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Risk factors for postpartum stress urinary incontinence: An updated systematic review and meta-analysis

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ABSTRACT

Background: The objective of this meta-analysis was to identify and quantify postpartum stress urinary incontinence (SUI) risk factors.

Methods: We systemically searched three electronic databases (PubMed, Scopus, and Web of Science). The evaluated variables as risk factors were pooled as odds ratio (OR) with the corresponding 95% confidence intervals (CI).

Results: 63 studies were included. The analysis found a significant positive association between SUI and vaginal delivery (OR=2.15), age (OR=1.44), BMI (OR=1.19), parity (OR=1.43), and fetal-birth weight (OR=1.08).

Conclusions: Age, parity, delivery with forceps, birth weight, maternal body mass index, induction of labor, length of the second stage of labor, history of prenatal SUI, and vaginal delivery were all risk factors for postpartum SUI.

Scientific novelty: This systematic review and meta-analysis provides the most comprehensive and updated evidence to date.

Practical significance of the results: Healthcare personnel should be taught to recognize and treat postpartum SUI risk factors.

Keywords: postpartum stress urinary incontinence, risk factors, SUI, vaginal delivery

INTRODUCTION

Postpartum stress urinary incontinence (SUI) affects women following childbirth [1]. It is characterized by involuntary leakage of urine during physical activity that places strain on the bladder, such as coughing, sneezing, laughing, and exercise [2]. This disorder can have a substantial influence on a woman's quality of life, creating humiliation, worry, and a sense of solitude [3].

Postpartum SUI results from the weakened pelvic floor muscles and stretched pelvic floor ligaments that develop during pregnancy and childbirth [4]. These alterations might cause the bladder and urethra to lose support, resulting in urine incontinence. Women who have had vaginal births, especially those with instrumental births or a long second stage of labor, have an increased chance of developing postpartum SUI [5, 6].

Other risk factors for postpartum SUI include maternal age, birth weight, obesity, and number of previous pregnancies [4]. Not all women who experience these risk factors will develop postpartum SUI, and some women may acquire SUI despite the absence of these risk factors.

Postpartum SUI can be treated with pelvic floor muscle exercises, lifestyle adjustments like weight loss and smoking cessation, and in certain circumstances, surgery [7-9]. Educating women on preventative techniques and assisting them with symptom management can improve their quality of life.

The objective of this meta-analysis is to identify and quantify postpartum SUI risk factors. By summarizing the available evidence, we aim to provide a more comprehensive understanding of this condition's risk factors and to improve clinical practice and future research in this field.

METHODS

We followed PRISMA statement guidelines when reporting this systematic review and meta-analysis [10]. All steps were done in strict accordance with the Cochrane handbook of systematic reviews and meta-analysis of Interventions [11].

Eligibility Criteria

Studies were included in our review if they satisfied the following criteria:

1. **Population:** Studies on patients with postpartum SUI.
2. **Intervention:** Studies, where exposed group had a delivery, either normal vaginal, assessed, or cesarean section.
3. **Outcome:** Studies reporting at least one of following outcomes as a risk factor for developing SUI: mode of delivery, birth weight, length of second stage of labor, age, body mass index (BMI), parity, gestational age, fetal head circumference, episiotomy, epidural anesthesia, induction of labor (IOL), or SUI during pregnancy.
4. **Study design:** Any observational studies or clinical trials evaluating any of the previous outcomes.

We excluded studies whose data were not reliable for extraction and analysis, studies that were reported as abstracts only or thesis, studies whose complete full-texts were not available, review articles, case reports, case series, and studies that were not published in the English language.

Information Sources & Search Strategy

We performed a comprehensive search of three electronic databases (PubMed, Scopus, and Web of Science) from inception until 1 March 2021 using the following query: ("stress incontinence" OR "stress urinary incontinence" OR "SUI" OR "urinary stress incontinence") AND ("after birth" OR "after delivery" OR "post-natal" OR "postnatal" OR "lying in" OR "puerperal" OR "childbirth" OR "postpartum" OR "postpartum period") AND ("risk factor" OR "association" OR "relative risk" OR "OR" OR "populations at risk"). Additionally, the listed studies' references were carefully examined for any potential being eligible research.

Selection Process

Duplicates were removed using Endnote (Clarivate Analytics, Philadelphia, PA, USA), and the retrieved references were screened in two steps: the first step was to screen titles/abstracts of all identified articles independently by all authors to assess relevance to this meta-analysis, and the second step was to screen the full-text articles of the identified abstracts for final eligibility to meta-analysis. The selection process was done on Rayyan website [12].

Data collection Process & Data Items

Data were extracted to a uniform data extraction sheet. The extracted data included

(1) characteristics of the included studies (study ID, design, country, sample size, and follow-up time),

(2) characteristics of the population of included studies (age, BMI, and parity),

(3) risk of bias domains, and

(4) outcome measures (mode of delivery, birth weight, length of second stage of labor, age, BMI, parity, gestational age, fetal head circumference, episiotomy, epidural anesthesia, IOL, or SUI during pregnancy).

Assessing Risk of Bias in Individual Studies

Newcastle Ottawa scale (NOS) was used to assess the risk of bias for observational, cohort, and case-control studies [13]. This tool evaluates the risk of bias in observational studies depending on three crucial reporting domains: selection of the research participants, comparability of groups related

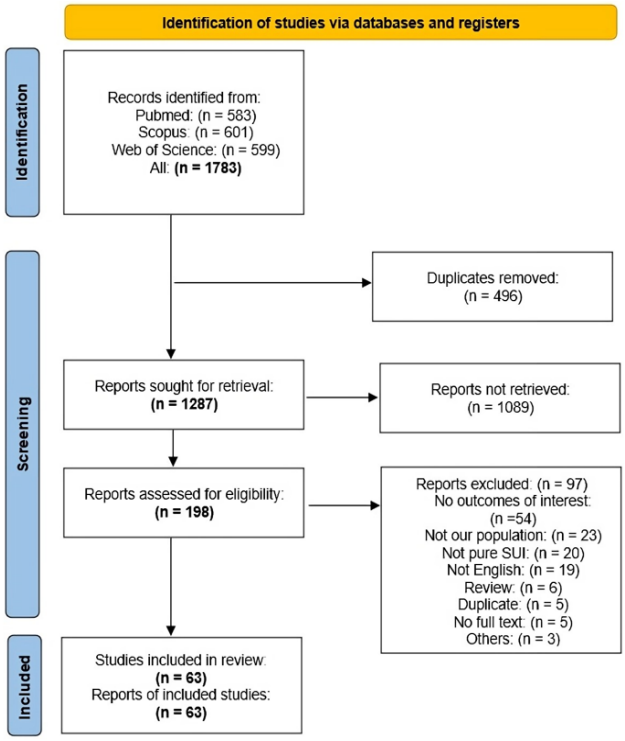

Figure 1. PRISMA flow diagram of study selection process (Source: Authors' own elaboration)

demographic features and important potential confounders and determining the prespecified result.

