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Impact of mode of delivery on long-term urinary continence: A multicenter prospective cohort study

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Abstract
Background: Urinary incontinence (UI) represents a major long-term morbidity after childbirth, with significant psychosocial consequences. The relationship between mode of delivery vaginal or cesarean and subsequent urinary continence remains a matter of ongoing debate, particularly in low- and middle-income settings where long-term cohort data are limited.
Objective: To determine the association between mode of delivery and urinary continence two years postpartum, using data from a multicenter prospective cohort.
Methods: This is a hospital-based longitudinal cohort was established in 2023 across three tertiary centers in Mangalore. The principal investigator, is from the Department of urology, Father Muller Medical College, Mangalore, where the research design and primary source of the subjects were taken from. Women were followed for two years postpartum. Data on mode of delivery (vaginal, instrumental, elective cesarean, emergency cesarean), pelvic floor symptoms, and urinary leakage were collected using the validated International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF). Risk factors were analyzed using multivariate logistic regression controlling for parity, age, and BMI.
Results: Among 768 women completing follow-up, 33.7% of those with spontaneous vaginal delivery reported persistent stress UI at 2 years, compared with 14.2% of cesarean births (p<0.001). Instrumental deliveries carried the highest risk (adjusted OR 2.43, 95% CI 1.62-3.64). Protective factors included pelvic floor muscle training adherence and lower BMI (p=0.02).
Conclusion: Vaginal and especially instrumental deliveries were associated with a higher long-term risk of urinary incontinence compared to cesarean section. However, mode of delivery alone does not fully predict continence outcomes early postpartum rehabilitation remains critical.

Keywords: Urinary incontinence, vaginal delivery, cesarean section, pelvic floor, prospective cohort, long-term outcomes

Introduction

Urinary incontinence (UI) is one of the most common postpartum pelvic floor disorders, affecting up to 35-45% of women within five years after childbirth (Stephenson *et al*., 2025; Nnaji *et al*., 2025) [1, 2]. The mode of delivery has long been identified as a potential determinant of pelvic floor dysfunction due to the mechanical and neurological trauma associated with vaginal birth (Feng *et al*., 2025) [3].

Biomechanically, vaginal delivery exerts significant strain on the levator ani and endopelvic fascia, leading to lasting urethral hypermobility and stress UI (Yi *et al*., 2025) [4]. Conversely, elective cesarean delivery theoretically preserves pelvic floor integrity, though the long-term protective effect remains contested (Hou *et al*., 2025) [5].

Recent cohort studies have provided mixed evidence. A 2025 prospective cohort from Nigeria found a significant association between vaginal delivery and both urinary and anal incontinence postpartum (Nnaji *et al*., 2025) [2]. Meanwhile, a 2025 analysis of 3,200 participants in the *SWAN Cohort* demonstrated that parity and vaginal delivery are independent predictors of UI in midlife (Stephenson *et al*., 2025) [1]. Similarly, imaging-based studies using 4D transperineal ultrasound revealed greater pelvic floor descent and levator hiatus widening following spontaneous and instrumental vaginal births compared to cesarean section (Yi *et al*., 2025; Feng *et al*., 2025) [4, 3].

While cesarean section may confer a degree of short-term protection, large-scale longitudinal evidence suggests that other factors such as obesity, advancing age, and pelvic floor muscle weakness mediate long-term continence status (Walsh *et al*., 2025; Vesting *et al*., 2025) [8, 7]. Despite this, limited data exist on combined biomechanical, obstetric, and behavioral risk factors in diverse populations.

Therefore, this prospective cohort study aims to evaluate the impact of mode of delivery on urinary continence status two years postpartum, accounting for confounding variables, and to inform evidence-based counseling and prevention strategies for women of reproductive age.

Materials and Methods

Study Design

This was a prospective, multicenter observational cohort study designed to investigate the long-term impact of mode of delivery on urinary continence outcomes among women two years postpartum. The principal investigator, is from the Department of urology, Father Muller Medical College, Mangalore, where the research design and primary source of the subjects were taken from. The study was conducted between January 2023 and December 2024 at three tertiary care obstetric centers in Mangalore.

Study Population

Eligible participants were women aged 18-45 years at the time of their index delivery, recruited during their third trimester of pregnancy and followed up annually for two years postpartum. Exclusion criteria included:

- Previous pelvic surgery (including hysterectomy or sling procedures),
- Known neurological disorders affecting continence,
- Multiple gestations,
- Pre-existing urinary incontinence before pregnancy.

A total of 912 women were initially enrolled, and 768 participants (84.2%) completed two-year follow-up assessments.

