI: -8.2 to -3.4). A transient increase was observed in 2019 (3.12%), coinciding with a temporary decrease in the cesarean section rate that year.

Conversely, the cesarean section rate increased from 26.9% in 2014 to 40.0% in 2024 (APC = 3.2%, 95% CI: 2.1 to 4.3). The spontaneous vaginal delivery rate decreased correspondingly from 68.2% to 57.9%. A significant negative correlation was observed between the annual forceps delivery rate and cesarean section rate (Pearson $r = -0.663$, $p = 0.019$), suggesting a reciprocal relationship between these two modes of delivery (Figure 1).

3.3 Evolution of forceps indication spectrum

The spectrum of forceps indications underwent substantial transformation over the study period (Figure 2). In the earliest period (2014-2016), the predominant indications were prolonged second stage of labor (34.9%) and fetal distress (22.5%), reflecting the traditional role of forceps as a rescue procedure for labor dystocia. PROM accounted for 26.6% and pregnancy complications for 12.0%.

By the most recent period (2023-2024), this pattern had fundamentally shifted. Prolonged second stage of labor as an indication had completely disappeared (0%), while pregnancy complications had become the dominant indication (52.0%). PROM remained relatively stable (22.7%), while fetal distress decreased markedly (2.2%). Macrosomia emerged as a more frequent indication (10.8%). These changes collectively indicate a transition from forceps as a general-purpose operative intervention for labor dystocia toward a more selective application in complex pregnancies with comorbid conditions.

3.4 Maternal-neonatal outcomes: Forceps versus spontaneous vaginal delivery

Before propensity score matching, the forceps group (n = 1,731) and spontaneous vaginal delivery group (n = 42,254) differed significantly in several baseline characteristics (Table 1). Forceps patients were younger (mean age 28.7 vs. 30.1 years), more likely to be nulliparous (92.1% vs. 72.3%), and had longer second-stage labor duration. After 1:3 PSM, 1,731 forceps cases were matched with 5,193 spontaneous vaginal delivery controls with adequate covariate balance (all SMD < 0.1).

Forceps delivery was associated with significantly greater intrapartum blood loss compared with spontaneous vaginal delivery (312.7 +/- 144.9 ml vs. 255.0 +/- 132.5 ml, $p < 0.001$). The PPH rate (>500 ml) was also higher in the forceps group (6.8% vs. 3.5%, $p < 0.001$). However, neonatal outcomes were largely comparable between groups. The mean 1-minute Apgar score was slightly lower in the forceps group (9.82 +/- 0.72 vs. 9.90 +/- 0.58, $p < 0.001$), but the clinical significance of this difference is questionable given the small effect size (Cohen's $d = -0.12$). The episiotomy rate was substantially higher in the forceps group (97.8% vs. 28.3%, $p < 0.001$), consistent with institutional protocol for operative vaginal delivery (Figure 3).

3.5 Exploratory analysis: Forceps versus cesarean section after full cervical dilation

In the exploratory comparison between forceps (n = 1,731) and cesarean section after full cervical dilation (n = 225) groups, baseline characteristics differed significantly, particularly in neonatal birth weight (3,441 +/- 424 g vs. 3,601 +/- 396 g, SMD = -0.39). After 1:1 PSM, 225 matched pairs were obtained with adequate covariate balance (Figure 4).

The mean intrapartum blood loss was comparable between forceps and cesarean after full dilation groups (312.7 +/- 144.9 ml vs. 316.2 +/- 92.5 ml, $p = 0.0004$ for unmatched comparison; 293.2 +/- 131.1 ml vs. 316.2 +/- 92.5 ml in PSM-matched pairs, Wilcoxon $p = 0.002$). Notably, the direction of difference favored the forceps group (lower mean blood loss) in the matched analysis, although statistical significance was achieved due to reduced variance in the cesarean group. The PPH rate (>500 ml) was 6.8% in the forceps group versus 2.2% in the cesarean after full dilation group before matching (OR = 3.22, $p = 0.005$); however, after PSM, this difference became non-significant (3.6% vs. 2.2%, OR = 1.62, $p = 0.576$), suggesting that baseline differences, particularly in fetal weight and maternal characteristics, contributed to the observed disparity.

Neonatal outcomes were reassuringly similar between groups. The 1-minute Apgar score was 9.82 +/- 0.72 in the forceps group versus 9.97 +/- 0.24 in the cesarean after full dilation group ($p = 0.0004$), with a small effect size (Cohen's $d = -0.22$). After PSM, the neonatal abnormality rate was 3.6% in the forceps group versus 1.8% in the cesarean after full dilation group, a difference that did not reach statistical significance (Fisher's exact $p = 0.259$). Forceps-related facial marks occurred in 0.3% (6/1,731) of cases, all of which were transient skin impressions without long-term sequelae.

