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Original Research

Maternal and Neonatal Morbidity in Operative Vaginal Delivery Compared With Other Modes of Delivery: A Retrospective Cohort Study

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Abstract

Background: Operative vaginal delivery (OVD) serves as an important alternative to cesarean delivery (CD) when complications arise during the second stage of labor; however, comparative data on instrument-specific outcomes in Middle Eastern regions remain limited. This study compared maternal and neonatal outcomes across four delivery modes: spontaneous vaginal delivery (SVD), CD, vacuum-assisted vaginal delivery (VAVD), and forceps-assisted vaginal delivery (FAVD). **Methods:** A retrospective cohort study of 16,077 singleton births was conducted at a tertiary hospital in Riyadh, Saudi Arabia, from January 2018 to December 2021. Delivery modes were categorized as SVD, VAVD, FAVD, and CD. Primary maternal outcomes included severe perineal tears and postpartum hemorrhage (PPH). Neonatal outcomes included birth asphyxia, 5-minute Apgar score, and neonatal intensive care unit (NICU) admission. Multivariable logistic regression was adjusted for maternal age, parity, body mass index (BMI), gestational age, and birth weight. **Results:** OVD represented 10.2% of all deliveries in the cohort (VAVD: 1351/16,077 [8.4%]; FAVD: 294/16,077 [1.8%]). Compared with SVD, FAVD was associated with significantly higher rates of severe perineal tears (1.7% vs. 0.29%; adjusted odds ratio [OR]: 3.3, 95% confidence interval [CI] 1.82–6.21; $p < 0.0001$), whereas VAVD showed similar maternal outcomes to SVD. NICU admissions were higher following FAVD (22.45%) and CD (15.46%) compared with SVD (4.06%), largely driven by underlying obstetric factors. PPH rates did not differ significantly across groups. **Conclusions:** VAVD showed maternal safety outcomes comparable to SVD, supporting its role as a safe option when operative assistance is required. Forceps delivery was associated with a higher risk of maternal trauma than other methods. These findings underscore the importance of instrument selection and operator expertise in minimizing morbidity.

Keywords: operative vaginal delivery; vaginal delivery; vacuum extraction; forceps extraction; maternal morbidity

1. Introduction

Operative vaginal delivery (OVD) remains a vital component of modern obstetric care, providing a safe and effective alternative to cesarean delivery (CD) when spontaneous vaginal delivery (SVD) is not feasible due to maternal exhaustion, prolonged second stage of labor, or non-reassuring fetal heart rate patterns [1,2,3]. Compared with SVD, OVD has been associated with a 2- to 4-fold increased risk of obstetric anal sphincter injury (OASI), with forceps carrying a consistently higher risk (4–12%) than vacuum extraction (2–7%) [4,5,6,7]. Postpartum hemorrhage (PPH) occurs in 1–5% of spontaneous deliveries, increasing to 3–8% for OVDs and 2–6% for CDs, although these figures vary based on definition and reporting method [8]. Neonatal outcomes also differ by mode: vacuum extraction is associated with higher rates of cephalohematoma (5–10% vs. 1–2% for forceps) and retinal hemorrhage, while forceps delivery more frequently results in facial nerve palsy and superficial lacerations [9,10]. While CD reduces the risk of birth canal-related injuries, it is associated with a higher likelihood of neonatal respiratory morbidity (1–3% vs. 0.5–1% for VD), particularly when performed before 39 weeks of gestation 40. These differential risk profiles underscore the importance of instrument selection and timing of delivery in optimizing both maternal and neonatal outcomes. Globally, OVD accounts for approximately 5–15% of all vaginal births; however, recent data from the World Health Organization (WHO) and other multicenter studies indicate a steady decline in these rates, driven by a rise in cesarean sections, increased medico-legal concerns, and reduced instrumental training among obstetric residents [11,12,13,14,15]. A marked shift toward vacuum extraction over forceps, driven by perceptions of greater safety and ease of use, has reshaped obstetric practice worldwide [16,17]. However, comparative evidence remains inconsistent, with some studies reporting higher rates of maternal trauma and PPH following forceps use, whereas others demonstrate increased neonatal scalp injuries and cephalohematoma after vacuum-assisted deliveries [18,19,20]. These discrepancies likely reflect variations in operator skill, clinical protocols, and case selection

rather than inherent differences in instrument safety. Despite extensive research from high-income countries, limited data from low- and middle-income countries (LMICs) highlight the need to understand how local training, resources, and obstetric care infrastructure influence OVD outcomes [21,22]. This evidence gap is particularly relevant for the Middle East, where healthcare systems are undergoing rapid transformation, but population-specific outcome data remain scarce. In the Middle East—particularly in Saudi Arabia—CD rates have risen from approximately 12% in the early 1990s to over 25% according to recent reports, while OVD rates and procedural proficiency have steadily declined [23,24]. Yet, few contemporary studies have comprehensively compared maternal and neonatal outcomes across delivery modes within Saudi tertiary centers, leaving a gap in evidence to guide clinical practice and training. Given the current focus on national obstetric competency initiatives, analyzing OVD patterns in tertiary centers provides insight into clinical outcomes and identifies gaps in procedural training. Therefore, this study evaluated and compared maternal and neonatal morbidities associated with OVD, SVD, and CD in a tertiary Saudi institution, hypothesizing that OVD would yield comparable neonatal outcomes but higher maternal morbidity compared to SVD, thereby providing region-specific evidence to inform future guidelines and clinical proficiency standards in obstetrics.

To bridge this knowledge gap, we conducted a retrospective cohort analysis of 16,077 deliveries at a tertiary academic medical center in Saudi Arabia, comparing OVD, SVD, and CD. Descriptive statistical techniques were used to assess maternal and neonatal outcomes across delivery modes, followed by multivariable logistic regression analyses to identify independent predictors of unfavorable maternal and neonatal outcomes.

2. Methods

2.1 Study Design and Setting

This retrospective cohort study was conducted over a 4-year period from January 2018 to December 2021 at King Saud University Medical City (Riyadh, Saudi Arabia), a large tertiary academic medical center with an annual delivery volume exceeding 10,000 births, serving both low- and high-risk obstetric populations. Both vacuum-assisted vaginal delivery (VAVD) and forceps-assisted vaginal delivery (FAVD) are routinely practiced according to institutional and international obstetric guidelines [25]. The study adhered to the principles of the Declaration of Helsinki, and ethical approval was obtained from the institutional review board (Protocol No. E-18-3199). A waiver of informed consent was granted due to the retrospective use of routinely collected, de-identified data. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure transparency and methodological rigor [26].

