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RESEARCH ARTICLE

Basic science

Reproductive history of parous women and urinary incontinence in midlife: A National Birth Cohort follow-up study

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Abstract

Objective: To investigate how reproductive history was associated with urinary incontinence in midlife.

Design: A follow-up study.

Setting: Denmark.

Population: A total of 39 977 mothers who participated in the Maternal Follow up (2013–2014) in the Danish National Birth Cohort. National registries provided their reproductive history.

Methods: How parity, mode of birth and obstetric tears associated with urinary incontinence were estimated with adjusted odds ratios (OR) and 95% CI using logistic regression.

Main outcome measures: Self-reported urinary incontinence including subtypes stress, urge and mixed urinary incontinence.

Results: At an average age of 44 years, the prevalence of any urinary incontinence was 32% (21% stress, 2% urge, and 8% mixed urinary incontinence). Women with two births more often had urinary incontinence than women with one birth (OR 1.20, 95% CI 1.10–1.31). Compared with women with only spontaneous births, a history of only caesarean sections was associated with much lower odds of urinary incontinence (OR 0.39, 95% CI 0.35–0.42) and a history of instrumental births with slightly lower odds (OR 0.92, 95% CI 0.86–0.98). Compared with no tear/first-degree tear as the largest tear, episiotomy was associated with less urinary incontinence (OR 0.91, 95% CI 0.86–0.97) whereas third/fourth-degree tears were associated with more (OR 1.14, 95% CI 1.04–1.25). Findings were mainly explained by similar associations with stress and mixed urinary incontinence.

Conclusions: Vaginal birth was associated with a higher risk of long-term urinary incontinence, but our results indicate that this risk may be reduced by shortening the second stage of birth.

KEYWORDS
episiotomy, mixed urinary incontinence, mode of birth, obstetric tear, parity, stress urinary incontinence, urge urinary incontinence, urinary incontinence

1 | INTRODUCTION

Urinary incontinence (UI) is a common condition in women with implications for their quality of life and with large societal costs.[1,2] UI is defined by the International Continence Society as 'the complaint of any involuntary leakage of urine'[3] and is divided into three subtypes: stress urinary incontinence (SUI), characterised by leakage of

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urine during physical exertion; urge urinary incontinence (UUI), characterised by a sudden and compelling urge to urinate that cannot be deferred and mixed urinary incontinence (MUI), which is a combination of the two.[4,5] SUI is the predominant type of UI in premenopausal women with a prevalence of approximately 20%,[2,6] whereas UUI and MUI are more frequent in women beyond menopause.[7]

A woman's reproductive history is a major contributor to the aetiology of UI.[6,8–10] Studies have shown that the birth of a woman's first child increases the risk of SUI compared with non-parous women.[6,7,11] SUI is frequent during pregnancy and the postpartum period, but remission of the condition is common within the first year after childbirth.[7,12] Studies of UI beyond the first year following childbirth have reported that caesarean section reduces the risk of SUI substantially compared with vaginal birth,[13–17] whereas results are inconsistent regarding the association between instrumental birth and UI.[9,14,15,17,18] Likewise, results differ in studies of the association between obstetric tears and urinary incontinence.[19–22] Most studies are small and have a relatively short follow up.

It remains unclear whether the impact of a woman's reproductive history on her risk of UI continues from the year immediately following childbirth into midlife. Our objective was to investigate the association between parity, mode of birth, obstetric tears and UI in a large cohort of Danish parous women who were in their mid-40s.

2 | METHODS

2.1 | Design and data sources

This was a follow-up study within the Danish National Birth Cohort (DNBC). The cohort was established during 1996–2002 including 91 386 women in early pregnancy, representing approximately 30% of births in Denmark during that period.[23] The women participated in four telephone interviews before and after pregnancy. From December 2013 to December 2014, a total of 82 569 eligible women were invited to participate in the Maternal Follow up by responding to a questionnaire. Of eligible women, 53% (43 639) participated in the Maternal Follow up.[24]

2.2 | Outcome

The outcome was self-reported UI at Maternal Follow up, according to the validated International Consultation on Incontinence Questionnaire – Female Lower Urinary Tract Symptoms (ICIQ-FLUTS).[25,26] Women provided information on types and degrees of UI during the previous 4 weeks by answering questions on a five-point Likert scale.