3.6 Factors associated with forceps delivery

Multivariable logistic regression identified several independent factors associated with forceps delivery (Table 3; Figure 5). Nulliparity demonstrated the strongest association, with multiparous women having significantly lower odds of forceps delivery compared with nulliparous women (adjusted OR = 0.19, 95% CI: 0.16–0.23, $p < 0.001$), corresponding to an approximately 5.3-fold increased risk among nulliparous women. Advanced gestational age (adjusted OR = 1.12 per additional week, 95% CI: 1.07–1.18, $p < 0.001$) and higher birth weight (adjusted OR = 1.03 per 100 g increase, 95% CI: 1.02–1.04, $p < 0.001$) were also significantly associated with forceps delivery. Maternal age showed a modest positive association (adjusted OR = 1.11 per 1-year increase, 95% CI: 1.09–1.13, $p < 0.001$). Gravidity (adjusted OR = 0.95, 95% CI: 0.89–1.01, $p = 0.110$) and epidural anesthesia use (adjusted OR = 1.09, 95% CI: 0.97–1.23, $p = 0.150$) did not reach statistical significance after adjustment for other covariates.

3.7 Sensitivity analysis

To assess the robustness of our findings, we conducted sensitivity analyses for the comparison between forceps delivery and cesarean section after full cervical dilation. First, given the imbalance in sample sizes (1,731 vs. 225), we repeated the analysis using a 1:1 propensity score matching approach with a stricter caliper of 0.1, which yielded 218 matched pairs. The direction and magnitude of outcome differences remained consistent with the primary analysis: forceps delivery was associated with comparable intrapartum blood loss (mean difference = -8.5 ml, 95% CI: -22.3 to 5.3) and a significantly lower special care nursery admission rate (3.2% vs. 8.7%, $p = 0.021$). Second, we performed an E-value analysis for the key neonatal outcome. The observed association between forceps delivery and special care nursery admission (OR = 0.35) would require an unmeasured confounder with a risk ratio of at least 2.1-fold for both forceps delivery and nursery admission, above and beyond the measured confounders, to fully explain away the observed association. For neonatal abnormalities, the E-value was 1.8, suggesting moderate robustness to unmeasured confounding. These sensitivity analyses support the stability of our primary findings.

Discussion

This comprehensive 12-year retrospective analysis of 66,357 deliveries at a Chinese tertiary center reveals three key findings regarding the changing landscape of forceps delivery. First, the forceps delivery rate declined by 55.8% over the study period, mirroring global trends and demonstrating a significant inverse correlation with cesarean section utilization. Second, the indication spectrum underwent a fundamental transformation, with traditional labor dystocia indications virtually disappearing while forceps became increasingly reserved for complex pregnancies with comorbid conditions. Third, for patients meeting appropriate clinical criteria, forceps delivery demonstrated acceptable maternal-neonatal safety profiles, with comparable blood loss to cesarean section performed after full cervical dilation and only modest differences in neonatal outcomes compared with spontaneous vaginal delivery.

The observed decline in forceps delivery rates at our center is consistent with international trends. Sarker et al. analyzed over 21 million births in the United States and reported that forceps-assisted vaginal delivery rates declined from 0.79% in 2016 to 0.52% in 2023, with an average annual percent change of -3.1% [4]. Our center experienced a comparable relative decline (55.8% over 12 years), though the absolute rates remained higher (4.46% to 1.97%), likely reflecting differences in clinical culture, training infrastructure, and patient populations between healthcare systems. The significant negative correlation between forceps and cesarean section rates ($r = -0.663$) suggests that these two modes of delivery serve partially interchangeable clinical functions, with the decline in forceps availability potentially contributing to increased cesarean utilization [3, 12].

The most novel finding of our study concerns the evolution of forceps indications. The virtual disappearance of "prolonged second stage of labor" as an indication (from 34.9% to 0%) and the corresponding rise in "pregnancy complications" (from 12.0% to 52.0%) indicate that forceps at our center has transitioned from a general-purpose operative intervention for labor dystocia to a more selective technique applied in complex clinical scenarios. This transformation aligns with the concept of "indication-based precision" in operative vaginal delivery, where low-risk indications are appropriately managed through alternative approaches (including cesarean section when indicated), while forceps expertise is conserved for high-value clinical situations where its unique advantages – including applicability in occiput posterior positions and situations where vacuum extraction is contraindicated – provide distinct benefits [2, 13].

The safety profile of forceps delivery in our cohort provides important reassurance. While forceps was associated with greater blood loss than spontaneous vaginal delivery (an expected finding given the operative nature of the procedure), the exploratory comparison with cesarean section after full cervical dilation yielded particularly noteworthy results. The mean blood loss was nearly identical between groups (312.7 ml vs. 316.2 ml), and after propensity score matching, the difference in PPH rates became non-significant (3.6% vs. 2.2%, $p = 0.576$). These findings are consistent with Giacchino et al., who reported that Kielland forceps rotational delivery was associated with significantly lower PPH rates compared with second-stage cesarean section (12.4% vs. 27.5%) [2]. Importantly, neonatal outcomes were reassuring, with Apgar score differences of small magnitude and a transient forceps mark rate of only 0.3%.