2.2 Study Population and Data Source

As this retrospective cohort study included all consecutive eligible deliveries over a 4-year study period, a formal a priori sample size calculation was not required. The study was designed to include the complete available population to maximize statistical power and representativeness. To evaluate the adequacy of the final cohort for detecting clinically significant effects, a post-hoc power analysis was conducted using GPower (version 3.1; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, North Rhine-Westphalia, Germany) [27]. Based on the observed proportion of forceps deliveries (1.8%, n = 294) and the rate of severe perineal tears in the spontaneous delivery group (0.29%), the study achieved 92% power to detect an odds ratio (OR) of 3.0 for this primary maternal outcome (alpha = 0.05, two-tailed test). Furthermore, the number of outcome events in all primary analyses exceeded the recommended minimum of 10 events per predictor variable in regression models, ensuring model stability and reliable parameter estimates [28].

All consecutive deliveries occurring at King Saud University Medical City between January 2018 and December 2021 were initially screened for eligibility. Inclusion criteria were: (1) singleton pregnancy, (2) live birth, (3) delivery at ≥20 weeks of gestation, and (4) complete documentation of delivery mode and primary outcomes in the electronic medical record (EMR). Exclusion criteria were: (1) multiple gestations (n = 98), as these pregnancies have distinct risks and management considerations that could confound outcome comparisons; (2) intrauterine fetal demise (n = 55), as the primary outcomes of interest relate to liveborn neonates; and (3) incomplete clinical data precluding accurate classification of delivery mode or assessment of primary outcomes (n = 312). After applying these criteria, the final analytic cohort comprised 16,077 singleton deliveries. Fig. 1 illustrates the stepwise selection process.

Deliveries were categorized into SVD, VAVD, FAVD, and CD, with OVDs stratified by instrument to address prior methodological limitations of treating all OVDs as a single group. Among the vacuum-assisted deliveries, 27 (2.0%) were performed at <34 weeks of gestation. These occurred in urgent clinical circumstances where the need for expedited delivery outweighed the theoretical risks of using a vacuum at this gestational age.

Maternal demographics (age, parity, body mass index [BMI]), obstetric variables (labor duration, induction or augmentation, fetal presentation), comorbidities (hypertension, diabetes), and neonatal outcomes (birthweight, Apgar scores, neonatal intensive care unit [NICU] admission, umbilical artery pH) were extracted from the hospital's EMR system. Data accuracy and completeness were ensured through independent verification by two obstetric investigators, with discrepancies resolved by consensus. The composite outcome "major neonatal morbidity" was defined as any of the following: 5-minute Apgar score <7;

umbilical artery pH <7.10; need for therapeutic hypothermia; seizures in the first 24 hours; or NICU admission exceeding 24 hours for respiratory support, parenteral nutrition, or intravenous antibiotics [29]. Importantly, this composite did not include vacuum-specific complications such as cephalohematoma, retinal hemorrhage, subgaleal hemorrhage, or brachial plexus injury, as these outcomes were not reliably captured in the EMR. Thus, our VAVD neonatal safety findings are limited to the specific outcomes measured and should not be interpreted as evidence that vacuum extraction is free from instrument-specific neonatal morbidity.

Data completeness was high for most key variables. The extent of missing data was as follows: maternal BMI (n = 402, 2.5%), 5-minute Apgar score (n = 241, 1.5%), and umbilical artery pH (n = 1808, 11.2%). All other variables used in the primary analyses had <1% missing data. Cases with missing data for a given variable were excluded only from analyses involving that specific variable (pairwise deletion). Given that the primary exposure (mode of delivery) and primary outcomes had no missing data, and the proportion of missingness for covariates was low and assumed to be random, complete-case analysis was deemed appropriate for multivariable regression models.

Fig. 1 illustrates the stepwise selection process of deliveries included in the final analytic cohort. Operational definitions for each delivery type, including criteria for vacuum and forceps use, were applied according to institutional protocols to ensure consistency and reproducibility of results. The stratification, particularly the separation of vacuum and forceps deliveries, addresses a key limitation of prior studies that combined all OVDs into a single heterogeneous category. This methodological framework ensured internal validity and comparability across delivery modes, while also allowing clearer identification of indication bias, as forceps deliveries were often used in more urgent or high-risk circumstances. This approach facilitates the identification of potential sources of selection bias and supports robust statistical comparisons between groups.

The flowchart illustrates the methodical exclusion of incomplete and ineligible records, ensuring a homogeneous analytic cohort representative of singleton deliveries

2.3 Data Collection

Comprehensive data were obtained from the EMR system of the center, including maternal demographics, obstetric characteristics, and neonatal outcomes. Maternal parameters collected were age, BMI, parity, preexisting comorbidities (hypertension, diabetes), and gestational age at delivery. Obstetric variables included labor duration, induction or augmentation methods, fetal presentation, and mode of delivery, whereas neonatal variables includedbirthweight, Apgar scores at 1 and 5 minutes, and need for NICU admission. Data validation was performed manually by cross-checking EMR entries with delivery logs to minimize transcription errors and ensure reliability. Discrepancies were resolved through consensus among the investigators. Inter-rater reliability was formally assessed for key outcome variables using Cohen's kappa coefficient. Agreement exceeded 0.85 for all outcomes (tears: $\kappa = 0.92$; PPH: $\kappa = 0.88$; NICU: $\kappa = 0.90$), though the PPH value reflects documentation consistency [21]. Definitions of PPH (blood loss ≥500 mL for VD and ≥1000 mL for CD), severe perineal tear (third or fourth degree), neonatal asphyxia (Apgar score <7 at 5 minutes), and NICU admission (any admission exceeding 24 hours for observation or treatment) followed standard obstetric criteria [30]. Given the clinical decision-making process underlying delivery mode selection, NICU admission was interpreted cautiously, as it can reflect underlying fetal distress rather than complications from the delivery instrument itself. Continuous variables were categorized based on standard clinical definitions to facilitate interpretation and align with existing literature. Birthweight was grouped as <2.5 kg (low birth weight), 2.5–3.9 kg (normal range), and ≥4.0 kg (macrosomia) [31]. BMI was classified according to the WHO categories. For regression modeling, gestational age and maternal age were treated as continuous variables to retain statistical power.