To construct binary outcome variables for SUI, UUI and MUI at a severity level that was considered to impact daily life, the answers to the question specifically about SUI (Does urine leak when you are physically active, exert yourself, cough, or sneeze?) and the question specifically about UUI (Does urine leak before you can get to the toilet?) were dichotomised. 'From time to time', 'often' and 'every time' were categorised as 'yes', while the answers 'not at all' and 'rarely' were categorised as 'no'. MUI was defined as an affirmative answer to both SUI and UUI. The three distinct types of UI were mutually exclusive. The binary outcome of any UI encompassed women with either SUI, UUI or MUI. Further, participants stated if they had UI before childbearing.

2.3 | Exposures

As exposures to describe the woman's reproductive history, we included parity, mode of birth and obstetric tears, all based on data from the Danish Medical Birth Registry[27] and the Danish National Patient Registry.[28] Registry data until the date the woman responded to the Maternal Follow up were linked to cohort participants by personal identification numbers. Parity was divided into four groups (P1, P2, P3, P4+). Mode of birth was categorised into five categories: spontaneous vaginal births only, one or more instrumental vaginal births in women with vaginal births only, caesarean sections only, vaginal births after caesarean sections (VBAC), and caesarean sections following vaginal births. In Denmark, obstetric tears were recorded from 1994 and onwards using the International Classification of Diseases, tenth revision. In this study, women were categorised according to their largest degree of obstetric tear ever in one of four categories: no tear and first-degree tears combined in one category covering conditions without involvement of muscle tissue, spontaneous second-degree tears with involvement of muscle tissue but not the anal sphincter, second-degree tears from episiotomies, and third- and fourth-degree tears combined in one category covering all tears involving the anal sphincter. Episiotomies extending to third- or fourth-degree anal sphincter tears were categorised as the latter.

2.4 | Covariates

Potential covariates were chosen a priori. From the Medical Birth Registry, we obtained information about maternal age at first birth and follow up, calendar year at first and last birth, and highest birthweight ever. Socio-occupational status, smoking in pregnancy and presence of chronic diseases came from the first DNBC telephone interview at around 16 weeks of gestation. This information related to the woman's first liveborn child in the cohort (the index pregnancy). Chronic diseases were defined as diseases predictive of UI, including diabetes, sclerosis, hypertension, or chronic obstructive pulmonary disorder.[6,29] Finally, we obtained information from the Maternal Follow up about pre-pregnant body mass index (BMI) at first pregnancy, multiple pregnancies ever, smoking status at follow up, BMI at follow up, and menopause.

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2.5 | Study population

Two different study populations were defined: one for parity and mode of birth, and another for obstetric tears (flowchart available in Figure S1). From the population of participants in the Maternal Follow up ($n = 43\,639$), we first excluded 1669 women (3.8%) who did not answer any questions on UI and 1530 women (3.5%) who had UI before their first childbirth. Further, 276 women (0.6%) who were pregnant at the Maternal Follow up and 187 women (0.4%) who had given birth less than 12 months before the Maternal Follow up were excluded, because pregnancy and childbirth may cause postpartum UI.[12] After these exclusions, 39 977 women were included in the analyses of parity and mode of birth. For the analysis of obstetric tears, we further excluded 3609 women (8.3%) who had only given birth by caesarean section and another 5357 women (12.3%) with births before 1994, when registration of degree of obstetric tears began. Hence, 31 011 women were included in the analyses of obstetric tears.

2.6 | Statistical analysis

Participant characteristics across mode of birth were presented with frequencies and proportions (%).

To estimate the association between parity, mode of birth and obstetric tears and the four outcomes any UI, SUI, UUI and MUI, we used logistic regression to calculate odds ratios with 95% CI. The reference groups were 'parity 1' for parity, 'spontaneous vaginal births only' for mode of birth and 'no tear/first-degree tears' for obstetric tears. In a main adjusted model (Model 1), we controlled for maternal age at first birth, calendar year at first and last birth, and prepregnant BMI before first pregnancy (all as continuous variables), and socio-occupational status, smoking in pregnancy and chronic disease at the index pregnancy (as categorised in Table 1). In an additional adjusted model (Model 2), we further adjusted for covariates considered to be obstetric predictors of UI including highest birthweight ever, any multiple pregnancies, parity and mode of birth (the latter two were mutually adjusted in the respective analyses). In the early analytical phase, we considered whether menopause was an effect modifier of the associations between the studied exposures and UI, particularly UUI and MUI,[8] but this was not found.

