GYNECOLOGY

The effect of childbirth on urinary incontinence: a matched cohort study in women aged 40–64 years

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BACKGROUND: The relative impact of age, pregnancy and vaginal delivery on urinary incontinence is still an unresolved issue that involves the controversial question about the protective effect of cesarean delivery.
OBJECTIVE: The purpose of this study was to estimate and compare the effect size of 1 pregnancy, 1 vaginal delivery, and the derived protective effect of cesarean delivery for different aspects of urinary incontinence in women 40–64 years old, all 20 years after birth.
STUDY DESIGN: This Swedish nationwide matched cohort study involved 14,335 women. Data from 3 restricted, randomly selected, source cohorts of (1) nulliparous women who were unexposed to childbirth (n=9136), (2) primiparous women who had experienced cesarean delivery and who had been exposed to 1 pregnancy (n=1412), and (3) primiparous women who had been exposed to 1 pregnancy followed by vaginal delivery (n=3787) were retrieved from The Swedish Medical Birth Register and Statistics Sweden and surveyed in 2008 and 2014, respectively. Parous women were all assessed 20 years postnatally. One-to-one matching with an interval for pairing of 3 years and 3 body mass index units was used in women 40–64 years old with information about body mass index (kilograms/square meters) and urinary incontinence. The procedure succeeded in 2630 of 2635 women (99.8%) and resulted in an adequate distribution of age and body mass index between groups. The surveys used a postal- and an internet-based questionnaire with validated questions for various aspects of urinary incontinence. Fisher's exact test and the Mann-Whitney *U* test were used for comparisons between matched groups; trend was analyzed with Mantel-Haenszel statistics. Predicted, age-related values of different aspects of urinary incontinence were obtained by logistic regression analysis.
RESULTS: Pregnancy increased the prevalence of urinary incontinence from 20.1–30.1% (odds ratio, 1.71; 95% confidence interval, 1.43–2.05; $P<.0001$]. Urinary incontinence increased further after vaginal delivery to 43.0% (odds ratio, 1.75; 95% confidence interval, 1.49–2.05; $P<.0001$); "moderate" and "severe" urinary incontinence increased from 12.7–19.5% (odds ratio, 1.67; 95% confidence interval, 1.35–2.07; $P<.0001$). There was a parallel increase in urinary incontinence from 40–65 years of age in nulliparous and vaginally and cesarean delivered women. Cesarean delivery, compared with vaginal delivery, was associated with a 30.0% reduction of urinary incontinence ($P<.0001$) and a 35–52% reduction of more severe grades of urinary incontinence ($P<.0001$) and was unaffected by age.
CONCLUSION: Both pregnancy and vaginal delivery incurred an increased risk of urinary incontinence in the long term. The age-related gap for urinary incontinence between nulliparous and primiparous women who were delivered by vaginal delivery or cesarean delivery was constant between parallel trajectories that spanned ages from 40–64 years. The calculated protective effect of cesarean delivery was unaltered and significant during the same age interval.

Key words: cesarean delivery, matched cohort study, nulliparous women, pelvic floor, pregnancy, stress urinary incontinence, urge urinary incontinence, urinary incontinence, vaginal delivery

Female urinary incontinence (UI) constitutes a huge global health issue that adversely affects women's quality of life, productivity, socializing, and sexuality and has an enormous impact on healthcare costs.[1] Nonetheless, there are still significant gaps in current knowledge regarding the cause of UI, and there is a continuing controversy regarding the possible long-term effects of pregnancy itself, the additive effect of vaginal delivery (VD), and accordingly, the impact of cesarean section delivery (CS) to avoid UI.[2–5] This means that women are left with inadequate information concerning factors that influence the occurrence of the most prevalent long-term pelvic floor disorder that is associated with childbirth.