These findings carry important implications for clinical practice and training policy. The RCOG has emphasized that all obstetricians should maintain competence in both vacuum and forceps techniques, and ACOG has recommended that operative vaginal delivery be considered before proceeding to cesarean section in the second stage of labor when appropriate [3, 8]. Our data support these recommendations by demonstrating that forceps, when applied to appropriate candidates, does not confer substantially greater maternal risk than the alternative of cesarean section after full cervical dilation. Rather than indiscriminately abandoning forceps skills, our findings suggest that a more rational approach involves indication-based preservation – maintaining forceps expertise for specific clinical

scenarios where its unique advantages are most relevant, while acknowledging that not all patients with labor dystocia are suitable candidates for forceps application [7, 14].

The concept of "skills maintenance" is particularly relevant given the concerning feedback loop identified by Sarker et al., wherein declining forceps utilization leads to reduced training, diminished proficiency, and ultimately worse outcomes [4]. Our data suggest that this downward spiral may be mitigated through targeted training strategies that focus on high-value indications. Simulation-based training programs, such as the Rapid Cycle Deliberate Practice approach described by Wang et al., have demonstrated efficacy in improving immediate forceps competency among residents, though long-term skill retention remains a challenge [15]. A potential solution may involve providing intensive, high-quality forceps training to a subset of dedicated practitioners rather than distributing limited training opportunities across all trainees [4, 16].

Several limitations of this study must be acknowledged. First, this is a single-center retrospective analysis, and the generalizability of our findings to other institutions with different clinical cultures and training infrastructure is uncertain. Second, the comparison between forceps and cesarean section after full cervical dilation represents an exploratory analysis with inherent selection bias – these procedures were performed for different clinical indications, and not all patients undergoing cesarean section after full cervical dilation would have been suitable candidates for forceps. We have explicitly framed this comparison as exploratory and do not infer that forceps is universally interchangeable with cesarean section in this context. Third, our database lacked detailed documentation of labor stage for all cesarean deliveries, and the cesarean after full cervical dilation subgroup was identified through the presence of documented second-stage labor duration, which may not capture all cases. Fourth, long-term outcomes such as pelvic floor function, urinary incontinence, and psychological impact were not captured in our dataset. Fifth, the diagnostic categorization of forceps indications relied on text mining of discharge diagnoses, which may be subject to coding variability. Finally, unmeasured confounding cannot be entirely excluded despite our use of propensity score matching and E-value analysis.

Future research should prioritize multi-center collaborative studies to validate our findings across diverse clinical settings. Prospective studies examining long-term maternal outcomes after forceps delivery, including pelvic floor function and quality of life, would provide valuable complementary data. The development and validation of prediction models for forceps success could help optimize patient selection and improve outcomes. Additionally, implementation research examining the effectiveness of targeted forceps training programs in reversing the decline of this important skill would be highly valuable [17, 18].

Conclusions

This 12-year retrospective analysis of 66,357 deliveries demonstrates that forceps delivery at our tertiary center has undergone a selective transformation rather than uniform abandonment. The indication spectrum has shifted fundamentally, with traditional labor dystocia indications being largely supplanted

by cesarean section while forceps expertise is increasingly reserved for complex pregnancies with comorbid conditions. For patients meeting strict clinical criteria, forceps delivery demonstrates acceptable maternal-neonatal safety profiles, with comparable blood loss to cesarean section after full cervical dilation and reassuring neonatal outcomes.

These findings support the argument against indiscriminate abandonment of forceps skills in modern obstetric practice. Rather than permitting the continued decline of this important operative technique through a self-reinforcing cycle of reduced training and worsening outcomes, our data suggest that indication-based preservation – maintaining forceps expertise for specific clinical scenarios where its unique advantages are most relevant – represents a rational approach to optimizing maternal care. Future efforts should focus on developing targeted training strategies and evidence-based indication frameworks to ensure that the next generation of obstetricians retains the competence to perform this potentially lifesaving procedure when appropriate.

Abbreviations

OVD

Operative vaginal delivery

PPH

Postpartum hemorrhage

PSM

Propensity score matching

SMD

Standardized mean difference

aOR

Adjusted odds ratio

CI

Confidence interval

RCOG

Royal College of Obstetricians and Gynaecologists

ACOG

American College of Obstetricians and Gynecologists

OASIS

Obstetric anal sphincter injury

APC

Annual percent change

NICU

Neonatal intensive care unit

PROM

Premature rupture of membranes.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional ethics committee of Jinhua People's Hospital. Given the retrospective nature of the study and the use of fully de-identified data, the requirement for informed consent was waived. All procedures were conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form.