Synthesis Methods

Since all the study outcomes are dichotomous data from prospectively designed studies, we presented all outcomes as odds ratio (OR) of developing SUI.

Assessment of Heterogeneity

Statistical heterogeneity among studies was evaluated by Chi-square test (Cochrane Q test). Then, Chi-square statistic, Cochrane Q, was used to calculate the I-squared according to the equation: $I^2 = \left(\frac{Q-df}{Q}\right) x100\%$. A Chi-square p-value less than 0.1 was considered as significant heterogeneity. I-square values ≥50% were indicative of high heterogeneity.

Reporting Bias Assessment

We created funnel plots to show the link between effect size and standard error in order to investigate the publication bias across research. Both the Egger's regression test [14] and the Begg and Mazumdar rank correlation test [15] (also known as Kendall's tau) were used to evaluate the evidence of publication bias.

Literature Search Results

Our search for literature turned up 1,783 results. 198 articles were qualified for full-text screening after being subjected to title and abstract screening. 63 of these papers made up the meta-analysis. No further papers were included after manually searching the references of the listed studies. **Figure 1** depicts PRISMA flow diagram of the study selection procedure.

Table 1. Summary of the studies included in this systematic review and meta-analysis

ID	Design	Country	SS	A-M (SD)	BMI-M (SD)	Parity status
[6]	Prospective cohort study	Iran	286	29.10 (7.20)	NR	All nulliparous
[16]	Cross-sectional study	Saudi Arabia	802	NR	NR	Multiparous (80%)
[17]	Prospective cohort study	Sweden	309	29.90 (4.10)	NR	All primiparous
[18]	Prospective cohort study	Spain	396	30.90 (18.50)	23.10 (3.60)	All primiparous
[19]	Prospective cohort study	Spain	458	31.10 (3.60)	23.30 (3.80)	All primiparous
[20]	Cross-sectional study	Switzerland	1,231	36.95 (5.35)	NR	Multiparous (34%)
[21]	Cross-sectional study	Edmonton	632	29.00 (21.48)	NR	Parity M (SD) 2.50 (2.50)
[22]	Prospective cohort study	Sweden	728	42.00 (20.74)	34.00 (12.50)	Parity M (SD) 3.00 (1.53)
[23]	Cross-sectional study	Birmingham	1,023	NR	NR	All primiparous
[24]	Prospective cohort study	USA	523	28.60 (20.70)	NR	Primigravida (41%)
[25]	Case-control study	USA	51	28.10 (4.00)	23.30 (4.00)	Primigravida (66%)
[26]	Prospective cohort study	Turkey	1,439	33.10 (4.30)	NR	Parity M (SD) 3.25 (0.88)
[27]	Cross-sectional study	UK	549	29.00 (21.48)	NR	All nulliparous
[28]	Prospective cohort study	Hong Kong	328	30.60 (3.80)	21.00 (2.80)	All nulliparous
[29]	Prospective cohort study	Taiwan	1,447	33.66(4.02)	24.88 (3.44)	Primigravida (33%)
[30]	Prospective cohort study	Taiwan	303	33.60 (3.90)	26.00 (4.50)	Parity M(SD) 1.70 (0.70)
[31]	Prospective cohort study	China	634	30.40 (4.10)	20.96 (3.05)	All primiparous
[32]	Prospective cohort study	China	360	25.00 (70%)< & <25.00 (30%)	22.52 (3.19)	Multiparous (23%)
[33]	Retrospective cohort study	Taiwan	539	30.58 (5.28)	28.22 (3.76)	NR
[34]	Prospective cohort study	Taiwan	378	28.10 (5.00)	27.00 (3.60)	All primigravida
[35]	Prospective cohort study	Taiwan	6,910	3.10(4.40)	24.40% BMI>30.00	Multiparous (11%)
[36]	Prospective cohort study	Spain	352	31.20 (3.50)	23.20 (3.60)	All primiparous
[37]	Prospective cohort study	Spain	479	43.40 (11.10)	24.00 (35.60)	Parity M (SD) 1.80 (5.19)
[38]	Prospective cohort study	UK	3,002	26.20 (4.80)	24.80 (29.90)	All primigravida
[39]	Prospective cohort study	Irland	1,774	30.50 (4.20)	25.00 (4.10)	All nulliparous
[40]	Prospective cohort study	Iran	10,000	NR	NR	All nulliparous
[41]	Prospective cohort study	Indonesia	447	27.00 (13.30)	26.65 (12.50)	All primiparous
[42]	Cross-sectional study	Denmark	2,631	30.00-59.00	NR	Multiparous (63%)
[43]	Retrospective cohort study	France	307	29.30 (4.40)	21.30 (2.90)	NR
[44]	Prospective cohort study	France	2,002	29.50 (4.70)	NR	Multiparous (51%)
[45]	Prospective cohort study	China	612	22.13 (5.25)	27.12 (5.07)	All primiparous
[46]	Cross-sectional study	USA	769	42.75 (15.66)	NR	Parity M (SD) 3.00 (7.40)
[47]	Cross-sectional study	USA	542	47.00 (70.00)	26.40 (6.10)	Parity M (SD) 2.75 (2.07)
[48]	Prospective cohort study	Israel	2,573	34.20 (3.70)	24.80 (4.00)	Parity M (SD) 3.50 (0.65)
[49]	Prospective cohort study	Sweden	5,236	NR	NR	All primiparous
[50]	Prospective cohort study	Denmark	1,018	27.00 (5.13)	24.00 (5.10)	All nulliparous
[51]	Prospective cohort study	Iran	618	23.60 (4.50)	27.00 (3.30)	All nulliparous
[52]	Longitudinal cohort study	Brazil	120	26.40	NR	NR
[53]	Case control study	Multicentral	2,355	32%≥30.00	NR	61% parity≥1.00
[54]	Prospective cohort study	Sweden	670	28.90 (3.80)	25.00 (5.00)	All nulliparous
[55]	Prospective cohort study	China	6,370	29.86 (3.68)	22.88 (2.80)	All nulliparous
[56]	Prospective cohort study	USA	74	17.40 (1.43)	30.75 (6.80)	58% parity≥1.00
[57]	Prospective cohort study	China	180	30.10 (3.20)	23.47 (1.10)	NR
[58]	Prospective longitudinal study	Spain	79	32.22 (5.80)	25.20 (4.26)	NR
[59]	Cross-sectional study	Spain	196	32%≥30.00	68%≥30.00	43% parity≥1.00
[60]	Cross-sectional study	France	210	39.72 (7.95)	34%≥25.00	NR
[61]	Prospective cohort study	France	186	29.60 (4.60)	22.40 (3.50)	All nulliparous
[62]	Prospective cohort study	Norway	15,307	37.70 (10.00)	25.35 (4.32)	2.17 (0.80)
[63]	Cross-sectional study	Brazil	340	26.40	NR	33% parity≥2.00
[64]	Prospective cohort study	Sweden	2,390	29.50 (4.60)	54%≥30.00	56% parity≥1.00
[65]	Retrospective cohort study	USA	1,182,650	70%≥30.00	48%≥30.00	NR
[66]	Prospective longitudinal study	Australia	124	91%≥25.00	NR	36% parity≥1.00
[67]	Retrospective cohort study	Norway	13,694	46.98 (10.50)	18%≥30.00	2.3701 (0.87)
[68]	Case-controlled Study	Iran	250	40.03 (6.64)	NR	75% parity≥1.00
[69]	Retrospective case-controlled study	USA	173	39.70 (22.60-52.90)	23.80 (4.60)	NR
[70]	Prospective cohort study	Norway	241	26.00 [17.00-41.00]	22.10 (15.20-36.10)	All nulliparous
[71]	Retrospective cohort study	China	410	64%≥55.00	11% ≥25.00	48% parity≥1.00
[72]	cross-sectional study	China	2,637	76.5%≥40.00	24% ≥30.00	82% parit ≥2.00
[73]	Retrospective cohort study	China	172	69.2%≥35.00	19% ≥24.00	100% parity≥2.00
[74]	Prospective cohort study	Spain	479	31.40 (3.39)	23.19 (3.66)	All primiparous
[75]	Prospective cohort study	China	1,137	30.70 (3.20)	≥30: 55.00 (4%)	9% parity≥1.00
[76]	Prospective cohort study	Taiwan	312	29.40 (4.10)	22.10 (7.20)	58% parity≥1.00
[77]	Prospective cohort study	China	1,889	30.61 (4.07)	Weight: 72.94 (9.08)	All nulliparous