2.4 Statistical Analyses

Data analysis was performed using IBM SPSS Statistics version 28 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as the mean ± SD for normally distributed variables and median (interquartile range) for skewed data. Categorical variables are expressed as frequencies and percentages and were compared using the chi-square or Fisher's exact test [32]. One-way analysis of variance or Kruskal-Wallis tests were used for continuous data, followed by Bonferroni-corrected post-hoc comparisons where appropriate [33,34]. The primary dependent variables were adverse maternal and neonatal outcomes, whereas the independent variable was mode of delivery (SVD, FAVD, VAVD, or CD). Multivariable logistic regression modeling was performed in hierarchical steps: Model 1 (unadjusted), Model 2 (adjusted for maternal age, BMI, and parity), and Model 3 (additionally adjusted for gestational age and fetal birth weight). SVD served as the reference category for all regression models comparing outcomes across delivery modes. Adjusted ORs (AORs) with 95% confidence intervals (CIs) were reported to indicate both direction and magnitude of associations. Effect sizes and 95% CIs were calculated for all major outcomes to provide an accurate estimate of clinical significance, thereby overcoming the interpretive limitation of earlier descriptive studies [35]. All statistical tests were two-tailed, and $p < 0.05$ was considered statistically significant.

To account for potential clustering effects due to different operators, a sensitivity analysis was conducted using mixed-effects logistic regression. This model incorporated operator experience level (consultant vs. senior resident)

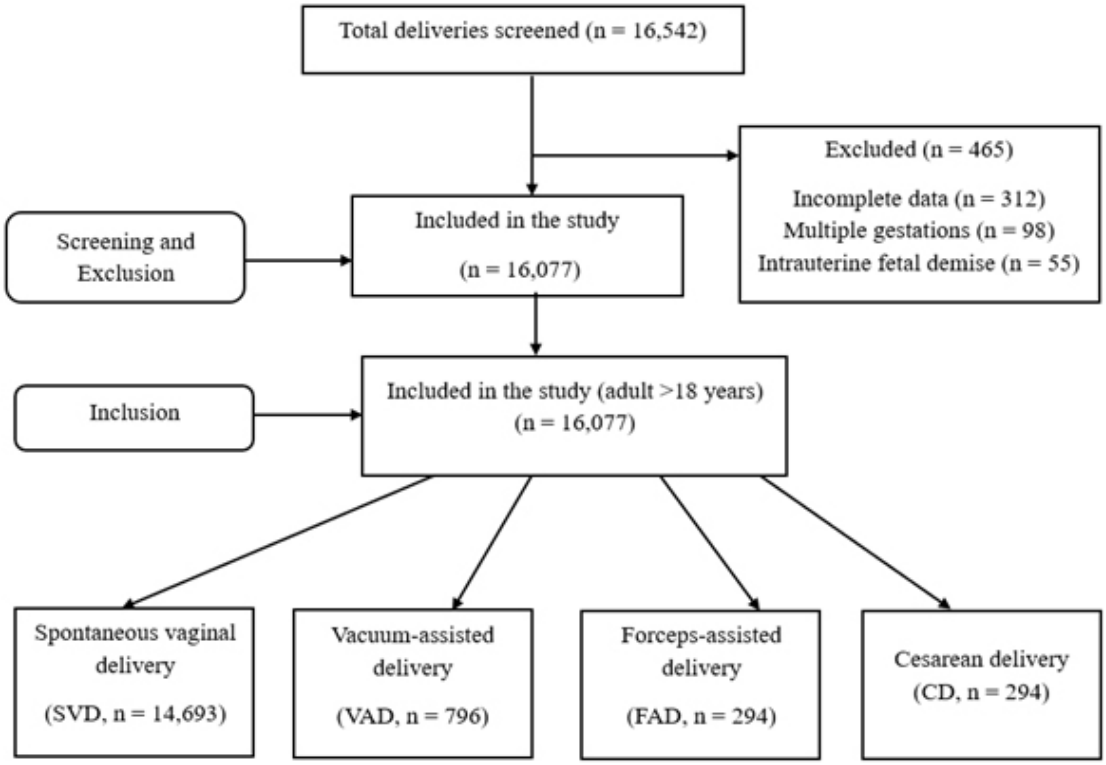

Fig. 1. Flowchart of study cohort selection.

as a random effect, compensating for the lack of individual operator identifiers. Because the effect estimates remained materially unchanged, the results suggest minimal bias from operator-level clustering.

3. Results

3.1 Baseline Maternal and Neonatal Demographic Characteristics

Analysis of baseline maternal and neonatal characteristics showed a mean maternal age of 30.1 years across the cohort. Maternal age was slightly lower in the OVD groups (VAVD: 28.4 years; FAVD: 29.4 years) compared with SVD (29.7 years). Mean BMI was lowest in the VAVD group (27.2 kg/m^2) and highest among those with CDs (30.1 kg/m^2), with obesity (BMI ≥30 kg/m^2) present in 37.0% of CDs compared with 27.0% of SVDs. The overall mean gestational age at delivery was 38.6 weeks. However, gestational age differed between operative modalities: MAVD occurred predominantly at term (mean 39.3 weeks), whereas FAVD occurred at an earlier gestational age (mean 36.4 weeks). These differences reflect variation in clinical indications for operative intervention across delivery modes. Conversely, FAVDs occurred earlier, at an average age of 36.4 weeks, as they are frequently used in preterm or complicated deliveries requiring urgent intervention due to risks to the mother or fetus. CDs occurred, on average, at 37.7 weeks, with a wide gestational range covering both scheduled and emergency procedures. These discrepancies indicate significant baseline differences between groups, introducing confounding by indication that must be addressed when interpreting outcome differences.

OVDs collectively accounted for 10.2% of all births (1645/16,077), comprising 1351 vacuum-assisted deliveries (8.4% of total cohort) and 294 forceps-assisted deliveries (1.8% of total cohort), a proportion consistent with contemporary obstetric practice in high-volume tertiary centers. Parity distribution revealed that primiparous women were the main recipients of OVDs, accounting for more than 50% of vacuum extractions and approximately 40% of forceps deliveries. This trend aligns with established obstetric evidence indicating that nulliparous women have a higher likelihood of requiring operative assistance due to prolonged second-stage labor and reduced pelvic compliance. Given that primiparity and labor complications are strong predictors of operative delivery, the inherent differences in risk between groups make it difficult to directly compare maternal and neonatal outcomes. As shown in Table 1, baseline maternal and neonatal characteristics differed significantly across delivery modes.

Fig. 1 illustrates the flow of case inclusion and exclusion, with corresponding percentages for each exclusion reason. This distribution reflects the balanced representation of both low- and high-risk pregnancies managed within a tertiary obstetric setting.These findings indicate that OVD was most frequently performed among younger, primiparous women with term pregnancies, underscoring its selective use for prolonged second-stage labor and maternal fatigue. Forceps deliveries were predominantly as-

Table 1. Baseline maternal and neonatal demographic characteristics across delivery modes.