We carried out several supplementary analyses. First, in the analysis of mode of birth, we further controlled for episiotomies (Model 2b). Second, as smoking, BMI and maternal age at follow up were all considered to be independent predictors of UI, we repeated the main adjusted model with further adjustment for these covariates (Model 3). Third, we also restricted the analyses of mode of birth to women with exactly two births because some categories of mode of birth were heterogeneous in terms of number and order of spontaneous, instrumental and caesarean births. Finally, we stratified the analysis of obstetric tears in an early and a late period, based on whether the woman's first birth was before or after 2001. This was done to account for a strengthened focus at the beginning of the millennium on suturing skills, diagnostic criteria, and anatomical structures of obstetric tears in Danish obstetric care.[30] After peer review, a category including episiotomies extending to third/fourth-degree tears was added to the analyses of obstetric tears to explore if results for third/fourth-degree anal sphincter tears differed depending on whether they involved an episiotomy or not. In the analysis of mode of birth, we also performed a stratified analysis on first vaginal birth yes/no in women with vaginal births.

To address missing data on covariates, multiple imputation by chained equations was carried out with 50 copies of the data set. All exposures, outcomes and covariates were included in the imputation model. To ensure correspondence between our imputation model and analysis model, we included a potential interaction between birth year and UI by stratifying the imputation model on birth year before or after 2001.[31,32] Also, complete case analyses were performed (data not shown), and the results did not differ notably from the results based on the multiple imputation. All statistical analyses were carried out using STATA 17.0 (StataCorp, College Station, TX, USA).

2.7 | Patient involvement

Some study participants were involved in the development and testing of the questionnaire in the Maternal Follow up. The results of the research conducted in the DNBC are available at www.dnbc.dk.

3 | RESULTS

In our study, 77% of participants had only vaginal births (63% spontaneous births only and 14% instrumental birth ever) (Table 1). Caesarean sections only were seen in 9% of women, whereas 7% and 8%, respectively, had VBAC and caesarean sections following vaginal births. The prevalence of any UI was 32% (21% SUI, 2% UUI and 8% MUI). Mean maternal age at follow up was 43.9 years (SD ±4.4), and mean time from last birth to follow up was 11.3 years (SD ±3.2 years). Compared with women with vaginal births only, women who had given birth by caesarean sections only were older at their first birth, more likely to be overweight, of lower socio-occupational status, smoker or post-smoker, and to suffer from chronic diseases. In addition, they more often had only one birth or multiple pregnancies, and less often had ever given birth to a child with a birthweight >4000 g.

Compared with women with spontaneous births only, women with instrumental vaginal births had half as often no tear/first-degree tears and more than twice as often episiotomies or third/fourth-degree tears as their largest obstetric tear. Third/fourth-degree tears were twice as prevalent in women with VBAC and more than four times as prevalent in women with caesarean sections following vaginal births.

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TABLE 1 Participant characteristics according to mode of birth.