Note. ID: Study number; SS: Sample size; A-M (SD): Maternal age in years mean (standard deviaiton); & BMI-M (SD): BMI mean (standard deviaiton)

Characteristics of Included Studies

63 studies were included in the meta-analysis with a total of 1,284,161 patients. A summary of the characteristics of the included studies is provided in **Table 1**.

Overall, the included studies' quality was good for 28 studies, fair for 32 studies, and poor for only three studies according to NOS tool.

Table 2. Quality of included cohort studies according to NOS (ID: Study ID)

ID	Selection				Comparability	Outcome			Outcome score	Quality of evidence
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on basis of design/analysis controlled for confounders	Assessment of outcome	Follow up long enough for outcomes to occur	Adequacy of follow up of cohorts		
[6]	*	*	*	*	*	*	*	*	8	Good
[17]	*		*				*	*	4	Fair
[18]	*		*	*		*	*		4	Fair
[19]	*		*	*	*	*	*		6	Fair
[22]	*	*	*		*	*			5	Fair
[24]	*		*			*	*	*	5	Fair
[26]	*		*			*	*		4	Fair
[28]	*	*	*		*	*	*		6	Fair
[29]	*		*			*	*		4	Fair
[30]	*		*		*		*	*	4	Fair
[31]	*		*	*		*	*	*	6	Fair
[32]	*		*	*	*	*	*		6	Fair
[33]	*	*	*		*	*	*		6	Fair
[34]	*	*	*	*	*	*	*		7	Good
[35]	*	*	*			*	*	*	6	Fair
[36]	*	*	*	*		*	*	*	7	Good
[37]	*		*			*	*	*	5	Fair
[38]	*		*				*		3	Poor
[39]	*		*				*		3	Poor
[40]	*			*			*	*	4	Fair
[41]	*		*			*	*	*	5	Fair
[43]	*			*			*	*	4	Fair
[44]	*			*	**		*	*	6	Fair
[45]	*	*	*	*	**	*		*	8	Good
[48]	*	*	*	*	**		*		7	Good
[49]	*		*				*		3	Poor
[50]	*	*	*	*	**		*	*	8	Good
[51]			*	*	**		*	*	6	Fair
[52]	*	*	*	*	*	*	*	*	8	Good
[54]	*	*	*	*	**		*	*	7	Good
[55]	*	*	*	*	**	*		*	8	Good
[56]	*		*	*	*	*		*	6	Fair
[57]	*	*	*	*	**	*		*	8	Good
[58]	*	*	*	*	*	*			6	Fair
[61]	*	*	*	*	*	*	*	*	8	Good
[62]	*	*	*	*	**	*	*	*	9	Good
[64]	*	*	*	*	**	*	*	*	9	Good
[65]	*	*	*	*	*	*			6	Fair
[66]	*	*	*	*	**	*	*		8	Good
[67]	*	*	*	*	**	*		*	8	Good
[70]	*	*	*	*	*		*	*	7	Good
[71]	*	*	*	*	**	*		*	8	Good
[73]	*	*	*	*	*		*	*	7	Good
[74]	*		*	*		*	*	*	5	Fair
[75]			*	*	*	*		*	5	Fair
[76]	*	*	*	*	**	*	*	*	9	Good
[77]	*	*	*	*	**	*		*	8	Good

Table 3. Quality of included case-control studies according to NOS (ID: Study ID)

ID	Selection				Comparability	Outcome			Outcome score	Quality of evidence
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on basis of design/analysis controlled for confounders	Assessment of outcome	Follow up long enough for outcomes to occur	Adequacy of follow up of cohorts		
[25]	*	*		*	**	*	*		7/9	Good
[53]	*	*	*	*	**	*	*	*	9	Good
[68]	*	*	*	*	*	*	*	*	8	Good
[69]	*	*	*	*	**	*	*	*	9	Good

Table 2 shows quality of the included cohort studies according to NOS.