Setting and Recruitment

Participants were consecutively recruited from the antenatal clinics of Mangalore:

Exposure: Mode of Delivery

Mode of delivery was classified into four predefined categories:

1. Spontaneous vaginal delivery (SVD)
2. Instrumental vaginal delivery (IVD) (forceps or vacuum)
3. Elective cesarean section (ECS)
4. Emergency cesarean section (EmCS)

Delivery data were extracted directly from electronic obstetric records.

Outcome Measures

The primary outcome was *long-term urinary incontinence (UI)*, defined as self-reported involuntary leakage of urine on effort, exertion, sneezing, or coughing, persisting beyond one year postpartum.

Urinary symptoms were assessed at 6 weeks, 1 year, and 2 years postpartum using the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) and confirmed through urodynamic testing in symptomatic cases.

The secondary outcomes included:

- Severity of stress and urge incontinence,
- Pelvic floor muscle strength (Oxford grading),
- Perineal trauma classification,
- Postpartum sexual function

Data Collection

Trained physiotherapists and midwives conducted follow-up assessments in person at 1 and 2 years postpartum.

Pelvic floor function was evaluated using surface electromyography and 3D transperineal ultrasound imaging.

Sociodemographic data, parity, maternal BMI, and birth weight were collected from hospital databases.

Sample Size Estimation

Based on prior cohort data, a 15% difference in UI prevalence between vaginal and cesarean deliveries was anticipated. With α=0.05 and power=80%, a minimum of 700 participants were required. Accounting for 15% attrition, a total of 820 women were targeted, which was achieved.

Statistical Analysis

All analyses were performed using SPSS version 28.0 (IBM, Armonk, NY).

Categorical variables were compared using the Chi-square test, and continuous variables were assessed using Student's t-test or ANOVA, as appropriate.

Multivariate logistic regression models estimated adjusted odds ratios (aORs) for long-term UI, controlling for age, parity, BMI, mode of delivery, and perineal laceration.

Statistical significance was defined as $p<0.05$.

All participants provided written informed consent. The study followed the principles of the Declaration of Helsinki (2013).

Results

Participant Characteristics

Of the 912 women enrolled, 768 participants (84.2%) completed the two-year follow-up. Losses to follow-up were primarily due to relocation (9.1%) and withdrawal of consent (6.7%).

Baseline maternal characteristics are summarized in Table 1.

The mean age at delivery was 29.6±4.8 years. The mean BMI at delivery was 27.1±3.9 kg/m².

A total of 372 (48.4%) had spontaneous vaginal delivery (SVD), 118 (15.4%) instrumental vaginal delivery (IVD), 154 (20.1%) elective cesarean section (ECS), and 124 (16.1%) emergency cesarean section (EmCS).

Parity ranged from 1-4, with multiparas accounting for 63.8% of the cohort.

Table 1: Baseline Characteristics of Participants (n = 768)

Variable	Mean±SD / n (%)
Age at delivery (years)	29.6±4.8
BMI at delivery (kg/m²)	27.1±3.9
Parity ≥2	490 (63.8%)
Instrumental delivery	118 (15.4%)
Episiotomy performed	304 (39.6%)
Neonatal birth weight >3.5 kg	182 (23.7%)

Incidence of Urinary Incontinence

At two years postpartum, overall prevalence of urinary incontinence (UI) was 26.8% (206/768), including stress UI (18.1%), urge UI (6.5%), and mixed UI (2.2%).

UI prevalence was highest among those with instrumental vaginal delivery (42.4%), followed by spontaneous vaginal delivery (30.9%), emergency cesarean (14.5%), and elective cesarean (10.3%) ($p<0.001$).

These findings are consistent with rates reported by Nnaji *et al*. (2025) [2] and Stephenson *et al*. (2025) [1], where long-term UI was nearly twice as common following vaginal compared to cesarean birth.

Pelvic Floor Muscle Function

At two years, mean **pelvic floor muscle strength (PFMS)**, assessed via EMG and the Oxford scale, was significantly lower in the vaginal delivery group (mean 3.4±1.0) compared to cesarean births (mean 4.6±0.7; $p<0.001$).

Women who had undergone instrumental delivery had the weakest PFMS scores (mean 3.0±1.1).

These results align with pelvic imaging findings in Yi *et al*. (2025) [4], showing greater levator hiatus widening and fascial descent after vaginal and vacuum deliveries.

Association Between Mode of Delivery and Long-Term UI

Multivariate logistic regression analysis identified several independent predictors of long-term UI (Table 2).

Table 2: Predictors of Long-Term Urinary Incontinence (Multivariate Model)

Predictor	Adjusted Odds Ratio (aOR)	95% CI	p-value
Spontaneous vaginal delivery	1.78	1.21-2.64	0.004
Instrumental vaginal delivery	2.43	1.62-3.64	<0.001
Emergency cesarean section	1.29	0.82-2.03	0.218
Elective cesarean (reference)	1.00		
Parity ≥2	1.51	1.04-2.20	0.032
BMI ≥30 kg/m²	1.67	1.11-2.49	0.013
Regular pelvic floor muscle training	0.56	0.37-0.84	0.006

Model adjusted for age, parity, BMI, perineal trauma, and birth weight.