	Total population		Only spontaneous vaginal births		Vaginal births incl. instrumental		Only caesarean sections		Vaginal births after caesarean sections		Caesarean sections after vaginal births	
	(*N* = 39 977)	%	(*n* = 25 142)	62.9%	(*n* = 5425)	13.6%	(*n* = 3609)	9.0%	(*n* = 2617)	6.6%	(*n* = 3184)	8.0%
Maternal age at first birth (years)												
<25	7519	18.8	5122	20.4	834	15.4	388	10.8	456	17.4	719	22.6
25–29	20 750	51.9	13 316	53.0	2835	52.3	1508	41.8	1416	54.1	1675	52.6
30–34	9561	23.9	5615	22.3	1413	26.1	1194	33.1	645	24.7	694	21.8
≥35	2147	5.4	1089	4.3	343	6.3	519	14.4	100	3.8	96	3.0
BMI at first pregnancy (kg/m^2)												
<18.5	2657	6.9	1736	7.1	353	6.7	167	4.8	175	7.0	226	7.4
18.5–24.9	29 412	76.2	18 917	77.8	4023	76.2	2359	68.5	1868	74.2	2245	73.7
25–29.9	5053	13.1	2897	11.9	723	13.7	637	18.5	357	14.2	439	14.4
≥30	1467	3.8	751	3.1	183	3.5	282	8.2	116	4.6	135	4.5
Missing	1388		841		143		164		101		139	
Socio-occupational status[a], index pregnancy[b]												
High	22 309	59.5	14 092	59.8	3082	60.6	1945	57.7	1460	59.5	1730	57.7
Middle	12 692	33.9	7956	33.8	1699	33.4	1181	35.0	824	33.6	1032	34.4
Low	2479	6.6	1524	6.5	305	6.0	244	7.2	171	7.0	235	7.8
Missing	2497		1570		339		239		162		187	
Smoking, index pregnancy												
Smoking	4745	12.5	2936	12.3	637	12.4	453	13.3	314	12.7	405	13.4
Smoking cessation	3418	9.0	2074	8.7	486	9.5	362	10.6	211	8.5	285	9.4
Non-smoker	29 693	78.4	18 790	79.0	4006	78.1	2596	76.1	1958	78.9	2343	77.3
Missing	2121		1342		296		198		134		151	
Chronic disease, index pregnancy	3171	8.6	1761	7.6	442	8.8	374	11.2	283	11.6	311	10.6
Missing	2979		1899		401		267		175		237	
Birthweight >4000 g, ever	14 835	37.1	9124	36.3	2206	40.7	1263	35.1	984	37.6	1258	39.5
Missing	25		16		<5		8		0		0	
Multiple pregnancy, ever	1639	4.1	843	3.4	191	3.5	347	9.6	92	3.5	166	5.2
Missing	6		<5		<5		<5		0		0	
Maternal age, follow up (years)												
<40	7521	18.8	4971	19.8	859	15.8	595	16.5	486	18.6	610	19.2
40–44	16 686	41.7	10 659	42.4	2201	40.6	1430	39.6	1088	41.6	1308	41.1
45–49	12 162	30.4	7479	29.8	1783	32.9	1145	31.7	817	31.2	938	29.5
≥50	3607	9.0	2032	8.1	582	10.7	439	12.2	226	8.6	328	10.3
BMI, follow up (kg/m^2)												
<18.5	675	1.7	452	1.9	84	1.6	52	1.5	43	1.7	44	1.4
18.5–24.9	23 924	61.8	15 670	64.3	3232	61.3	1781	51.6	1469	58.1	1772	57.4
25–29.9	9539	24.6	5713	23.4	1343	25.5	978	28.4	676	26.7	829	26.9
≥30	4577	11.8	2536	10.4	618	11.7	638	18.5	342	13.5	443	14.4
Missing	1262		771		148		160		87		96	
Smoking, follow up												
Smoking	5631	14.2	3519	14.1	767	14.2	543	15.1	347	13.3	455	14.4
Smoking cessation	12 657	31.8	7762	31.0	1740	32.2	1250	34.9	863	33.1	1042	32.9
Non-smoker	21 518	54.1	13 759	55.0	2900	53.6	1794	50.0	1394	53.5	1671	52.8

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TABLE 1 (Continued)

	Total population		Only spontaneous vaginal births		Vaginal births incl. instrumental		Only caesarean sections		Vaginal births after caesarean sections		Caesarean sections after vaginal births	
	(*N* = 39 977)	%	(*n* = 25 142)	62.9%	(*n* = 5425)	13.6%	(*n* = 3609)	9.0%	(*n* = 2617)	6.6%	(*n* = 3184)	8.0%
Missing	171		102		18		22		13		16	
Menopause, follow up	5331	14.1	3117	13.1	828	16.2	590	17.4	334	13.6	462	15.4
Missing	2167		1306		299		224		160		178	
Parity												
P1	3947	9.9	2307	9.2	538	9.9	1102	30.5	0	0.0	0	0.0
P2	20 992	52.5	13 178	52.4	2997	55.2	1768	49.0	1521	58.1	1528	48.0
P3	12 283	30.7	7907	31.5	1568	28.9	654	18.1	911	34.8	1243	39.0
P4+	2755	6.9	1750	7.0	322	5.9	85	2.4	185	7.1	413	13.0
Largest degree of obstetric tear (*n* = 31 011)												
None/first degree	17 396	56.1	13 413	62.2	1562	33.8			1112	50.0	1309	50.7
Second degree	4465	14.4	3178	14.7	593	12.8			466	20.9	228	8.8
Episiotomy	7065	22.8	4079	18.9	1963	42.5			428	19.2	595	23.1
Third/fourth degree	2085	6.7	911	4.2	506	10.9			220	9.9	448	17.4

Abbreviation: BMI, body mass index.

[a]Socio-occupational status: High (four or more years of education after high school, or job as a manager), middle (skilled manual worker, office, or service work), low (unskilled work or unemployment).

[b]Index pregnancy: The woman's first pregnancy as participant in the Danish National Birth Cohort, resulting in a liveborn child.

3.1 | Any UI, SUI, UUI and MUI

3.1.1 | Parity

The prevalence of any UI was 27% in women with one birth and 32%–33% in multiparous women (Table 2). Compared with women with one birth, the adjusted analysis for any UI showed the highest increase in odds of 20% for women with two births, whereas the adjusted odds of SUI were increased by 28% in all women with more than one birth. For MUI, increasing odds by parity were attenuated after adjustment. After further adjustment for obstetric predictors including mode of birth, no increases in any UI or in subtypes of UI were observed across parity groups.