Table 3 shows quality of the included case-control studies according to NOS.

Table 4. Quality of included cross-sectional studies according to NOS (ID: Study ID)

ID	Selection				Comparability	Outcome			
	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of exposure (risk factor)	Subjects in different outcome groups are comparable on study design & analysis & confounding factors are controlled	Assessment of outcome	Statistical test	Outcome score	Quality of evidence
[16]	*				**	*	*	5/9	Fair
[20]	*	*	*	*	**	*	*	8/9	Good
[21]	*			**	**	*	*	7/9	Good
[23]	*			**		*	*	5/9	Fair
[27]	*			*	*	*	*	5/9	Fair
[42]	*		*		*	*	*	5/9	Fair
[46]	*			**		*		4/9	Fair
[47]	*			**		*	*	5/9	Fair
[59]	*	*	*	*			*	5	Fair
[60]		*	*	*	*	*	*	6	Fair
[63]	*	*	*	*	*	*	*	7	Good
[72]	*	*	*	*	*	*	*	7	Good

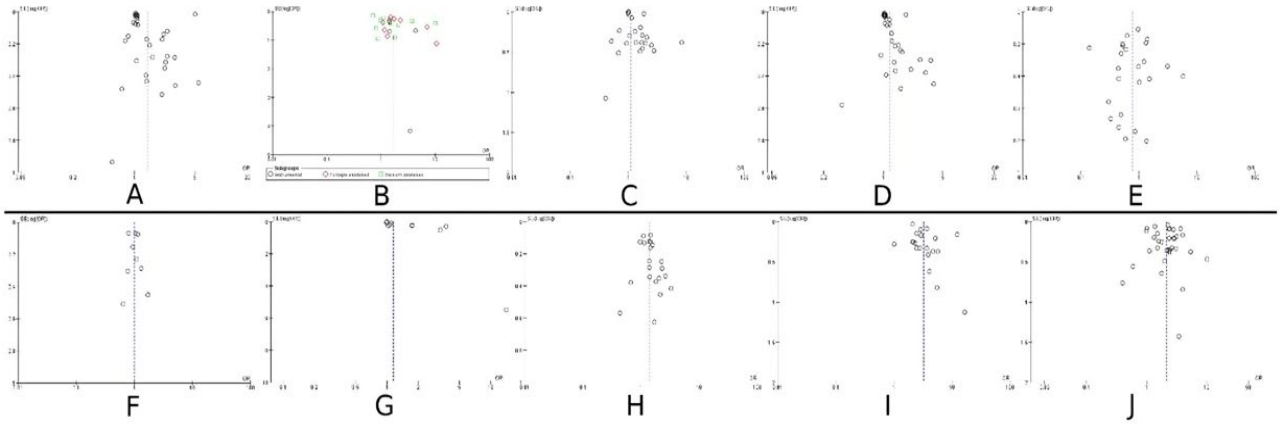

Figure 2. Funnel plots showing publication bias across included studies for each risk factor: Age (A), assessed delivery (B), birth weight (C), BMI (D), CS (E), fetal head circumference (F), length of second stage of labor (G), parity (H), history of SUI during pregnancy (H), & vaginal delivery (J) (Source: Authors' own elaboration)

Table 4 shows quality of the included cross-sectional studies according to NOS.

OUTCOMES

Demographical Risk Factors

Age

Pooled analysis of 33 studies involving 1,221,815 participants, age is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=1.44, 95% confidence intervals [CI]=1.16-1.79), indicating a strong association between age and SUI.

The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 3**, which showed no significant heterogeneity (I^2=100%, p<0.00001) or publication bias.

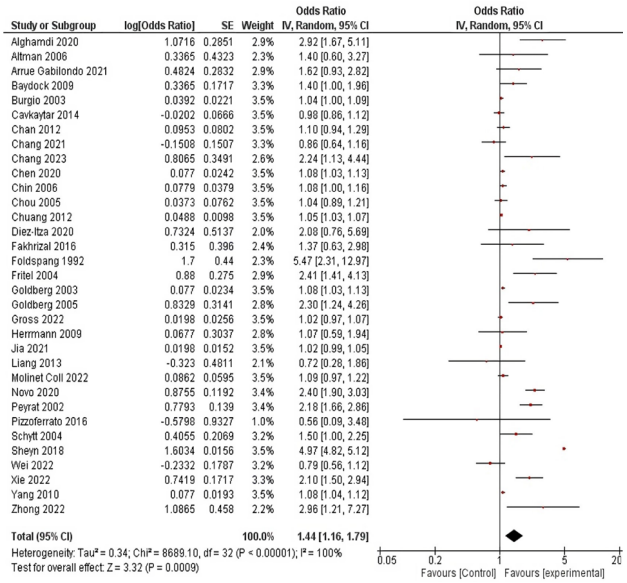

Figure 3. Forest plot showing OR of age as a risk factor for postpartum SUI (Source: Authors' own elaboration)

Body mass index

Pooled analysis of 32 studies involving 1,225,855 participants, BMI is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=1.19, 95% CI=1.11-1.28), indicating a strong association between BMI and SUI. Data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 4**, which showed no significant heterogeneity (I^2=96%, p<0.00001) or publication bias.