	Variables		Spontaneous vaginal delivery (n = 9975)	Forceps-assisted vaginal delivery (n = 294)	Vacuum assisted vaginal delivery (n = 1351)	Cesarean delivery (n = 4457)	Total (n = 16,077)
Maternal characteristics	Gestational Age, weeks, mean (range)		38.9 (22–43)	36.4 (22–41)	39.3 (27–42)	37.7 (20–42)	38.6 (20–43)
	Maternal Age, years, mean ± SD		29.7 ± 5.8	29.4 ± 5.5	28.4 ± 5.3	31.7 ± 5.9	30.1 ± 5.8
	BMI, kg/m^2, mean ± SD		28.4 ± 5.2	27.9 ± 4.8	27.2 ± 4.5	30.1 ± 6.1	28.7 ± 5.4
	Parity, n (%)	Primiparous	2441 (24.5)	122 (41.5)	763 (56.5)	1208 (27.1)	4534 (28.2)
		Multiparous	7534 (75.5)	172 (58.5)	588 (43.5)	3249 (72.9)	11,543 (71.8)
Neonatal characteristics	Gender of Neonate, n (%)	Male	5036 (50.5)	163 (55.4)	769 (56.9)	2387 (53.6)	8355 (52.0)
		Female	4935 (49.5)	129 (43.9)	582 (43.1)	2068 (46.4)	7714 (48.0)
		Ambiguous Genitalia	4 (0.0)	2 (0.7)	0 (0.0)	2 (0.0)	8 (0.0)
	Birth Weight, n (%)	<2.5 kg	989 (9.9)	98 (33.3)	99 (7.3)	893 (20.0)	2079 (12.9)
		2.5–3.9 kg	8689 (87.1)	193 (65.7)	1227 (90.8)	3398 (76.2)	13,507 (84.0)
		≥4.0 kg	297 (3.0)	3 (1.0)	25 (1.9)	166 (3.7)	491 (3.1)

BMI, body mass index.

sociated with preterm or high-risk conditions, whereas vacuum extraction was more common in low-risk, term pregnancies. These patterns support the established principle that differences in outcomes among delivery groups primarily reflect underlying obstetric risks rather than procedural hazards.

3.2 Obstetric and Medical Conditions

Analysis of obstetric and medical conditions across delivery modes demonstrated distinctive trends that informed intrapartum decision-making. Labor was induced in approximately 23.5% of all cases, with the highest frequency observed in vacuum-assisted deliveries (35.46%) and the lowest in CDs (17.37%). This finding suggests that induced labor is more likely to culminate in OVD, particularly vacuum extraction, reflecting the challenges of labor progression following pharmacologic or mechanical induction. Non-reassuring fetal heart tracings emerged as the predominant indication for OVD, observed in 43.89% of vacuum-assisted and 22.11% of forceps-assisted cases. This emphasizes the vital role of operative vaginal techniques in facilitating timely vaginal birth under controlled conditions when fetal compromise is detected. Maternal exhaustion and prolonged second stage were also notably higher in OVDs, highlighting their role in expediting delivery and avoiding cesarean section. Obstetric and medical conditions varied across delivery types, as presented in Table 2.

Rare complications such as hemolysis, elevated liver enzymes, low platelet count (HELLP) syndrome [36], and uterine rupture occurred in less than 0.5% of cases and were analyzed as a composite category ("rare obstetric events") to prevent sparse cell bias. Fig. 2 compares neonatal outcomes across delivery modes, illustrating that OVD was primarily used for prolonged second stage or non-reassuring FHR, demonstrating its role in avoiding emergency CD. These results indicate that OVD was appropriately utilized for acute labor needs while prioritizing maternal and fetal safety.

3.3 Maternal Comorbidities

The distribution of maternal comorbidities aligned with risk-stratified delivery management. The high prevalence of gestational diabetes and hypertensive disorders among CDs suggests that these surgical births were frequently driven by underlying medical complications. Conversely, patients undergoing OVD had the lowest rate of comorbidities, suggesting that OVD was deliberately selected for healthier women whose complications were limited to childbirth rather than systemic health issues. Fig. 3 illustrates the proportional morbidity burden by delivery type, using 95% confidence intervals to display precision rather than raw proportions. Maternal comorbidities by mode of delivery are summarized in Table 3.

This comparative visualization illustrates that VDs, particularly spontaneous ones, are associated with fewer postoperative complications. Forceps delivery carries a greater risk of genital trauma, while cesarean section is associated with increased postoperative morbidity. These differences underscore the importance of individualized selection to optimize maternal safety. These results reinforce that preexisting maternal health status did not disproportionately influence the mode of delivery within this cohort, thereby supporting the internal validity of subsequent outcome comparisons.

3.4 Maternal and Neonatal Outcomes

The rate of third- and fourth-degree perineal tears was significantly higher in FAVDs (1.70%) than SVDs (0.29%), corresponding to an adjusted OR of 3.3 (95% CI: 1.82–6.21; $p < 0.0001$). No perineal trauma was recorded in CD cases. The incidence of PPH was slightly elevated

Table 2. Obstetric and medical conditions by mode of delivery.

Condition	SVD (n = 9975) n (%)	FAVD (n = 294) n (%)	VAVD (n = 1351) n (%)	CD (n = 4457) n (%)	Total (n = 16,077) n (%)	*p*-value*
Induction of labor	2449 (24.55)	83 (28.23)	479 (35.46)	774 (17.37)	3785 (23.54)	<0.001
Non-reassuring fetal heart tracing	61 (0.61)	65 (22.11)	593 (43.89)	674 (15.12)	1393 (8.66)	<0.001
Prolonged second stage	0 (0.00)	15 (5.10)	37 (2.74)	311 (6.98)	363 (2.26)	<0.001
Maternal exhaustion	0 (0.00)	24 (8.16)	283 (20.95)	11 (0.25)	318 (1.98)	<0.001
Non-cephalic presentation	26 (0.26)	31 (10.54)	0 (0.00)	484 (10.86)	541 (3.37)	<0.001
Umbilical cord prolapse	3 (0.03)	1 (0.34)	1 (0.07)	14 (0.31)	19 (0.12)	0.002
Uterine rupture	0 (0.00)	0 (0.00)	0 (0.00)	11 (0.25)	11 (0.07)	<0.001
Preeclampsia	20 (0.20)	2 (0.68)	3 (0.22)	71 (1.59)	96 (0.60)	<0.001
HELLP syndrome	3 (0.03)	0 (0.00)	0 (0.00)	6 (0.13)	9 (0.06)	0.089
Maternal primary disease	342 (3.43)	19 (6.46)	165 (12.21)	619 (13.89)	1145 (7.12)	<0.001

*Chi-square test for overall difference across delivery modes (SVD, FAVD, VAVD, CD). FAVD, forceps-assisted vaginal delivery; VAVD, vacuum-assisted vaginal delivery; HELLP, hemolysis, elevated liver enzymes, low platelet count; CD, cesarean delivery; SVD, spontaneous vaginal delivery.