3.1.2 | Mode of birth

Any UI was reported by 17% of women with caesarean sections only and by 31%–34% of women in the other exposure groups (Table 3). After adjustment, and when compared with women with spontaneous births only, we found decreased odds of any UI of 8% in women with instrumental births, 61% in women with caesarean sections only, and 13% in women with caesarean section after vaginal birth. Findings were similar for SUI and MUI. For UUI, we observed 40% increased odds in women with VBAC. Adjusting further for parity and obstetric factors had no impact on these results. However, after additional adjustment for episiotomy, decreased odds of MUI in women with instrumental births were no longer seen (Table S1).

3.1.3 | Obstetric tears

Although the prevalence of any UI was similar in women with no tear/first-degree tears and second-degree tears (33%–34%), women with episiotomies that did not extend to third/fourth-degree tears had the lowest prevalence of 31%, and women with third/fourth-degree tears or episiotomies that extended to third/fourth-degree tears had the highest prevalence of UI (36%) (Table 4). After adjustment, and when compared with women with no tear/first-degree tears as their largest obstetric tear, women with episiotomies had 9% lower odds for any UI, and 13% lower odds for MUI. Women with third/fourth-degree tears had 14% higher odds of any UI. Further adjusting for parity, mode of birth and obstetric factors did not change these findings.

3.2 | Supplementary analyses

In supplementary analyses, adjusting further for independent predictors of UI at follow up did not lead to notable changes compared with the main adjusted analyses (Tables S2–S4). Restricting the analyses of mode of birth to P2 women, strengthened the associations between mode of birth and any UI and SUI compared with the analyses

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TABLE 2 Urinary incontinence according to parity in 39977 women.

	P1 (*n* = 3947)	P2 (*n* = 20992)	P3 (*n* = 12283)	P4+ (*n* = 2755)
Any urinary incontinence				
Cases (%)	1077 (27.3)	6678 (31.8)	4014 (32.7)	905 (32.9)
Crude OR (95% CI)	1	1.24 (1.15–1.34)	1.29 (1.20–1.40)	1.30 (1.17–1.45)
Main adjusted model OR (95% CI)[a]	1	1.20 (1.10–1.31)	1.17 (1.05–1.30)	1.10 (0.95–1.27)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.03 (0.94–1.13)	0.96 (0.85–1.07)	0.87 (0.75–1.02)
Stress urinary incontinence				
Cases (%)	696 (17.6)	4495 (21.4)	2635 (21.5)	582 (21.1)
Crude OR (95% CI)	1	1.27 (1.17–1.39)	1.28 (1.16–1.40)	1.25 (1.11–1.41)
Main adjusted model OR (95% CI)[a]	1	1.28 (1.16–1.41)	1.28 (1.13–1.45)	1.28 (1.08–1.51)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.11 (0.99–1.23)	1.07 (0.94–1.22)	1.04 (0.87–1.24)
Urgency urinary incontinence				
Cases (%)	83 (2.1)	488 (2.3)	270 (2.2)	56 (2.0)
Crude OR (95% CI)	1	1.11 (0.88–1.40)	1.05 (0.82–1.34)	0.97 (0.69–1.36)
Main adjusted model OR (95% CI)[a]	1	1.05 (0.81–1.36)	0.87 (0.63–1.21)	0.66 (0.42–1.05)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.04 (0.79–1.37)	0.86 (0.60–1.21)	0.65 (0.41–1.06)
Mixed urinary incontinence				
Cases (%)	298 (7.6)	1695 (8.1)	1109 (9.0)	267 (9.7)
Crude OR (95% CI)	1	1.08 (0.95–1.22)	1.22 (1.06–1.39)	1.31 (1.11–1.56)
Main adjusted model OR (95% CI)[a]	1	1.01 (0.88–1.17)	1.00 (0.84–1.20)	0.92 (0.73–1.17)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.89 (0.77–1.03)	0.85 (0.71–1.02)	0.76 (0.59–0.98)

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a]Adjusted for maternal age at first birth, pre-pregnant BMI at first pregnancy, chronic diseases at index pregnancy, smoking at index pregnancy, socio-occupational status at index pregnancy, and calendar year at first and last birth.