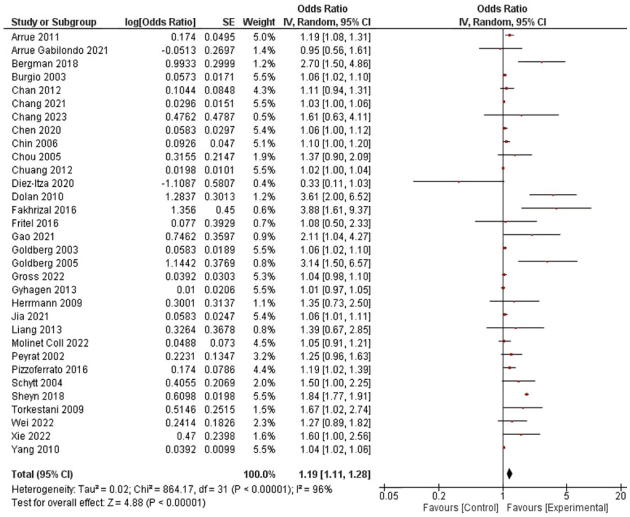

Figure 4. Forest plot showing OR of BMI as a risk factor for postpartum SUI (Source: Authors' own elaboration)

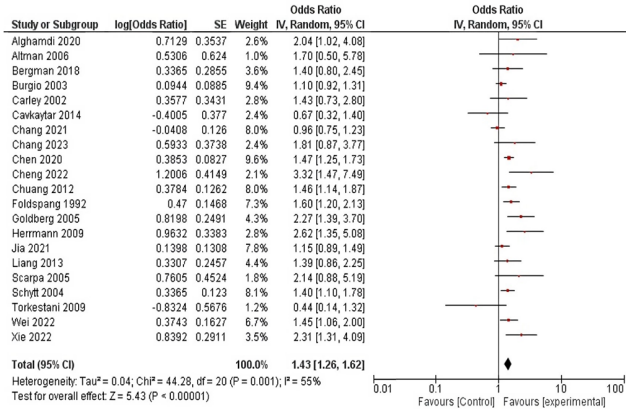

Figure 5. Forest plot showing OR of parity as a risk factor for postpartum SUI (Source: Authors' own elaboration)

Parity

Pooled analysis of 21 studies involving 29,507 participants, Parity is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=1.43, 95% CI=1.26-1.62), indicating a strong association between parity and SUI.

The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 5**, which showed no significant heterogeneity (I^2=55%, p=0.001) or publication bias.

Fetal Risk Factors

Fetal-birth weight

Pooled-analysis of 24 studies involving 31,836 participants, fetal-birth weight is a risk factor for developing postpartum SUI. The analysis revealed (OR=1.08, 95% CI=1.06-1.11), indicating a strong association between fetal-birth weight and SUI.

Data was analyzed using a random effects model and shown in **Figure 2** and **Figure 6**, which showed no significant heterogeneity (I^2=97%, p<0.00001) or publication bias.

Fetal head circumference

Pooled analysis of nine studies involving 7,660 participants, fetal-head circumference is ot a risk factor for developing postpartum SUI. The analysis revealed (OR=1.01,

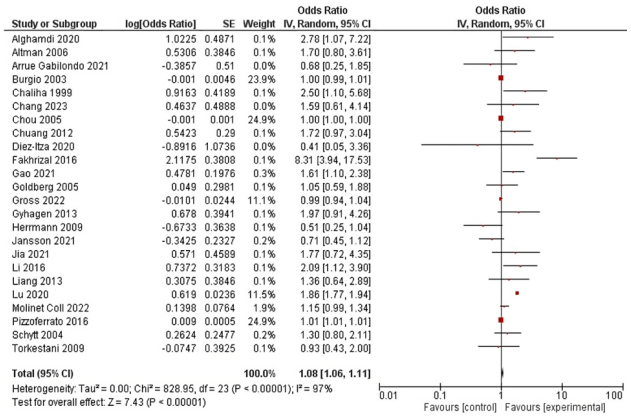

Figure 6. Forest plot showing OR of birth weight as a risk factor for postpartum SUI (Source: Authors' own elaboration)

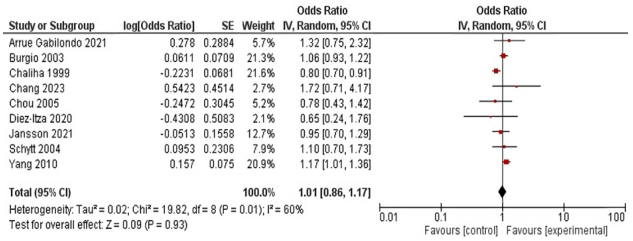

Figure 7. Forest plot showing OR of fetal head circumference as a risk factor for postpartum SUI (Source: Authors' own elaboration)

95% CI=0.86-1.17), indicating no association between fetal-head circumference and SUI.

The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 7**, which showed no significant heterogeneity (I^2=97%, p<0.00001) or publication bias.

Delivery Related Risk Factors

Vaginal delivery

Pooled analysis of 34 studies involving 1,232,882 participants, vaginal delivery is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=2.15, 95% CI=1.82-2.53), indicating strong association between vaginal delivery and SUI. The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 8**, which showed no significant heterogeneity (I^2=89%, p<0.00001) or publication bias.

C-section

Pooled analysis of 24 studies involving 48,736 participants, C-section is a significant protective factor for developing postpartum SUI. The analysis revealed (OR=0.77, 95% CI=0.57-1.04), indicating strong protective association between C-section and postpartum SUI. The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 9**, which showed no significant heterogeneity (I^2=85%, p<0.00001) or publication bias.