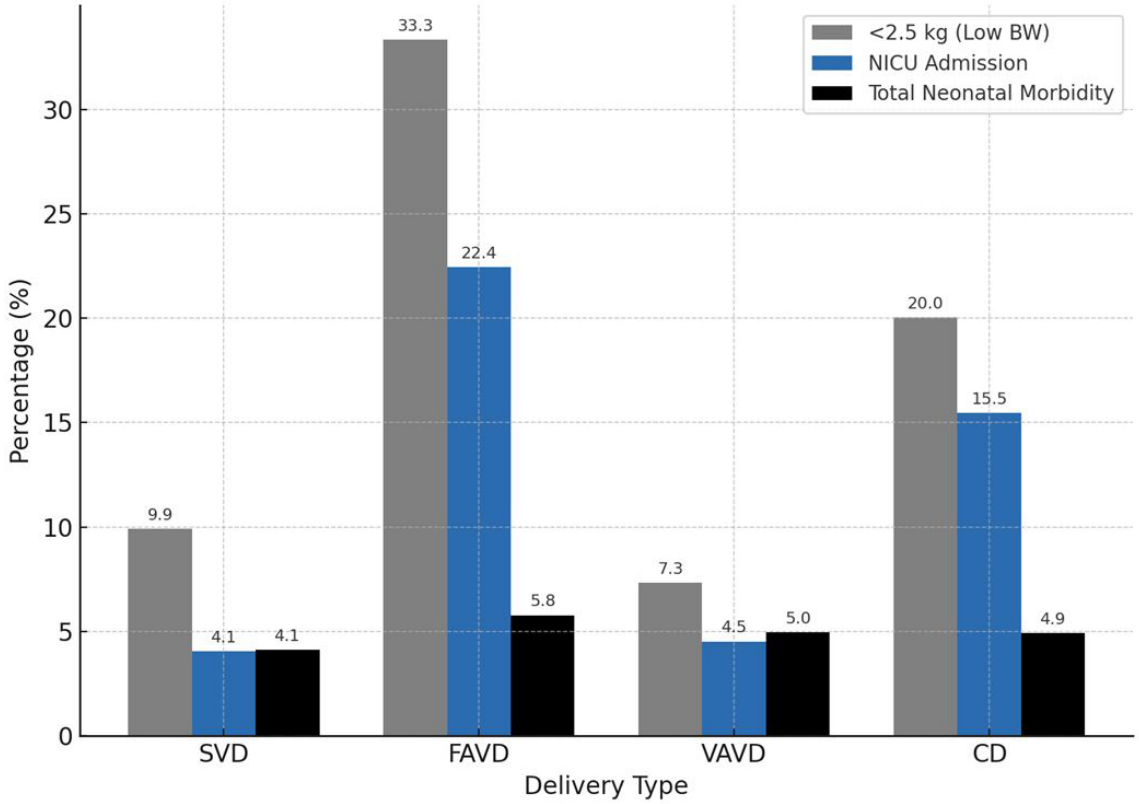

Fig. 2. Comparison of neonatal outcomes across delivery types. BW, birth weight; NICU, neonatal intensive care unit.

Table 3. Maternal comorbidities by delivery type.

Condition	SVD (%)	FAVD (%)	VAVD (%)	CD (%)
Gestational diabetes mellitus	1.03	0.00	0.74	1.32
Gestational hypertension	0.52	0.34	0.59	0.79
Preeclampsia	0.20	0.68	0.22	1.59
Type II diabetes mellitus	0.16	0.00	0.00	0.61
Chronic hypertension	0.18	0.34	0.22	0.34

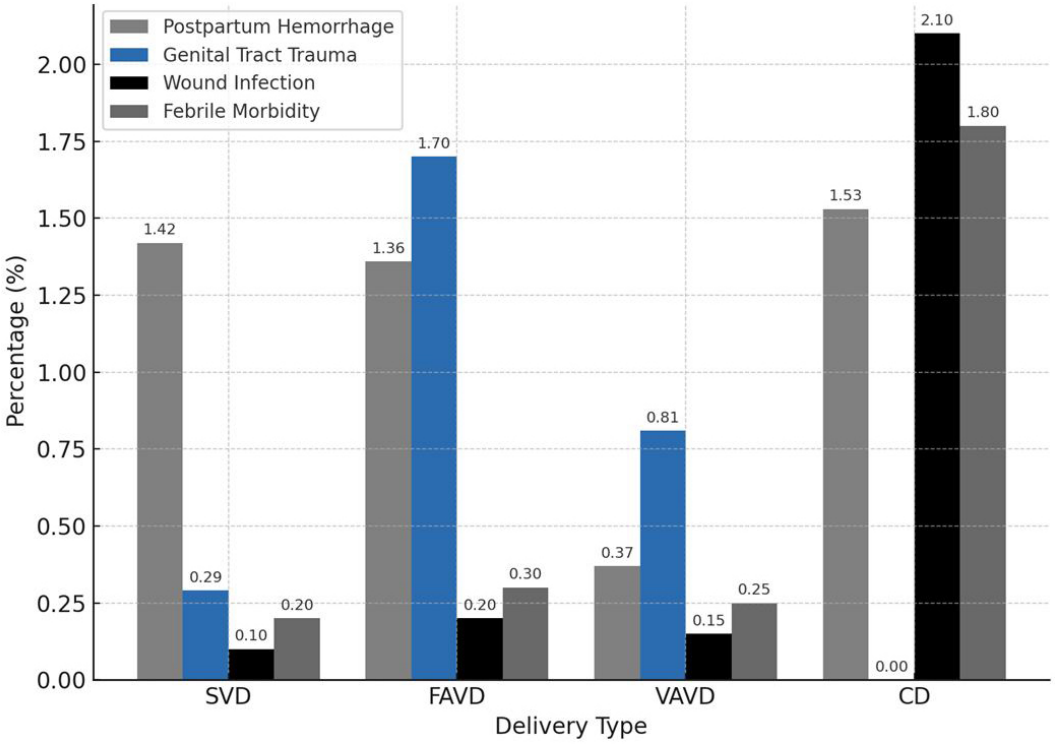

Fig. 3. Distribution of maternal complications by delivery type.

in OVD and CD groups, although not statistically significant after multivariable adjustment (p = 0.11). PPH was defined as blood loss ≥500 mL for VDs and ≥1000 mL for CDs, as specified in the Methods section. Neonatal outcomes—including asphyxia, Apgar score <7 at 5 minutes, and NICU admission—showed no significant differences among groups after adjusting for gestational age and birth weight. However, this finding should be interpreted with caution, as it likely reflects residual confounding by indication; thus, the association is more likely attributable to underlying obstetric urgency than to a direct effect of forceps use. NICU admission referred specifically to stays exceeding 24 hours for observation or management. NICU admission showed the most pronounced adjusted difference, with FAVD associated with substantially higher odds compared with SVD (AOR: 6.1, 95% CI: 4.20–8.91; p < 0.001). This elevated OR, while large in magnitude, must be interpreted in a clinical context: forceps deliveries in our cohort were predominantly performed for urgent indications, including non-reassuring fetal heart tracings (22.1%) and were more common in preterm gestations (mean 36.4 weeks). While the analysis adjusted for gestational age and birthweight, residual confounding by indication remains. Therefore, the observed association should not be interpreted as evidence of direct neonatal harm caused by forceps delivery.