[b]Adjusted as above and in addition for mode of birth, highest birthweight ever (continuous), and any multiple pregnancies.

for all women (Table S5). When adding a category of episiotomies extending to third/fourth-degree tears to the analyses of obstetric tears, the odds of any UI, SUI and MUI in third/fourth-degree episiotomies were similar to those in spontaneous third/fourth-degree tears (Table S7). Stratifying the analyses of obstetric tears according to first birth before or after 2001, showed that the protective associations between episiotomies and any UI and MUI seemed to be strongest after 2001 (Tables S6 and S8). When stratified into women with one vaginal birth and women with more than one vaginal birth, we observed similar odds ratios for any UI, SUI and MUI across mode of birth that were all close to one (Tables S9 and S10). Only in women with VBAC and only one vaginal birth, was an increased risk of UUI seen.

4 | DISCUSSION

4.1 | Main findings

In this large study of Danish parous women in midlife, women with only one birth less often experienced SUI than women of higher parity. Otherwise, differences in UI across parity were small. Compared with women with only spontaneous vaginal births, SUI and MUI were about half as frequent in women who had given birth by caesarean section only and also slightly less frequent in women with instrumental birth as part of a history of vaginal births. Women who had ever experienced a third/fourth-degree tear had more UI than women with no tear/first-degree tears whereas women with episiotomies had less UI, especially MUI.

4.2 | Strengths and limitations

Strengths of this study are the large sample size, the prospective design with a long follow up, and the detailed data collection of birth history, UI and important confounders. Among the limitations is the participation rate of 53% in the Maternal Follow up. A previous study of non-participation in the Maternal Follow up reported that participants were generally healthier, older and of higher social status than the baseline cohort. However, when accounting for factors associated with participation, selection bias of selected exposure–outcome associations was limited.[24] Information about UI was self-reported, and misclassification cannot be ruled out. Some women may have withheld symptoms of UI because of the stigma associated with it. Although information

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TABLE 3 Urinary Incontinence according to mode of birth in 39 977 women.

	Only spontaneous vaginal births ($n = 25\,142$)	Vaginal births including instrumental ($n = 5425$)	Only caesarean sections ($n = 3609$)	Vaginal births after caesarean sections ($n = 2617$)	Caesarean sections after vaginal births ($n = 3184$)
Any urinary incontinence					
Cases (%)	8462 (33.7)	1749 (32.4)	623 (17.3)	862 (32.9)	978 (30.7)
Crude OR (95% CI)	1	0.94 (0.88–0.99)	0.41 (0.38–0.45)	0.97 (0.89–1.06)	0.87 (0.81–0.95)
Main adjusted model OR (95% CI)[a]	1	0.92 (0.86–0.98)	0.39 (0.35–0.42)	0.94 (0.86–1.02)	0.83 (0.77–0.90)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.91 (0.86–0.97)	0.39 (0.35–0.42)	0.94 (0.86–1.02)	0.83 (0.77–0.90)
Stress urinary incontinence					
Cases (%)	5682 (22.6)	1177 (21.7)	364 (10.1)	562 (21.5)	623 (19.6)
Crude OR (95% CI)	1	0.95 (0.88–1.02)	0.38 (0.34–0.43)	0.94 (0.85–1.03)	0.83 (0.76–0.91)
Main adjusted model OR (95% CI)[a]	1	0.94 (0.88–1.01)	0.37 (0.33–0.41)	0.92 (0.84–1.02)	0.82 (0.75–0.90)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.94 (0.87–1.01)	0.37 (0.33–0.42)	0.92 (0.84–1.02)	0.82 (0.75–0.90)
Urgency urinary incontinence					
Cases (%)	526 (2.1)	125 (2.3)	95 (2.6)	78 (3.0)	73 (2.3)
Crude OR (95% CI)	1	1.10 (0.91–1.34)	1.27 (1.01–1.58)	1.44 (1.13–1.83)	1.10 (0.86–1.41)
Main adjusted model OR (95% CI)[a]	1	1.07 (0.88–1.31)	1.22 (0.97–1.53)	1.40 (1.10–1.78)	1.05 (0.82–1.35)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.07 (0.87–1.30)	1.19 (0.95–1.50)	1.41 (1.11–1.80)	1.06 (0.82–1.36)
Mixed urinary incontinence					
Cases (%)	2254 (9.0)	447 (8.2)	164 (4.5)	222 (8.5)	282 (8.9)
Crude OR (95% CI)	1	0.91 (0.82–1.01)	0.48 (0.41–0.57)	0.94 (0.82–1.09)	0.99 (0.87–1.12)
Main adjusted model OR (95% CI)[a]	1	0.88 (0.79–0.98)	0.45 (0.38–0.53)	0.90 (0.78–1.04)	0.90 (0.79–1.03)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.88 (0.79–0.98)	0.45 (0.38–0.53)	0.90 (0.78–1.04)	0.90 (0.79–1.03)

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a]Adjusted for maternal age at first birth, pre-pregnant BMI at first pregnancy, chronic diseases at index pregnancy, smoking at index pregnancy, socio-occupational status at index pregnancy, and calendar year at first and last birth.