Instrumental delivery

Instrumental assessed delivery: Pooled analysis of five studies involving 3,197 participants, showed that instrumental delivery is not associated with the development of postpartum

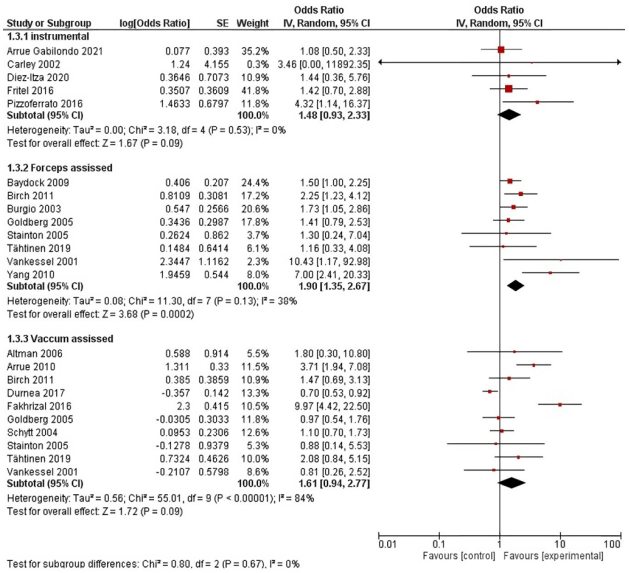

Figure 8. Forest plot showing OR of vaginal delivery as a risk factor for postpartum SUI (Source: Authors' own elaboration)

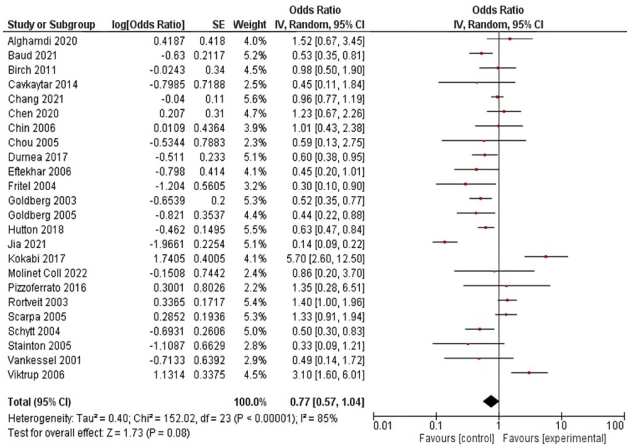

Figure 9. Forest plot showing OR of CS as a risk factor for postpartum SUI (Source: Authors' own elaboration)

SUI. Analysis revealed (OR=1.48, 95% CI=0.93-2.33), indicating strong protective association between c-section and SUI.

The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 10**, which showed significant heterogeneity that is failed to be resolved by sensitivity analysis (I^2=0%, p=0.53).

Forceps assisted delivery: Pooled-analysis of eight studies involving 18,600 participants, showed that forceps assessed delivery is a significant risk factor for developing SUI. Analysis revealed (OR=1.9, 95% CI=1.35-2.67), indicating strong risk association between forceps assessed delivery and SUI.

The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 10**, which showed significant heterogeneity that failed to be resolved by sensitivity analysis (I^2=38%, p=0.13).

Vacuum assisted delivery: Pooled-analysis of 10 studies involving 20,872 participants, showed that vacuum assessed delivery is not associated with development of postpartum SUI as the analysis revealed (OR=1.61, 95% CI=0.94-2.77). The data was analyzed using a random-effects model and displayed in

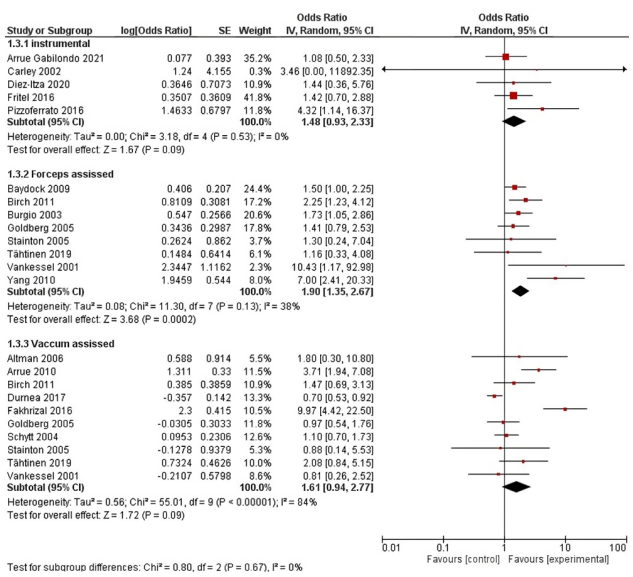

Figure 10. Forest plot showing OR of assessed delivery as a risk factor for postpartum SUI (Source: Authors' own elaboration)

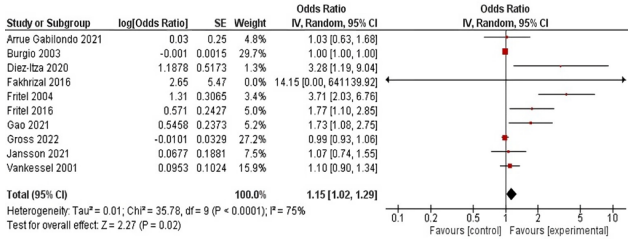

Figure 11. Forest plot showing OR of length of second stage of labor as a risk factor for postpartum SUI (Source: Authors' own elaboration)

Figure 2 and **Figure 10**, which showed no significant heterogeneity (I^2= 84%, p<0.00001) or publication bias.

Length of second stage of labor

Pooled-analysis of 10 studies involving 8,265 participants, higher duration of the second stage of labor is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=1.15, 95% CI=1.02-1.29), indicating strong risk association between length of second stage of labor and SUI. The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 11**, which showed no significant heterogeneity (I^2=75%, p<0.00001) or publication bias.

Induction of labor

Pooled analysis of five studies involving 3,951 participants, IOL is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=1.34, 95% CI=1.05-1.72), indicating strong risk association between IOL and SUI. The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 12**, which showed no significant heterogeneity (I^2=20%, p=0.28) or publication bias.