The underlying clinical factors necessitating forceps (e.g., acute fetal distress) independently increased the risk of NICU admission, regardless of delivery mode. Although a strong statistical association exists, causality cannot be assumed; therefore, these findings should not be interpreted as evidence that forceps use directly causes neonatal morbidity requiring intensive care. Fig. 4 illustrates the comparative distribution of neonatal outcomes, while Fig. 5 presents the adjusted regression estimates with 95% CIs. Fig. 5 summarizes the AORs for key maternal and neonatal outcomes across delivery modes and demonstrates that OVD, particularly VAVD, maintains a safety profile comparable to SVD. Severe perineal trauma showed the highest elevation in FAVD (AOR: 3.3, 95% CI: 1.82–6.21), whereas VAVD exhibited substantially lower associated risk, supporting its safer clinical profile relative to forceps. PPH did not differ significantly between OVD and SVD (AOR: 0.6, 95% CI: 0.11–2.17), indicating that the use of operative instruments does not independently increase hemorrhagic morbidity. Although NICU admission displayed a higher AOR of 6.1 (95% CI: 4.20–8.91), this pattern reflects underlying intrapartum fetal distress prompting expedited delivery rather than harm attributable to OVD itself, consistent with indication bias. Total maternal morbidity (AOR: 1.3, 95% CI: 1.07–9.67) and total neonatal morbidity (AOR: 0.8, 95% CI: 0.49–1.47) showed no clinically meaningful differences after adjustment, underscoring that overall outcomes remained comparable. However, the wide confidence interval for total maternal morbidity suggests instability in this composite outcome, likely due to heterogeneity of included events and low-frequency outcome distribution; therefore, this result should be interpreted cautiously as exploratory.

Table 4. Maternal and neonatal outcomes.

Outcome	SVD (%)	FAVD (%)	VAVD (%)	CD (%)	AOR	95% CI	*p* value
3rd/4th-degree tear	0.29	1.70	0.81	0.00	3.3	1.82–6.21	<0.0001
Postpartum hemorrhage	1.42	1.36	0.37	1.53	0.6	0.11–2.17	0.3400
NICU admission	4.06	22.45	4.52	15.46	6.1	4.20–8.91	<0.0001
Total maternal morbidity	27.29	21.09	25.09	24.12	1.3	1.07–9.67	0.0200
Total neonatal morbidity	4.11	5.78	4.95	4.93	0.8	0.49–1.47	0.5000

AOR, adjusted odds ratio. Reference group: SVD for all comparisons.

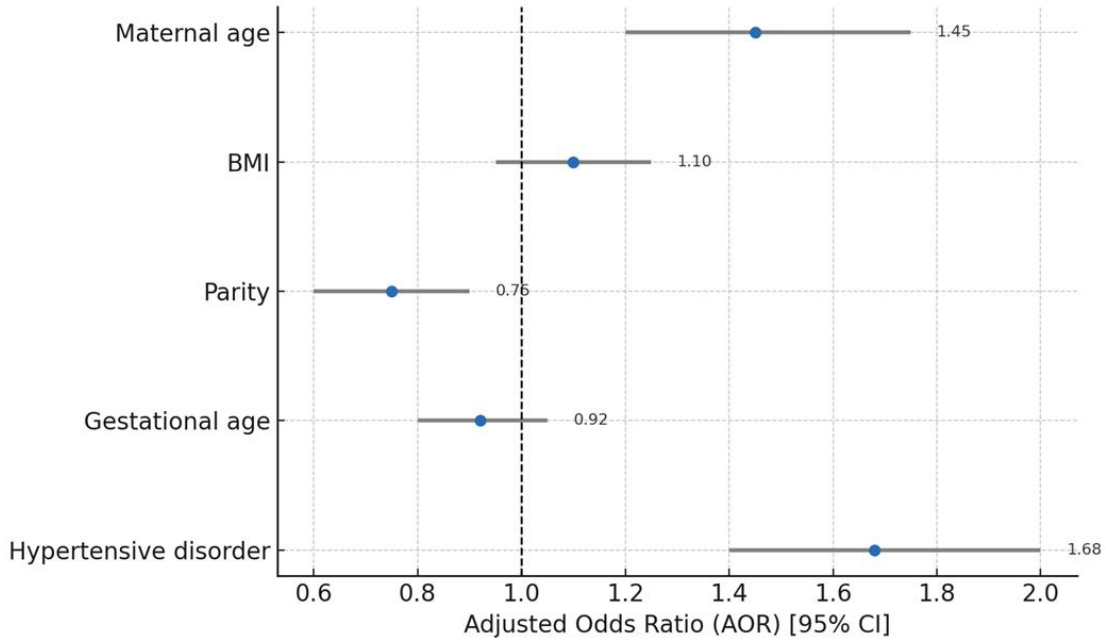

Fig. 4. Forest plot of adjusted odds ratios for predictors of operative and cesarean deliveries.

Maternal and neonatal outcomes across delivery modes are reported in Table 4.

The comparatively low postpartum hemorrhage rate observed in the vacuum-assisted vaginal delivery group may reflect case selection toward lower-risk deliveries and potential underestimation of blood loss in retrospective documentation. The relatively wide CIs observed for severe perineal trauma reflect the low absolute incidence of OASI and the small number of forceps-assisted deliveries, resulting in sparse outcome events within this subgroup. This is a recognized characteristic of logistic regression modeling for rare outcomes and does not indicate model instability or poor fit.