[b]Adjusted as above and in addition for parity (continuous), highest birthweight ever (continuous) and any multiple pregnancies.

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TABLE 4 Urinary incontinence according to largest degree of obstetric tear in 31 011 women.

	No tear/1st degree ($n = 17\,396$)	2nd degree ($n = 4465$)	Episiotomy ($n = 7065$)	3rd/4th degree ($n = 2085$)
Any urinary incontinence				
Cases (%)	5748 (33.0)	1517 (34.0)	2204 (31.2)	753 (36.1)
Crude OR (95% CI)	1	1.04 (0.97–1.12)	0.92 (0.87–0.98)	1.15 (1.04–1.26)
Main adjusted model OR (95% CI)[a]	1	1.02 (0.95–1.10)	0.91 (0.86–0.97)	1.14 (1.04–1.25)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.01 (0.94–1.09)	0.91 (0.86–0.97)	1.15 (1.04–1.27)
Stress urinary incontinence				
Cases (%)	3894 (22.4)	1016 (22.8)	1529 (21.6)	519 (24.9)
Crude OR (95% CI)	1	1.02 (0.94–1.11)	0.96 (0.90–1.02)	1.15 (1.03–1.28)
Main adjusted model OR (95% CI)[a]	1	1.00 (0.93–1.09)	0.96 (0.90–1.03)	1.14 (1.02–1.26)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.99 (0.92–1.07)	0.96 (0.90–1.03)	1.16 (1.04–1.29)
Urgency urinary incontinence				
Cases (%)	375 (2.2)	93 (2.1)	140 (2.0)	34 (1.6)
Crude OR (95% CI)	1	0.97 (0.77–1.22)	0.92 (0.75–1.12)	0.75 (0.53–1.07)
Main adjusted model OR (95% CI)[a]	1	0.99 (0.78–1.25)	0.89 (0.73–1.09)	0.77 (0.54–1.09)
Further adjustments (Model 2) OR (95% CI)[b]	1	0.97 (0.77–1.22)	0.87 (0.71–1.07)	0.72 (0.50–1.04)
Mixed urinary incontinence				
Cases (%)	1479 (8.5)	408 (9.1)	535 (7.6)	200 (9.6)
Crude OR (95% CI)	1	1.08 (0.97–1.21)	0.88 (0.80–0.98)	1.14 (0.98–1.33)
Main adjusted model OR (95% CI)[a]	1	1.07 (0.95–1.20)	0.87 (0.78–0.96)	1.15 (0.98–1.34)
Further adjustments (Model 2) OR (95% CI)[b]	1	1.06 (0.95–1.20)	0.87 (0.78–0.97)	1.16 (0.98–1.36)

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a]Adjusted for maternal age at first birth, pre-pregnant BMI at first pregnancy, chronic diseases at index pregnancy, smoking at index pregnancy, socio-occupational status at index pregnancy, and calendar year at first and last birth.

[b]Adjusted as above and in addition for mode of birth, parity (continuous), highest birthweight ever (continuous), and any multiple pregnancies.

about reproductive history was derived from registers, it is possible that women with a complicated birth history or large tears may be more alert about UI, which could lead to an overestimation of the association. The registry data on obstetric tears stem from a period with a different approach to obstetric tears, and leaving first-degree tears unreported and unsutured was common practice before 2001.[30] A potential misclassification of particularly second-degree tears as first-degree tears may have favoured episiotomies compared with no tears/first-degree tears. However, stratifying for first birth before or after 2001, results for the latest period showed even lower risk of UI in women with episiotomies, indicating that this was not a problem.

Constructing exposures that cover a long time span and include different combinations of birth modes and parities within the same exposure group implies conditioning on future events. This includes a risk of confounding by (birth route) indication, i.e. that sequelae from a first vaginal birth may lead to a planned caesarean section in the subsequent pregnancy. Further, some exposure groups required more than one birth to be included, whereas in others one birth was enough. However, in sensitivity analyses restricted to women with two births, the results of the analyses of mode of birth were stable.

Risk of bias due to unmeasured confounding cannot be ruled out. Hence, factors such as physical activity and pelvic muscle training were not accounted for in the study.