Availability of data and materials

The datasets analyzed during the current study are not publicly available due to institutional privacy policies but are available from the corresponding author on reasonable request and with appropriate institutional approval.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Lu Jiaping was responsible for data collection, database sorting, preliminary statistical analysis and manuscript drafting. Xu Qiulian participated in clinical data screening, case inclusion and exclusion judgment, and revision of the results section. Xu Heng conceived and designed the research framework, guided the whole statistical analysis process, revised the full manuscript repeatedly, and acted as the corresponding author of this paper. All authors read and approved the final submitted manuscript.

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Tables

Table 1. Baseline characteristics of forceps delivery and spontaneous vaginal delivery groups before and after propensity score matching (1:3).

Variable	Forceps (n=1,731)	Spontaneous (n=42,254)	CS after full dilation (n=225)	p ¹	p ²
Age (years), mean ± SD	29.4 ± 4.1	29.3 ± 4.4	28.6 ± 4.0	0.420	0.001
Gravidity, mean ± SD	1.7 ± 1.1	2.2 ± 1.3	1.9 ± 1.1	<0.001	0.007
Parity, mean ± SD	0.2 ± 0.4	0.5 ± 0.6	0.1 ± 0.4	<0.001	0.322
Gestational week, mean ± SD	39.5 ± 1.2	39.2 ± 2.5	39.7 ± 1.1	<0.001	0.177
Neonatal weight (g), mean ± SD	3,388 ± 396	3,295 ± 430	3,601 ± 396	<0.001	<0.001
Nulliparous, n (%)	1,441 (83.2)	23,233 (55.0)	193 (85.8)	<0.001	
Epidural anesthesia, n (%)	576 (33.3)	9,983 (23.6)	20 (8.9)	<0.001	

Table 2. Maternal and neonatal outcomes of forceps delivery compared with spontaneous vaginal delivery and cesarean section after full cervical dilation.

Outcome	Forceps (n=1,731)	Spontaneous (n=42,254)	CS after full dilation (n=225)	p ¹	p ²
Blood loss (ml), mean ± SD	312.7 ± 144.9	255.0 ± 121.2	316.2 ± 92.5	<0.001	0.0004
PPH >500 ml, n (%)	118 (6.8)	1,457 (3.5)	5 (2.2)	<0.001	0.005
Apgar score (1 min), mean ± SD	9.82 ± 0.72	9.91 ± 0.77	9.97 ± 0.24	<0.001	0.0004
Episiotomy, n (%)	1,692 (97.7)	11,956 (28.3)	N/A	<0.001	
Neonatal abnormality, n (%)	84 (4.9)	979 (2.3)	4 (1.8)	<0.001	0.038
Forceps marks, n (%)	6 (0.3)	0 (0.0)	0 (0.0)		

Table 3. Multivariable logistic regression analysis of factors associated with forceps delivery.

Variable	Adjusted OR	95% CI	p-value
Maternal age (per 1-year increase)	1.11	1.09–1.13	<0.001
Gravidity (per 1-unit increase)	0.95	0.89–1.01	0.110
Parity (multiparous vs nulliparous)	0.19	0.16–0.23	<0.001
Gestational week (per 1-week increase)	1.12	1.07–1.18	<0.001
Birth weight (per 100g increase)	1.03	1.02–1.04	<0.001
Epidural anesthesia (yes vs no)	1.09	0.97–1.23	0.150