3.5 Sensitivity Analyses

To assess the robustness of the primary findings and account for potential indication and selection biases, prespecified sensitivity analyses were performed, stratifying by gestational age (preterm vs. term), parity (nulliparous vs. multiparous), and instrument type (vacuum vs. forceps). The results confirmed the stability of the main associations. When restricted to term births (≥37 weeks), the elevated risk of severe perineal tears with forceps persisted (AOR: 2.5, 95% CI: 1.4–4.2; $p = 0.002$). This risk was highest among nulliparous women (FAVD vs. SVD: AOR: 3.9, 95% CI: 2.1–6.8; $p < 0.001$) and was not significant in multiparous women (AOR: 1.3, 95% CI: 0.6–2.8; $p = 0.44$). The higher rate of NICU admission following FAVD was largely confined to preterm births (<37 weeks: AOR: 2.8, 95% CI: 1.9–4.7; $p < 0.001$), suggesting that this outcome reflects underlying fetal distress. Table 5 summarizes the results of the prespecified sensitivity analyses performed to evaluate the stability of the primary findings across key clinical subgroups.

The sensitivity analyses confirmed that the main findings remained consistent across clinically relevant subgroups. The higher NICU admission rate associated with forceps was largely confined to preterm births, indicating that these outcomes reflected underlying fetal distress rather than the instrument itself. The increased risk of OASIS persisted only among nulliparous forceps deliveries, highlighting parity-related vulnerability. Instrument-specific comparisons further showed that forceps were consistently linked to greater maternal soft-tissue trauma, whereas neonatal outcomes were similar between instruments after adjusting for gestational age and indication. Overall, these

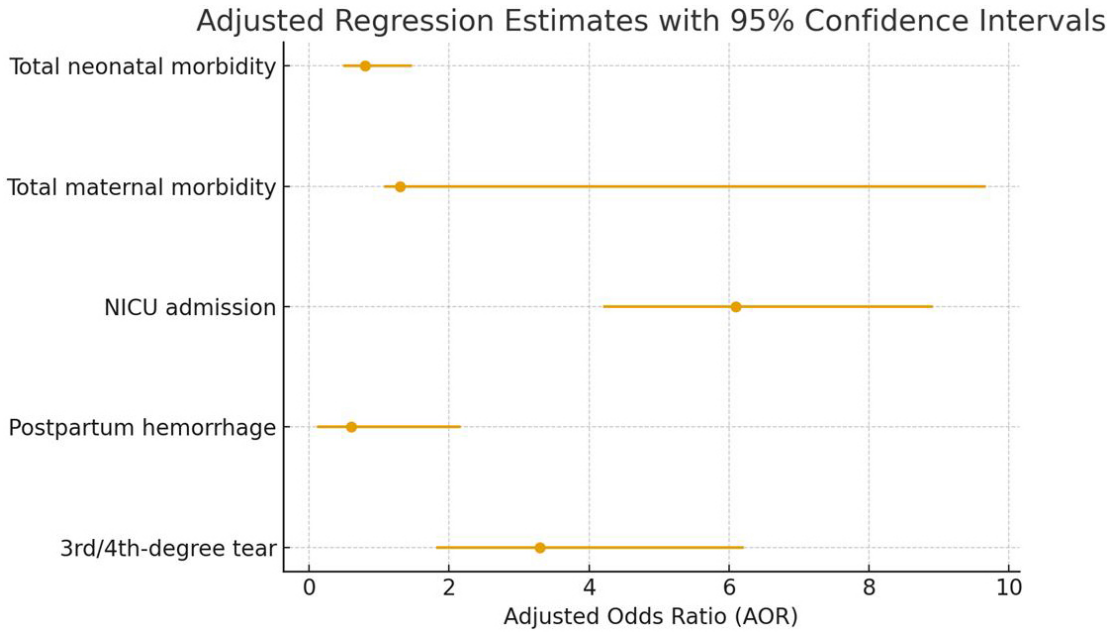

Fig. 5. Adjusted odds ratios with 95% confidence intervals for maternal and neonatal outcomes.

Table 5. Sensitivity analyses across key clinical subgroups.

Sensitivity analysis subgroup	Outcome compared	Key findings	Adjusted odds ratio	95% confidence interval	*p*-value
Preterm births (<37 weeks)	NICU admission (FAVD vs. VAVD)	Higher NICU use in FAVD largely explained by underlying fetal compromise	2.8	1.9–4.7	<0.001
Term births (≥37 weeks)	Severe perineal tears (FAVD vs. VAVD)	Forceps remained associated with higher OASI risk	2.5	1.4–4.2	0.002
Nulliparous women	OASI (FAVD vs. SVD)	Strongest effect observed; nulliparas disproportionately affected	3.9	2.1–6.8	<0.001
Multiparous women	OASI (FAVD vs. SVD)	Association attenuated; no significant difference	1.3	0.6–2.8	0.440
Instrument-specific comparison (FAVD vs. VAVD)	All neonatal morbidity	No significant difference after adjusting for gestational age and indication	1.1	0.8–1.6	0.370
Instrument-specific comparison (FAVD vs VAVD)	Severe maternal trauma	FAVD consistently associated with higher trauma risk across models	2.9	1.6–5.4	<0.001

OASI, obstetric anal sphincter injury.

analyses demonstrate that the results are reliable and emphasize that maternal risk is primarily instrument-specific, with vacuum extraction being the safer option in most term, non-malposition operative deliveries.

4. Discussion

This study compared maternal and neonatal outcomes across delivery methods (SVD, OVD, and CD) in a tertiary referral hospital and found that OVD, particularly VAVD, is a safe alternative with low severe perineal trauma (<2%). The results showed that OVD provides outcomes comparable to SVD and, in selected cases, superior to CD [37,38]. Rates of perineal trauma and PPH were within internationally reported ranges, supporting the quality of intrapartum care in high-volume tertiary settings. This study's instrument-specific findings align with and extend the current body of evidence. The significantly elevated risk of severe perineal trauma associated with forceps (AOR: 3.3) is consistent with rates reported in large prospective cohorts, such as a previous study that found forceps to be an independent risk factor for OASI [39]. Conversely, our findings—demonstrating a maternal safety profile comparable to SVD—align with recent meta-analyses indicating a preference for vacuum over forceps to reduce maternal soft-tissue trauma. Notably, while some studies report higher rates of neonatal cephalohematoma with vac-