Epidural anesthesia

Pooled analysis of seven studies involving 3,944 participants, C-section is a significant protective factor for developing postpartum SUI. The analysis revealed (OR=0.77, 95% CI=0.57-1.04), indicating strong protective association

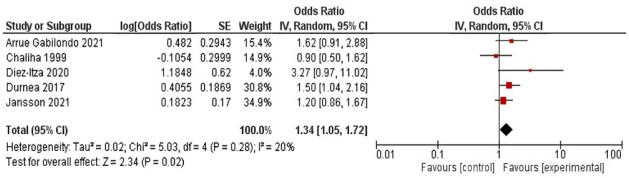

Figure 12. Forest plot showing OR of IOL as a risk factor for postpartum SUI (Source: Authors' own elaboration)

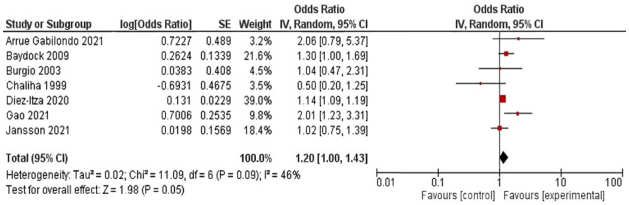

Figure 13. Forest plot showing OR of epidural anesthesia as a risk factor for postpartum SUI (Source: Authors' own elaboration)

between c-section and SUI. The data was analyzed using a random-effects model and displayed in **Figure 2** and **Figure 13**, which showed significant heterogeneity that is failed to be resolved by sensitivity analysis (I^2=46%, p=0.09).

Previous History of Stress Urinary Incontinence

Stress urinary incontinence in previous delivery

Pooled analysis of 20 studies involving 11,576 participants, history of previous SUI during pregnancy is a significant risk factor for developing postpartum SUI. The analysis revealed (OR=3.26, 95% CI=2.55-4.17), indicating strong protective association between previous history of SUI during pregnancy and development of SUI in postpartum period.

Data was analyzed using a random effects model and shown in **Figure 2** and **Figure 14**, which showed no significant heterogeneity (I^2=90%, p<0.00001) or publication bias.

DISCUSSION

Significance of the Study

To the best of our knowledge, this systematic review and meta-analysis of risk factors for developing postpartum SUI provides the most comprehensive and updated evidence to date. This study aimed to solve the controversy about the risk factors for developing postpartum SUI and provide comprehensive evidence on the predictive factors that contributed to the development of SUI after childbirth.

Summary of Findings

Our meta-analysis revealed that increased age, multiparity, forceps assessed delivery, increased birth weight (macrosomia), elevated maternal BMI, IOL, length of second stage of labor, history of SUI during pregnancy, and vaginal delivery were a significant risk factors for developing postpartum SUI. However, despite having OR more than one, vacuum assessed delivery, instrumental assessed delivery, and epidural anesthesia were non-significant risk factors. Moreover, CS seems to be a protective factor against postpartum SUI, despite having non-significant results. **Table 5** shows summary of meta-analysis results for each outcome.

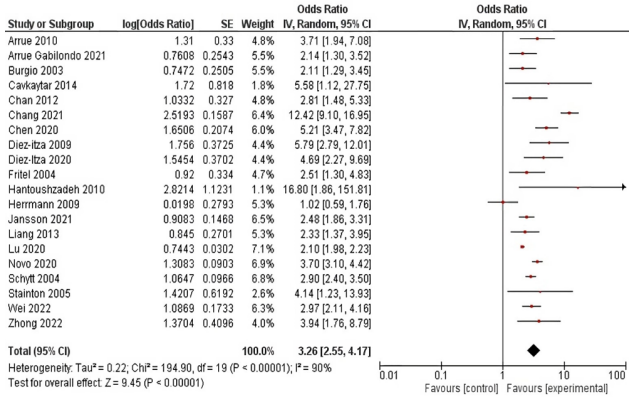

Figure 14. Forest plot showing OR of forest plot SUI in pregnancy as a risk factor for postpartum SUI (Source: Authors' own elaboration)

Explanation of the Findings

The pelvic floor muscles tend to weaken as women age, leaving them more prone to UI [78]. This deterioration may occur gradually over time, but it can also be accelerated by hormone fluctuations, menopause, and other medical conditions. Multiparity is a significant risk factor because of the fact that frequent straining and tearing of the pelvic floor muscles during delivery may eventually weaken them [79]. In addition, each successive pregnancy and delivery might progressively deteriorate the pelvic floor muscles, increasing the risk of incontinence [80]. The mood of delivery is the most important factor. In this meta-analysis, we evaluated five moods of delivery and its impact on developing postpartum SUI. Vaginal delivery is a significant risk factor for postpartum SUI due to the physical trauma that occurs during the delivery process. The stretching and pressure placed on the pelvic floor muscles and the pelvic organs during childbirth can cause damage to the muscles and nerves that control bladder function, leading to urinary incontinence [2]. Several factors connected to vaginal delivery affect the risk of postpartum SUI, including the duration of the second stage of labor, the use of equipment such as forceps or vacuum extraction, and the size of the newborn [3, 81].

A prolonged second stage of labor, i.e., the time between complete cervical dilatation and birth, might cause additional injury to the pelvic floor muscles and raise the risk of postpartum SUI [82]. Instrument-assisted births, such as those involving the use of forceps or vacuum extraction, can potentially increase the incidence of postpartum SUI by causing more damage to the pelvic floor muscles [81]. However, vacuum-assisted and instrumental-assisted delivery were not found to be a significant risk factor. This may be because the additional strain placed on the pelvic floor muscles during this type of delivery is not as significant as other factors, or because there were fewer studies (only 10) included in the meta-analysis that evaluated this outcome. However, forceps-assisted delivery was a significant risk factor as forceps that used to help guide the baby's head through the birth canal during delivery, can put additional strain on the pelvic floor muscles, increasing the risk of damage and incontinence [83].

Macrosomia, or a birth weight of more exceeding 4,000 grams (EİGHT pounds, 13 ounces), was found to be a significant risk factor for postpartum SUI. The higher risk may be a result of increased pressure on the pelvic floor muscles during vaginal delivery of a bigger infant [84, 85]. Although macrosomia is not