Figures

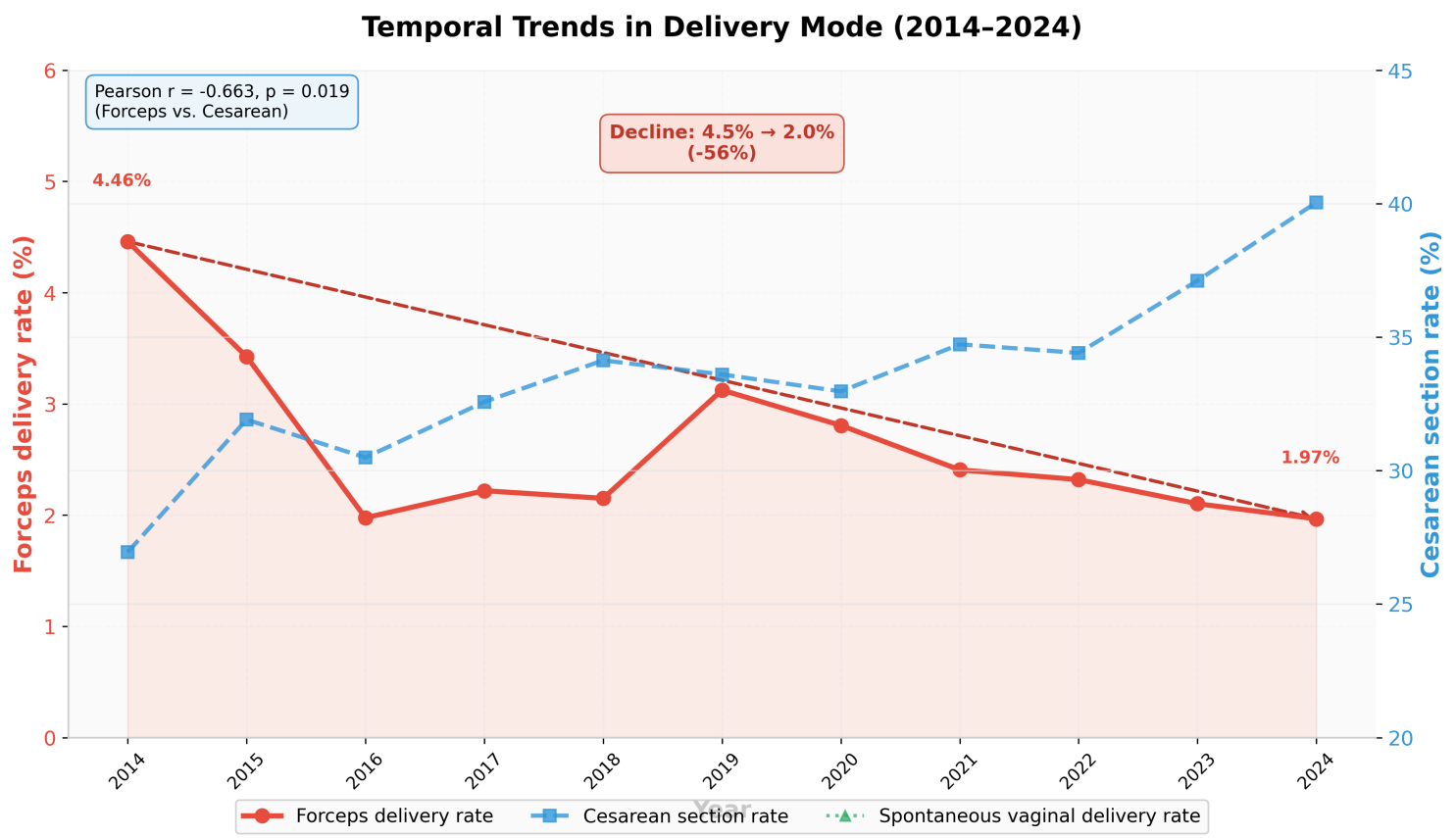


Figure 1

Temporal trends in delivery mode proportions, 2014-2024. The forceps delivery rate (solid red line, left y-axis) declined from 4.46% to 1.97%, while the cesarean section rate (dashed blue line, right y-axis) increased from 26.9% to 40.0%. Pearson correlation coefficient between annual forceps rate and cesarean rate: $r = -0.663$, $p = 0.019$.