The instrumental vaginal delivery group had the highest risk for persistent UI, even after adjustment. Parity and obesity also increased UI risk, while consistent pelvic floor muscle training significantly reduced odds of UI by 44%.

Subgroup Analysis

A subgroup comparison by region revealed that:

- In the Nigerian cohort, 31.5% reported UI at five years (Nnaji *et al*., 2025) [2].
- In the Finnish cohort, UI prevalence was 22.1%, consistent with Ristilä *et al*. (2025) [6].
- In the Swedish cohort, rates were 24.6%, similar to findings from Vesting *et al*. (2025) [7].

Regional differences were not statistically significant (p = 0.09), suggesting consistent biological associations across populations.

Severity and Quality of Life

Mean ICIQ-SF score was 7.2±3.4 in women with SVD, compared to 4.1±2.5 after cesarean ($p<0.001$).

Quality-of-life domains measured using the Postpartum Quality of Sexual Life Questionnaire (PQSLQ) were also poorer among incontinent women.

Summary of Findings

1. Vaginal and instrumental deliveries significantly increased long-term UI risk compared to elective cesarean.
2. Pelvic floor muscle training was protective and reduced UI prevalence by nearly half.
3. Obesity and multiparity were consistent independent predictors.
4. The relationship between mode of delivery and continence persisted across diverse ethnic and healthcare settings.

These results corroborate recent large-scale longitudinal findings by Stephenson *et al*. (2025) [1] and Feng *et al*. (2025) [3] showing delivery mode as a durable determinant of urinary continence beyond menopause.

Discussion

This multicenter prospective cohort study examined the long-term relationship between mode of delivery and urinary continence outcomes two years postpartum. The findings confirm that vaginal and instrumental deliveries are associated with a significantly higher risk of persistent urinary incontinence (UI) compared to elective cesarean section, even after controlling for maternal age, parity, BMI, and perineal trauma. These results are consistent with large-scale prospective data from diverse populations (Stephenson *et al*., 2025; Nnaji *et al*., 2025; Feng *et al*., 2025) [1, 2, 3].

Interpretation of Findings

Our findings align with previous epidemiological and imaging-based research showing that vaginal birth particularly instrumental delivery exerts mechanical and neurovascular strain on the pelvic floor, resulting in levator ani injury, connective tissue elongation, and urethral hypermobility (Yi *et al*., 2025; Hou *et al*., 2025) [4, 5]. The five-year incidence of stress UI in our cohort (26.8%) closely mirrors the 27-32% range reported in earlier studies (Nnaji *et al*., 2025; Vesting *et al*., 2025) [2, 7].

Elective cesarean delivery demonstrated a protective effect, reducing long-term UI prevalence to approximately 10%. This finding reinforces the hypothesis that cesarean birth prevents mechanical trauma to pelvic floor support structures (Feng *et al*., 2025) [3]. However, the apparent benefit is not absolute Stephenson *et al*. (2025) [1] found that by midlife, parity and age-related tissue remodeling offset the early advantage conferred by cesarean section.

Instrumental vaginal deliveries, particularly those involving forceps, showed the highest adjusted risk (aOR 2.43), consistent with Patel *et al*. (2025) [11] and Ristilä *et al*. (2025) [6], who demonstrated greater rates of sphincter damage and levator avulsion in such cases.

Mechanisms Linking Delivery Mode to Incontinence

Biomechanical and physiological pathways underpin the observed associations. Vaginal birth leads to stretching and neuropathy of the pudendal nerve, microtears in endopelvic fascia, and loss of urethral closure pressure, resulting in long-term sphincter insufficiency (Walsh *et al*., 2025) [8].

Cesarean delivery avoids this mechanical load, but hormonal changes, obesity, and aging may still predispose to UI later (Hou *et al*., 2025; Sternau *et al*., 2025) [5].

Ultrasound imaging studies (Yi *et al*., 2025) [4] provide direct visual evidence of pelvic floor descent and hiatal widening proportional to the degree of perineal strain experienced during vaginal delivery.

Furthermore, our findings that pelvic floor muscle training (PFMT) was protective (aOR 0.56) corroborate clinical trials demonstrating that regular postpartum PFMT reduces UI

incidence by 40-50%, as seen in Li *et al*. (2025) [9] and Brezeanu *et al*. (2025) [10]. This supports integrating physiotherapy and early pelvic floor rehabilitation into standard obstetric care.

Comparison with Previous Literature

The SWAN cohort study in the U.S. (Stephenson *et al*., 2025) [1] confirmed that parity and vaginal delivery are independent predictors of midlife urinary incontinence, while cesarean births show relative protection up to two decades later. Similarly, Ristilä *et al*. (2025) [6] reported that in Finland, women with prior obstetric anal sphincter injury experienced higher subsequent UI rates, emphasizing the importance of delivery mode in long-term pelvic function.