A longitudinal study theoretically would be the optimum means of answering these questions. Such a study, however, is hampered by the expected confounding of multiple and mixed modes of subsequent births, loss to follow up, and the need to wait years and decades for the final results. The incurred workload and costs for such a study would be enormous, which means that it most probably will never be completed successfully. The current project, the Swedish Pregnancy, Obesity, and Pelvic floor (SWEPOP) cohort study that involves nulliparous and primiparous women who were delivered by CS and VD was started in 2007. The project was designed originally to address these issues.[6–8]

The aim of this study was to use data from the SWEPOP study that involved 3 large, randomly selected, national cohorts of women (nulliparous women and primiparous women who had undergone either 1 VD or 1 CS) for a matched cohort study. The matched cohort design would, in a uniform methodologic context, allow for the comparison of the age-dependent effect of pregnancy in itself and the additive effect of a VD and the calculated risk reduction associated with CS.

Materials and Methods

Ethical approval for the study was obtained from the Regional Ethical Review Board in Gothenburg, Sweden (reference no. 381–07; August 13, 2007 and no. 776–13; November 18, 2013) and

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AJOG at a Glance

Why was this study conducted?

Earlier studies have shown an increase in the prevalence of urinary incontinence during pregnancy; however, it remains unclear whether pregnancy increases the long-term risk. Studies have shown a protective effect of cesarean delivery in the short term, but long-term protection has been questioned.

Key findings

Pregnancy increased urinary incontinence from 20−30%. Vaginal delivery increased urinary incontinence additionally to 43%. The protective effect of cesarean delivery was a 30% reduction of urinary incontinence.

What does this add to what is known?

The results indicate that the burden of birth-related urinary incontinence does not subside with ageing. More likely, it contributes to an earlier onset of urinary incontinence throughout life. The protective effect of cesarean delivery in women after 1 birth also persisted up to age 65 years and should therefore, with advancing age, contribute to maintaining continence and postpone the onset of urinary incontinence.

the National Review Board (no. 34−9148; October 26, 2007). All women received written information and gave their written consent before participation in the study.

Source cohorts

The groups intended for matching were recruited from 3 large, nationwide, population-based, randomly selected cohorts of nulliparous or vaginally and cesarean delivered primiparous women (n=14,335). The Swedish Medical Birth Register (MBR), which was started in 1973, is a national register that includes >98% of all births in Sweden. Data from all antenatal clinics and all obstetric units are sent to the MBR at the National Board of Health and Welfare. A description of the MBR in English can be found at http://www.socialstyrelsen.se/register/halsodataregister/medicinskafodelseregistret/inenglish.

In 2008, MBR recruited and surveyed primiparous women with 1 VD (n=3787) or 1 CS (n=1412) 20 years after the birth with a postal questionnaire (response rate, 65.2%). Inclusion criteria were 1 singleton birth between 1985 and 1988 and no further births. Instrumental vaginal and elective and emergency CS were included. Exclusion criteria were multifetal delivery and ongoing pregnancy.

A national nulliparous cohort was selected and surveyed with an internet-based and postal questionnaire by Statistics Sweden in 2014 and comprised 9136 women 25−64 years old (response rate, 52.3%). The lower limit of the age span was set to 25 years because studies of adolescent girls and young women indicate that the prevalence of UI seems to stabilize at a minimum during the third decade. The upper limit was set to 65 years because confounding age-dependent comorbidities potentially influence the prevalence of UI, which is known to increase rapidly from the seventh decade.