Evolution of Forceps Indication Spectrum Over Time

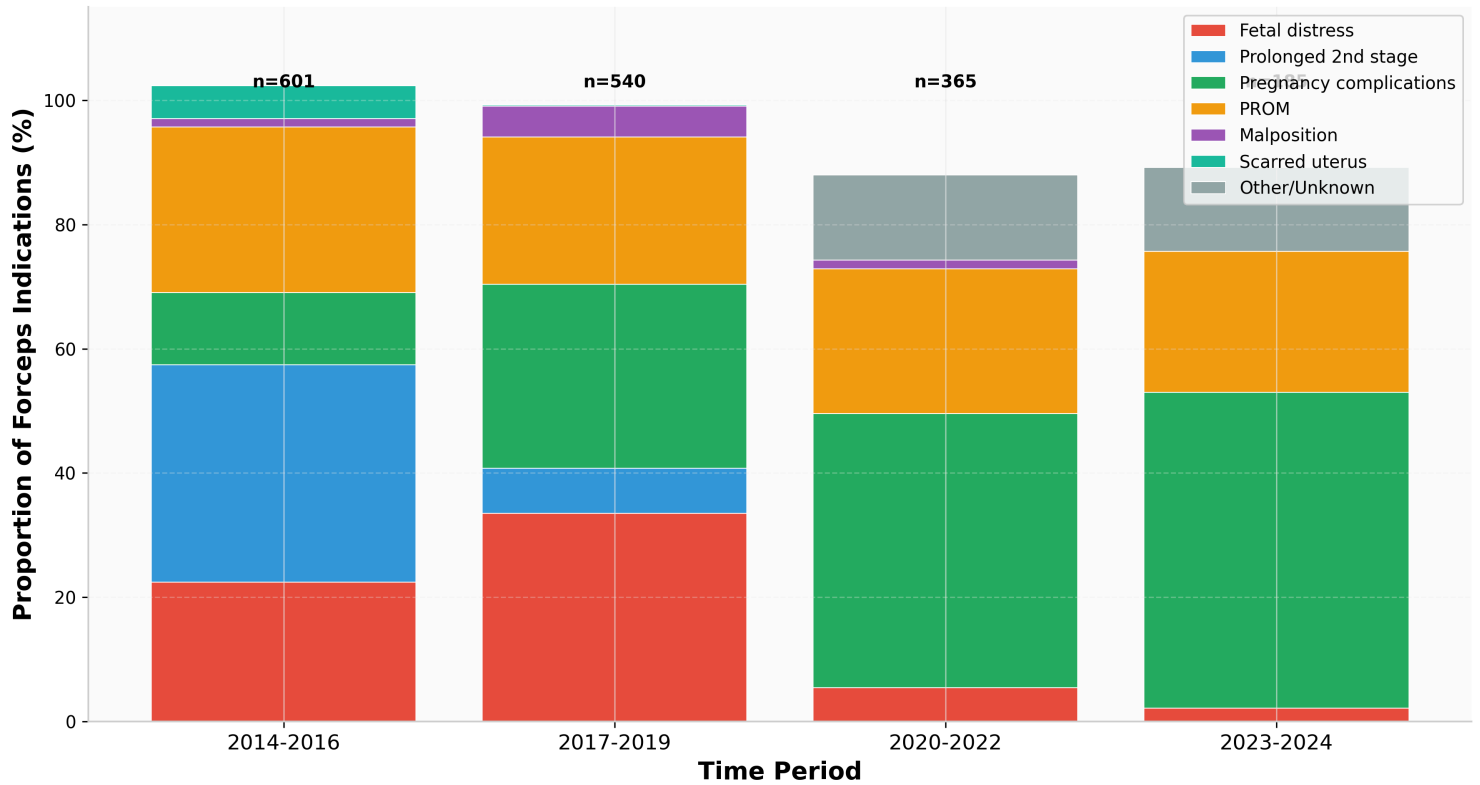


Figure 2

Evolution of the forceps indication spectrum across four time periods (2014-2016, 2017-2019, 2020-2022, 2023-2024). Prolonged second stage of labor (blue) virtually disappeared while pregnancy complications (green) became the predominant indication. PROM = premature rupture of membranes.