Table 5. Summary of meta-analysis results for each outcome

Outcome	NS	NP	OR	95% CI	Heterogeneity	Conclusion
Age	33	1,221,815	1.44	1.16-1.79	No significant heterogeneity (I^2=100%, p<0.00001)	Significant risk factor
BMI	32	1,225,855	1.19	1.11-1.28	No significant heterogeneity (I^2=100%, p<0.00001)	Significant risk facto
Parity	21	29,507	1.43	1.26-1.62	No significant heterogeneity (I^2=55%, p=0.00100)	Significant risk factor
Fetal-birth weight	24	31,836	1.08	1.06-1.11	No significant heterogeneity (I^2=97%, p<0.00001)	Significant risk factor
Fetal-head circumference	9	7,660	1.01	0.86-1.17	No significant heterogeneity (I^2=97%, p<0.00001)	No associatio with post-partum SUI
Vaginal delivery	34	1,232,882	2.15	1.82-2.53	No significant heterogeneity (I^2=89%, p<0.00001)	2nd strongly significant risk factor
C-section	24	48,736	0.77	0.57-1.04	No significant heterogeneity (I^2=85%, p<0.00001)	Significant protective factor
Instrumental assisted delivery	5	3,197	1.48	0.93-2.33	Showed significant heterogeneity that is failed to be resolved by sensitivity analysis(I^2=0%, p=0.53)	No associatio with post-partum SUI
Forceps assisted delivery	8	18,600	1.9	1.35-2.67	Showed significant heterogeneity that is failed to be resolved by sensitivity analysis((I^2=38%, p=0.13)	Significant risk factor
Vacuum assisted delivery	10	20,872	1.61	0.94-2.77	Showed no significant heterogeneity (I^2=84%, p<0.00001)	No associatio with post-partum SUI
Length of 2nd stage of labor	10	8,265	1.15	1.02-1.29	No significant heterogeneity (I^2=75%, p<0.00001)	Significant risk factor
Induction of labor	5	3,951	1.34	1.05-1.72	Showed no significant heterogeneity (I^2=20%, p=0.28)	Significant risk factor
Epidural anesthesia	7	3,944	0.77	0.57-1.04	Showed significant heterogeneity that is failed to be resolved by sensitivity analysis (I^2=46%, p=0.09)	Significant risk factor
History of SUI during pregnancy	20	11,576	3.26	2.55-4.17	No significant heterogeneity (I^2=90%, p<0.00001)	Most strongly significant risk factor

Note. NS: Number of studies & NP: Number of participants

always prevented, there are procedures that can be performed to reduce the likelihood of postpartum SUI [86]. In order to strengthen the muscles that support the bladder and prevent urine incontinence, healthcare professionals may offer prenatal instruction on pelvic floor muscle exercises [86].

It is important to highlight that the likelihood of having postpartum SUI is determined by a combination of circumstances, not a single cause. For instance, a woman with advanced maternal age, a high BMI, several pregnancies and vaginal deliveries, and a longer second stage of labor may be at a significantly greater risk for developing postpartum SUI than a woman with only one or two of these risk factors [87-89]. When assessing a woman's risk of developing postpartum SUI, it is crucial to consider the cumulative influence of various risk factors. This information can be used to assist therapeutic decision-making, including whether a woman should be referred for pelvic floor physical therapy or whether she may benefit from particular procedures during labor and delivery, such as a cesarean delivery [45, 90]. It is also essential to note that while some risk variables, such as vaginal delivery, are changeable, others, such as age and parity, cannot be. However, even non-modifiable risk variables can be used to identify women who may benefit from preventative measures, such as early pelvic floor muscle training or regular healthcare provider follow-up following delivery.

Agreement & Disagreement with Previous Studies

A previous meta-analysis in [5] included 45 articles and found that vaginal delivery, advanced age at gestation, advanced maternal BMI, excess weight gain during pregnancy, current BMI, diabetes, episiotomy, forceps delivery, gestational UI, gestational SUI, prenatal UI, and early postpartum UI, were identified to be associated with postpartum SUI. Moreover, elective CS and vacuum extraction were also identified as protective factors. They come in agree with our results except for CS and vacuum extraction as we found that its protective effect was statistically insignificant.

Strength Points & Limitations

Strengths of our meta-analysis include the comprehensive literature search that we conducted, which enabled us to identify and include a large number of studies in our analysis. Additionally, our use of strict inclusion and exclusion criteria helped to ensure that the studies included in our analysis were of high quality and were comparable to one another. Finally, our study is the most up to date and comprehensive study in the topic.

However, our study also has several limitations that should be considered when interpreting the results. One limitation is that our analysis only included studies published in English, which may have excluded relevant studies published in other languages. Another limitation of our study is that the studies included in our analysis used different definitions and methods for assessing postpartum SUI, which could have introduced heterogeneity into the analysis. Additionally, our analysis was unable to account for the potential interaction between different risk factors, as we were not able to conduct a stratified analysis due to limitations in the available data.

Despite these limitations, our meta-analysis provides important insights into the risk factors for postpartum SUI, which can be useful in guiding clinical decision-making and developing preventative interventions for women at high risk for this condition. Future studies should aim to address the limitations of our study and further refine our understanding of the risk factors for postpartum SUI.

Recommendations for Future Research & Clinical Practice

Based on our findings, there are several recommendations for future research and clinical practice that could help improve the prevention and management of postpartum SUI. Firstly, future research should focus on identifying additional risk factors for postpartum SUI and further exploring the interactions between different risk factors. Additionally, future studies should aim to develop and test preventative interventions that can be used to reduce the risk of postpartum SUI, such as pelvic floor muscle training and perineal massage during labor. In terms of clinical practice, healthcare providers should screen all women for postpartum SUI and provide education on pelvic floor muscle exercises and other preventative measures. Additionally, healthcare providers should be trained to identify and address risk factors for postpartum SUI, such as prolonged second stage of labor and macrosomia, in order to minimize the risk of developing this condition. It is also important for healthcare providers to

provide comprehensive and evidence-based management options for women who develop postpartum SUI. This may include behavioral and lifestyle modifications, pelvic floor muscle exercises, and pharmacologic and surgical interventions as appropriate.

CONCLUSIONS

In conclusion, our meta-analysis provides important insights into the risk factors for postpartum SUI. Our findings indicate that increased age, multiparity, forceps-assisted delivery, increased birth weight (macrosomia), elevated maternal BMI, IOL, length of the second stage of labor, history of SUI during pregnancy, and vaginal delivery were significant risk factors for postpartum SUI. On the other hand, vacuum-assisted delivery, instrumental-assisted delivery, and epidural anesthesia were not significant risk factors, despite having OR more than one. Additionally, our analysis revealed that cesarean section seemed to be a protective factor against postpartum SUI, despite having non-significant results.

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Ethical statement: The authors stated that the study does not contain any studies with human participants or animals performed by any of the authors. Thus, it does not require any ethical approval.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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