A more detailed description of the study populations, based on flow charts and cohort characteristics, response rates that include an analysis of non-responders, has also been described elsewhere.[6−8]

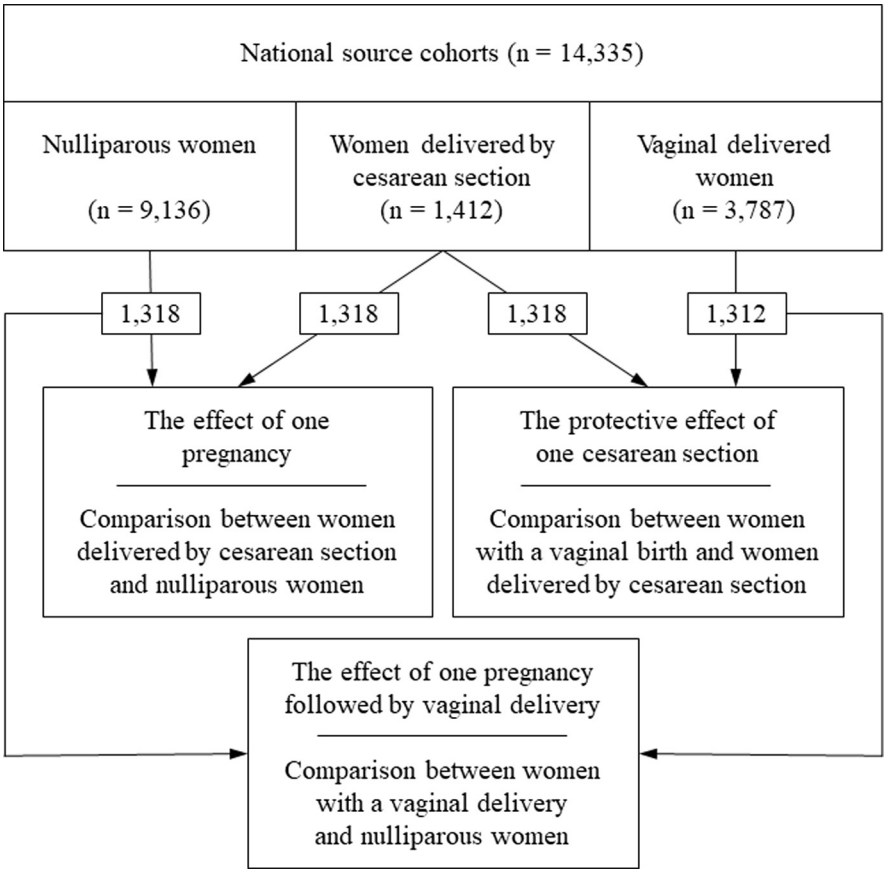
Study design and strategy

Because the CS group had the least number of women (n=1412), it served as the index group against which nulliparous women and women who had undergone a VD were matched (Figure 1). Those outside the age range of 40−64 years with missing data concerning body mass index (BMI) or information regarding UI were excluded from the matching procedure. One-to-one matching was used, taking into account BMI and age, which have been shown to be strong confounders of UI.[8] The interval for pairing was set to 3 years of age and 3 BMI units. The matching procedure resulted in 3 groups of women (nulliparous, 1318 women; cesarean delivered, 1318 women; vaginal delivered, 1312 women; (Figure 1). The matching procedures succeeded in 2630 of the 2636 women (99.8%) and resulted in an adequate distribution of age and BMI with probability values >.1 and standardized mean differences between 0 and 0.07 (ie, <0.10), which is considered to be the threshold for imbalance (Table 1). The effect of pregnancy was analyzed as the difference between the nulliparous and CS groups. The additive effect of VD, not including the effect of pregnancy, was analyzed as the difference between women delivered by CS and women delivered by VD and the sum effect of pregnancy and vaginal childbirth as the difference between the nulliparous and VD groups (Figure 1).

Survey questionnaire and definition of outcomes

Data from the same questionnaire, with minor deviations, was used in the SWEPOP-1 project (1 child group) in 2008 and in the SWEPOP-0 project (nulliparous group) in 2014, including the validated questions on UI by Sandvik et al.[9] The 40-item questionnaire included questions about current height and weight, urinary or fecal and anal incontinence, subtypes of UI, genital prolapse, severity and bothersomeness of symptoms, and menstrual status (information about current pregnancy, hysterectomy, menopausal status, and hormone treatment). The questionnaire is available in the Supplementary Material. Any UI and subtypes of UI were defined according to International Urogynecological Association/International Continence Society definitions.[10] Any UI was defined by the question "Do you have involuntary loss of urine?" Participants who reported UI were grouped according to the duration of UI (<5 years, 5−10 years, >10 years). Stress

FIGURE 1
Source of the matched cohorts, study design, and the main research questions



The protective effect of cesarean delivery equals the additive effect of vaginal birth over and above the effect of pregnancy.