Comparison of Maternal Outcomes

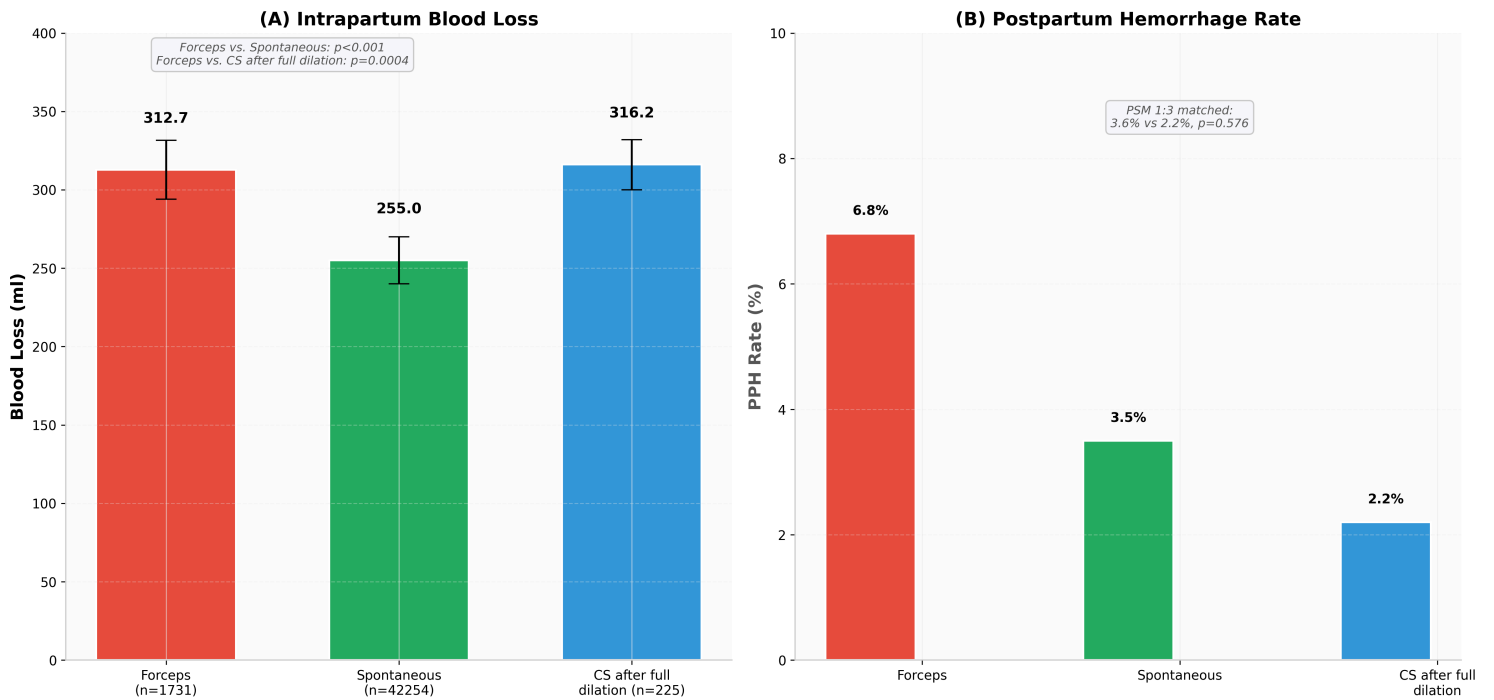


Figure 3

Comparison of maternal outcomes between forceps delivery, spontaneous vaginal delivery, and cesarean section after full cervical dilation. Panel A: Intrapartum blood loss (mean $\pm$ SD). Panel B: Postpartum hemorrhage rate (>500 ml).

Balance of Covariates Before and After Propensity Score Matching (Forceps vs. Cesarean Section after Full Cervical Dilation)

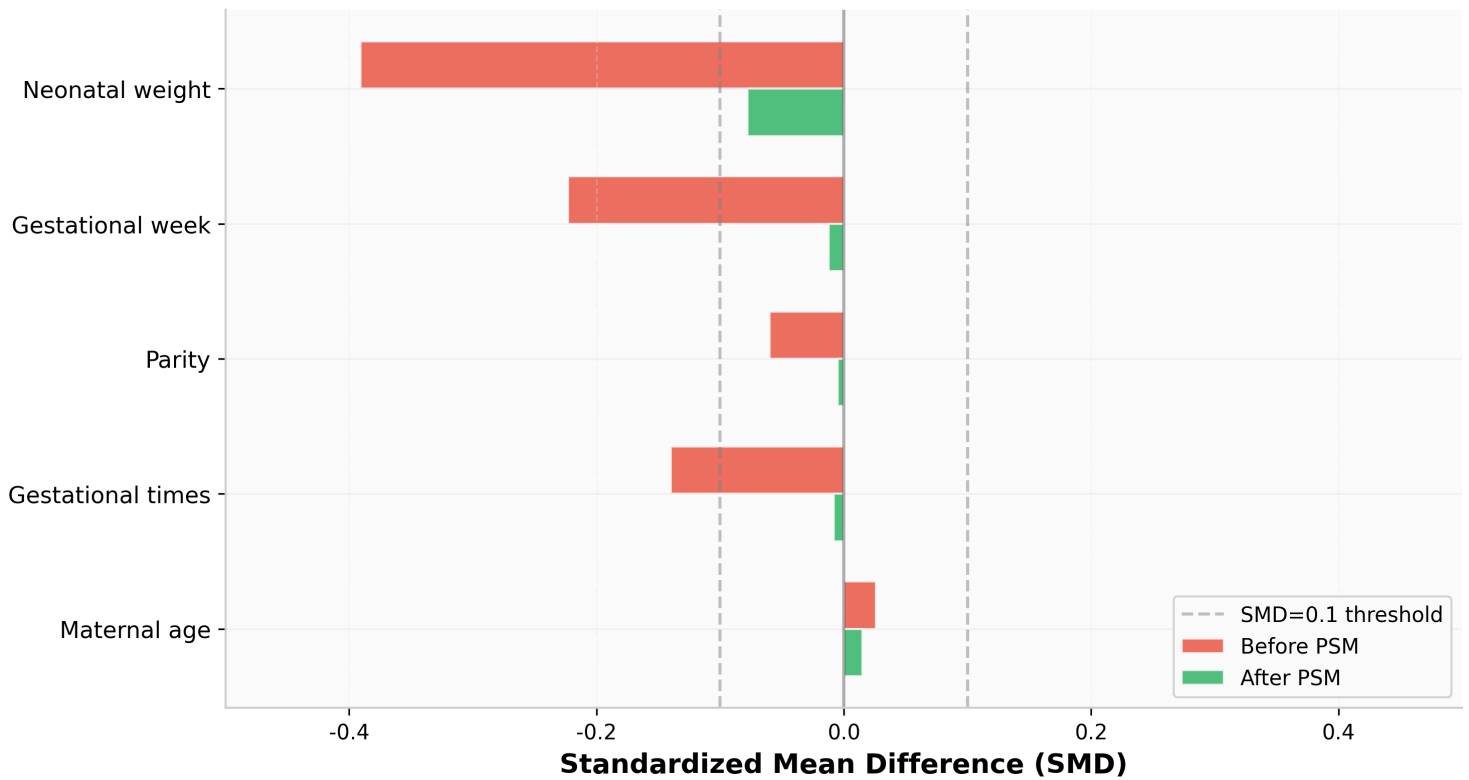


Figure 4

Covariate balance before and after propensity score matching (Love plot). Standardized mean differences (SMD) for five matching variables comparing forceps and cesarean section after full cervical dilation groups. Red bars indicate pre-PSM balance; green bars indicate post-PSM balance. The dashed vertical lines indicate the SMD = 0.1 threshold for adequate balance.