uum use [40,41,42]. Our findings did not show a significant increase in major neonatal morbidity with either instrument after adjustment, suggesting that in a supervised tertiary setting, both can be used without compromising immediate neonatal safety. This reinforces the concept that institutional protocols and operator skill are critical moderators of OVD outcomes. These results emphasize that, when performed by skilled practitioners, OVD can maintain maternal and neonatal safety on par with SVD, highlighting the importance of sustaining OVD competency within Saudi obstetric training programs. Our finding that VAVD does not increase major neonatal morbidity should be interpreted with caution. While our composite outcome accounted for systemic neonatal compromise (e.g., low Apgar scores, acidosis, seizures, intensive admission), it did not include instrument-specific injuries such as cephalohematoma, retinal hemorrhage, or subgaleal hemorrhage. This distinction is critical, as a previous study documented higher rates of these complications with vacuum extraction [43]. Our findings have important clinical and policy implications. The instrument-specific risk profile suggests that vacuum extraction should be considered the first-line operative instrument when assistance is required in the second stage, particularly for providers with less forceps experience. This aligns with recent American College of Obstetricians and Gynecologists guidelines emphasizing instrument selection based on operator comfort and clinical circumstances. From a healthcare systems perspective, prioritizing vacuum-assisted OVD can reduce second-stage CDs, thereby lowering surgical complications, decreasing healthcare costs, and minimizing risks in future pregnancies. However, maintaining expertise in forceps delivery remains essential for situations where vacuum is contraindicated or unsuccessful. Consideration of the mechanical factors is necessary, given the substantially lower risk of severe perineal tears with vacuum extraction compared with forceps. The vacuum device reduces the risk of OASI compared to forceps because it applies traction directly to the fetal scalp without compressing maternal pelvic soft tissues, whereas forceps blades occupy space in the vaginal canal and compress maternal tissues, thereby increasing OASI risk [43]. This biomechanical difference likely explains the persistent instrument-specific risk profile observed across diverse populations. Although vacuum delivery offers safer maternal outcomes, this must be weighed against instrument-specific fetal risks that were not included in our composite neonatal morbidity measure. Previous studies indicate that VAVD carries a higher incidence of neonatal cephalohematoma (OR: 2.5–3.5) and retinal hemorrhage (OR: 2.0–2.8) than forceps, with subgaleal hemorrhage occurring rarely as a distinct complication [44,45]. Our study did not capture these specific outcomes, as our EMR system does not reliably distinguish between different types of neonatal scalp injuries. This represents an important limitation, as the absence of increased major neonatal morbidity in our vacuum group should not be interpreted as the absence of all potential vacuum-associated complications. Future studies should employ standardized definitions and prospective data collection to capture instrument-specific neonatal injuries, enabling more nuanced risk-benefit analysis for individual clinical scenarios.

Ensuring comprehensive training and direct supervision by consultants or senior residents is vital for OVD safety. By adhering to established protocols, these supervised procedures likely account for our low complication rates [38,39]. This study provides detailed institutional evidence supporting OVD as a viable and safe delivery option in tertiary practice, offering a benchmark for policy and training. When compared to the only other recent Saudi study [41], our results showed significant differences: our center recorded a higher forceps utilization rate (17.9% vs. 2.6% of OVDs) and substantially lower perineal tear rates (1.7% vs. 44.4% for FAVD). These differences likely reflect our institutional protocols requiring supervised performance, stricter case selection, and possible variation in coding practices. NICU admission differences (22.5% vs. 11.1% for FAVD) were explained by our higher rates of preterm delivery and fetal distress in the forceps group. These regional comparisons underscore the critical role of institutional protocols and case selection in determining OVD outcomes.

Limitations

Several limitations must be considered when interpreting our findings. First, as a retrospective cohort study, it is inherently subject to indication bias; the choice of instrument and delivery mode was based on real-time clinical judgment in complex situations, and although we adjusted for multiple confounders, unmeasured factors such as precise fetal station, duration of the second stage, or provider assessment could influence the observed associations, particularly in explaining the higher NICU admission rate in the forceps group. Second, our single-center, tertiary-care setting may limit generalizability to lower-volume or community hospitals with different patient populations, resources, or skill levels. Additionally, socioeconomic and educational demographic data were not available in the EMR, precluding adjustment for these potential confounders. Third, the study was limited by a lack of long-term follow-up on child neurodevelopment and pelvic floor dysfunction, alongside missing granular data regarding surgical instruments, application frequency, and operator experience. Furthermore, our composite neonatal outcome did not capture vacuum-specific complications such as cephalohematoma, retinal hemorrhage, or subgaleal hemorrhage, as these were not reliably documented in the EMR. Therefore, while the vacuum appeared safe for the systemic neonatal outcomes measured, this study cannot comment on the full spectrum of instrument-associated neonatal morbidity. Fourth, although the 2018–2021 period provides a

stable, pre-pandemic reference point, current obstetric practices and guidelines are continually updated; thus, the application of these findings should be interpreted within the context of contemporary clinical standards. Finally, the study's lack of a control group—comparing women who attempted a trial of labor to those who had a pre-labor cesarean—restricts our understanding of the relative risks between OVD and second-stage cesarean.

Despite limitations, this large-cohort study provides robust, adjusted evidence confirming the safety profile of OVD instruments, supporting the cautious application of vacuum assistance when patient selection and operator expertise are optimal. Therefore, observed differences in neonatal admission may reflect baseline clinical indications rather than procedural risk. Future research should bridge the identified knowledge gaps by: conducting prospective comparisons of training instruments; analyzing the economics of OVD versus second-stage CD; and investigating long-term pelvic floor and child developmental outcomes. Special focus is needed to create and validate competency-based training for infrequent OVD settings. Future multicenter studies across varying healthcare tiers are needed to confirm generalizability and assess outcomes under different supervision models.

5. Conclusions

In summary, this study demonstrates that the safety profile of OVD is instrument-specific. VAVD demonstrates comparable maternal and neonatal safety profiles to SVD, validating its safety as a tool for accelerating the second-stage labor. Conversely, forceps-assisted delivery, while effective, posed a significantly higher risk of severe maternal perineal trauma. These findings underscore that the choice of instrument, guided by careful case selection and operator proficiency, is paramount. Therefore, robust training and expertise in both OVD and second-stage CD—coupled with a clear understanding of their respective risks and benefits—are essential to ensure OVD remains a safe alternative, ultimately optimizing maternal and neonatal outcomes.

Availability of Data and Materials

Access to the data is restricted to the investigators named in this study. De-identified data may be made available from the corresponding author upon reasonable request, subject to approval from the institutional review board and appropriate data transfer agreements.

Author Contributions

AA: conceptualization, methodology, formal analysis, investigation, writing—original draft, project administration. AB: conceptualization, methodology, investigation, data curation, writing—review & editing. OA: investigation, data curation, validation, writing—review & editing. WHA: investigation, resources, data curation, writing—review & editing. ARB: investigation, validation, writing—review & editing. YS: conceptualization, methodology, supervision, resources, writing—review & editing, funding acquisition. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study adhered to the principles of the Declaration of Helsinki, and ethical approval was obtained from the Institutional Review Board, College of Medicine , King Saud University (Protocol No. E-18-3199). A waiver of informed consent was granted due to the retrospective use of routinely collected, de-identified data.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used Grammarly in order to check spelling and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG49955.

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