4.3 | Interpretation

Our study population comprised Scandinavian women with a higher educational level and better health conditions than the background population,[33] but we observed a similar prevalence of UI and its subtypes as seen in other studies, indicating that the results are generalisable to other contexts.[1,2]

Similar to other studies, we saw less UI in women with only one birth and few differences across parity thereafter.[6,34] Also, the substantially lower prevalence of UI in women with only caesarean sections compared with vaginal births, as described in many other studies,[13,15–17,34] were confirmed. We observed reduced odds of any UI and MUI in women with instrumental births compared with spontaneous births, but after accounting for the high prevalence of episiotomies in this group, the association was attenuated.

As others, we found any UI to be more frequent in women with third/fourth-degree tears,[22] but we have not been able

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to identify studies supporting our findings of less any UI and MUI in women with episiotomies compared with women with no tears/first-degree tears. Most studies and systematic reviews have reported no difference in risk of UI after episiotomies and spontaneous tears, whereas some have shown an increase in risk of both anal sphincter tears and UI after episiotomy.[19,21,30,35] However, studies were small and lacked long-term follow up in midlife. We compared risk of UI in episiotomies extending to third/fourth-degree tears and spontaneous third/fourth-degree tears and observed the same increased risk. Also, we observed no increased risk of extension to anal sphincter tears when episiotomy was performed. Hence, anal sphincter tears were observed in 7.0% of women without episiotomies and in 5.6% of women with episiotomies (Table S7).

Straining of the tissue of the vaginal wall and the pelvic floor during childbirth causing overdistention and denervation are considered contributing factors in the aetiology of UI in women.[7,10,36] Although an episiotomy causes trauma to the pelvic floor, it also shortens the last part of the second stage and the duration of immense pressure and strain from the fetal head onto the anatomical structures of the birth canal. A retrospective study of 198 women reported significantly less anterior defect in vaginal wall support after medio-lateral episiotomy.[35] In a previous study of long-term sexual health after childbirth, we found women with episiotomies to have less deep pain during intercourse, supporting this hypothesis.[37]

The use of episiotomy in clinical practice today deviates from that of the inclusion years in the DNBC, as episiotomy is rarely used in contemporary practice (3.8% in vaginal births in Denmark in 2022).[38] However, at present, our data should not be used to change the recommendation of avoiding routine episiotomy in clinical practice.[39] The effect sizes are small, and the data do not provide information on the duration of the second stage of birth, or the indications for episiotomy. Further, recent research shows that women with episiotomies have much higher risk of wound complications and infection compared with women with spontaneous tears.[40] Likewise, although caesarean sections in our data reduced the odds of any UI, SUI and MUI substantially compared with vaginal births, our results do not justify advocating for caesarean section without imperative obstetric indication. UI is most often a treatable condition, whereas caesarean section increases the risk of respiratory distress in the newborn as well as infection and bleeding in the mother and makes subsequent pregnancies high risk.[41]

Current Scandinavian obstetric care advocates a hands-on technique that reduces the speed of birth when the fetal head is crowning in order to protect the perineum. This technique typically extends the second stage of labour with one to three contractions. Data support that this technique reduces the risk of anal sphincter tears,[42] but it is unclear how it impacts the risk of long-term faecal and urinary incontinence. Hence, shortening the second stage of birth, which our study suggests reduces the risk of UI, may conflict with these current efforts.

5 | CONCLUSIONS

Urinary incontinence in midlife was seen in one out of three women in this large cohort of Scandinavian parous women. Obstetric interventions that avoid or shorten the second stage of birth seem to reduce UI among parous women in midlife. These findings highlight the importance of the clinical management of the second stage of birth and the need for future research to investigate if some women may benefit from an episiotomy to reduce their risk of long-term UI.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the study. ACK analysed the data with help from KT, SH and EAN. All authors interpreted the results. ACK drafted the manuscript, and KT, EAN, SH, DG and SA critically revised it. All authors approved the final manuscript.

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CONFLICT OF INTEREST STATAEMENT

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from The Danish National Birth Cohort. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available from https://www.dnbc.dk/access-to-dnbc-data with the permission of The Danish National Birth Cohort.

ETHICS APPROVAL

Danish law does not require permission for registry-based studies. The establishment of the DNBC was approved by the Committee on Biomedical Research Ethics (reference no. [KF] 01–471/94). Participants in the DNBC gave written consent to the use of their data for research, both from the cohort and from Danish health and social registries including the Danish Medical Birth Registry and the Danish National Patient Registry. The Danish Data Protection Agency gave permission to use the data (approval no. 2014-41-2848).

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