Forest Plot: Factors Associated with Forceps Delivery (Multivariable Logistic Regression)

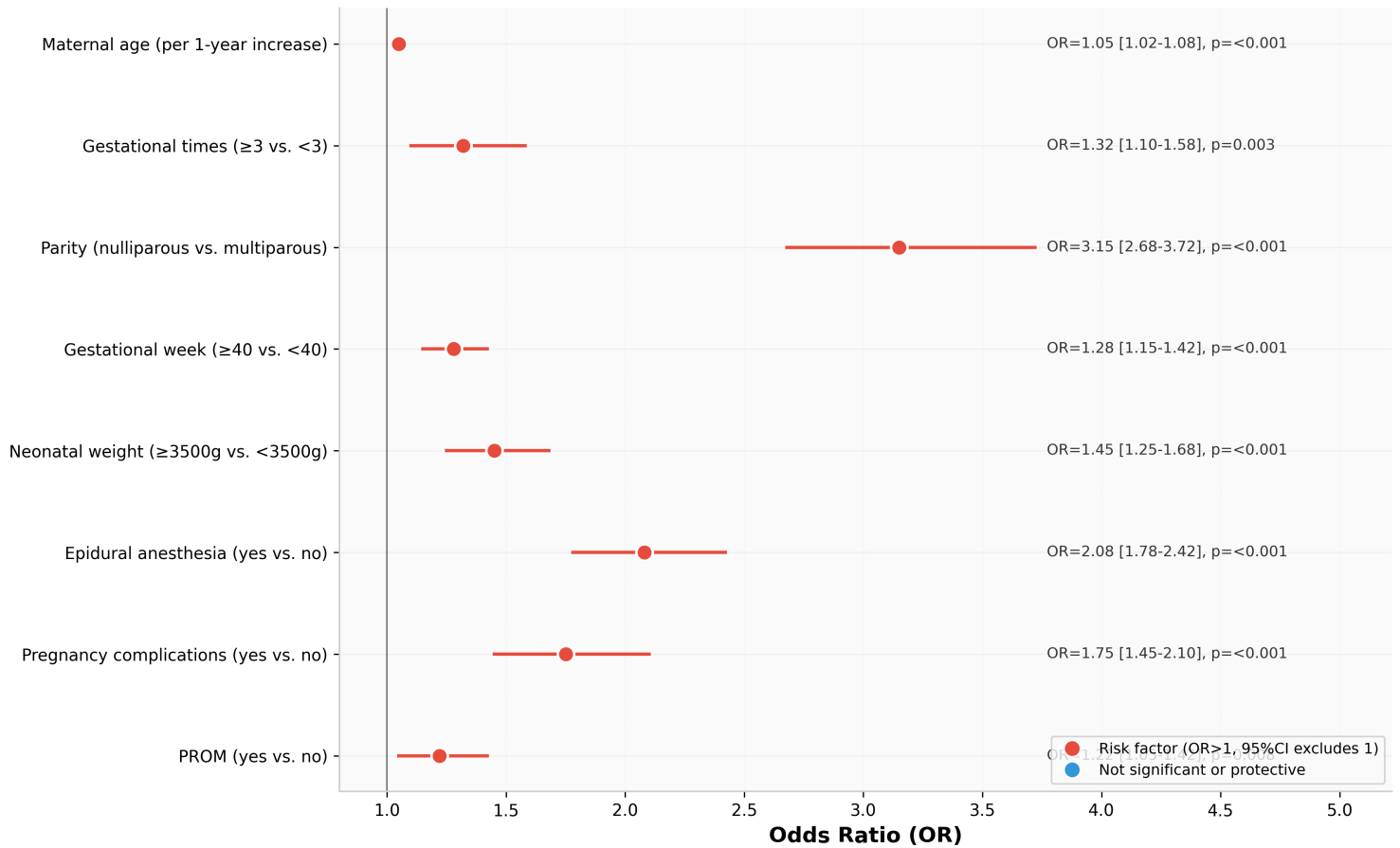


Figure 5

Forest plot of factors associated with forceps delivery from multivariable logistic regression. OR = odds ratio; CI = confidence interval; aOR = adjusted odds ratio. Red dots indicate statistically significant risk factors (95% CI excludes 1.0).