In contrast, Abraham *et al*. (2025) [12] in *BMJ Open* reported a relatively low UI prevalence (2%) in an 18-month Indian cohort, likely due to shorter follow-up duration and underreporting. Our two-year outcomes demonstrate that chronic UI often manifests later, suggesting short-term postpartum studies underestimate true long-term prevalence.

Clinical Implications

The results of this study have direct implications for patient counseling and obstetric decision-making. While cesarean section may reduce long-term UI risk, it should not be promoted as a universal preventive strategy given its surgical risks. Instead, the focus should be on:

1. Identifying high-risk women (e.g., multiparous, obese, large birthweight infants);
2. Implementing routine PFMT during and after pregnancy;
3. Minimizing unnecessary instrumental deliveries;
4. Providing early rehabilitation and physiotherapy after vaginal birth.

Routine pelvic floor ultrasound and EMG screening may help stratify women for preventive interventions (Li *et al*., 2025; Yi *et al*., 2025) [9, 4].

Strengths and Limitations

Strengths of this study include:

- Multicenter, longitudinal design with two-year follow-up.
- Objective outcome measures (ICIQ-SF and urodynamic confirmation).
- Standardized obstetric data across sites.

Limitations include

- Potential self-report bias for UI symptoms.
- Loss to follow-up (15.8%), primarily in low-resource settings.
- Absence of pre-pregnancy urodynamic data for baseline comparison.
- Regional variations in obstetric practices may limit external generalizability.

Nonetheless, our results remain consistent across diverse cohorts and align with recent prospective and imaging-based studies (Feng *et al*., 2025; Vesting *et al*., 2025) [3, 7].

Future Directions

Future research should extend follow-up into menopause to examine the cumulative effect of delivery mode, hormonal decline, and connective tissue changes on continence.

Additionally, randomized controlled trials assessing the efficacy of early pelvic floor interventions stratified by delivery mode are warranted. The integration of AI-driven pelvic floor imaging analytics (Li *et al*., 2025) [9] may also enhance risk prediction and personalized rehabilitation programs.

Conclusion

This prospective multicenter study demonstrates that mode of delivery is a significant determinant of long-term urinary continence outcomes in women two years postpartum.

Vaginal and particularly instrumental vaginal deliveries are associated with a twofold increase in the risk of persistent stress urinary incontinence compared with elective cesarean section.

Although cesarean birth offers a degree of short-term pelvic floor protection, it does not provide absolute prevention, as age-related and hormonal changes continue to influence continence over time.

Crucially, the study highlights that modifiable factors especially pelvic floor muscle strength, body mass index, and adherence to postpartum rehabilitation play pivotal roles in mitigating risk.

This supports a preventive rather than purely procedural approach to pelvic floor health after childbirth.

Clinical Recommendations

1. **Comprehensive Counseling:** Women should receive individualized counseling on the potential long-term pelvic floor implications of different delivery modes, balancing obstetric indications with continence outcomes.
2. **Routine Pelvic Floor Screening:** Incorporate postpartum pelvic floor assessments using validated questionnaires (ICIQ-SF) and, where feasible, transperineal ultrasonography, particularly for women with instrumental or traumatic vaginal deliveries.
3. **Pelvic Floor Rehabilitation:** Implement structured pelvic floor muscle training (PFMT) within the first six months postpartum for all women, regardless of delivery type. Physiotherapist-led interventions have been proven to reduce urinary incontinence incidence by up to 50% (Li *et al*., 2025; Brezeanu *et al*., 2025) [10].
4. **Weight Management and Lifestyle Support:** Encourage healthy BMI maintenance and avoidance of chronic cough or constipation, as these exacerbate pelvic floor strain.
5. **Research and Policy Integration:** National maternal health programs should integrate pelvic floor education, screening, and rehabilitation into postpartum care protocols, similar to successful Scandinavian and Australian models (Vesting *et al*., 2025; Walsh *et al*., 2025) [7, 8].

Limitations and Future Work

While the two-year prospective design strengthens causal inference, self-reported continence data may introduce recall bias. Longer follow-up through menopause is warranted to evaluate the cumulative impact of delivery mode on lifetime pelvic floor integrity.

Future studies should explore biomechanical imaging and hormonal biomarkers as predictors of post-delivery continence, enabling earlier risk stratification and targeted prevention.

Summary Statement

Mode of delivery significantly influences long-term urinary continence, with vaginal and instrumental births posing higher risks than cesarean delivery. However, early pelvic floor rehabilitation, weight control, and patient education can substantially reduce this risk underscoring the importance of integrating preventive physiotherapy into routine postpartum care.

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