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UI was defined as involuntary loss of urine in connection with coughing, sneezing, laughing, or lifting heavy items. Urge UI was present if loss of urine was in connection with a sudden and strong urge to void, and mixed UI was present if both components were present. Frequency of leakage was stratified into 4 categories: "less than once a month," "once or more per month," "once or more per week," and "every day and/or night." Volume of leakage was categorized into "a few drops" vs "small amounts" and "large amounts." The severity of UI was assessed with Sandvik's severity index that multiplies the reported frequency (4 levels) by the amount of leakage (2 levels). The resulting value (1−8) was further categorized into slight (1−2), moderate (3−4), and severe incontinence (6−8).[9] The mental impact of incontinence was dichotomized into "a minor problem" (no problem/a small nuisance=not bothersome) and "bothersome UI" (some bother/much bother/a major problem). BMI was the weight in kilograms divided by the square of the height in meters as reported in the questionnaire and categorized into normal weight (<25.0 kg/m^2), overweight (25.0−29.9 kg/m^2), moderately obese (30.0−34.9 kg/m^2), and severely obese (≥35.0 kg/m^2). Women were also asked whether they were using estrogen, were menstruating, or had undergone a hysterectomy.

Statistics

Statistical analyzes were performed with SAS software (version 9.4; SAS Institute Inc, Cary, NC). Descriptive data for continuous variables were presented as mean and standard deviation, median and interquartile range; categoric data were presented as number and percentage. The prevalence of different aspects of UI was calculated for all women. In each analysis, missing data was accounted for and excluded from the analysis. Results were presented as numbers, percentages, and 95% confidence interval (CI). Fisher's exact test was used for comparisons of categoric variables, and the Mann−Whitney U test was used for continuous variables. Trend between independent groups was analyzed with Mantel-Haenszel chi-square statistics. No adjustment was made for multiple testing. The overall risk of UI and the risk of UI in relation to age for nulliparous, CS, and VD cohorts were analyzed with logistic regression. Results were presented as odds ratio (OR) and 95% CI and probability value and were shown in the effect plots. Statistical significance was set at $P<.05$.

Results

The overall rate of missing values was 0.8%, 0.3% in the nulliparous cohort and 1.0% in the primiparous cohorts (Table S1). The rate of hysterectomy was similar between groups. In comparison with primiparous women, nulliparous women used estrogens less often and were more often postmenopausal (Table S2).

Based on the logistic regression analyses, effect plots demonstrated an approximately constant effect of age on UI parameters for nulliparity, pregnancy, and vaginal childbirth across the ages 40−64 years (Figure 2; Table S3). Pregnancy was associated with a 10 percentage points increase of UI (20.1−30.1%; OR, 1.71; 95% CI, 1.43−2.05; $P<.0001$). In comparison with CS, VD increased UI further by 12.9 percentage points (30.1−43.0%; OR, 1.75; 95% CI, 1.49−2.05; $P<.0001$; Table 2; Figure 3). Consequently, the

TABLE 1
Postmatching distribution of age and body mass index

Variable	Nulliparous women (n=1318)	Test of distribution		Cesarean delivery (n=1318)	Test of distribution		Vaginal delivery (n=1312)
		P value[a]	Standardized mean difference[b]		*P* value[a]	Standardized mean difference[b]	
Age		.77	0		.11	0.07	
Mean (standard deviation)	53.1±5.9			53.1±5.8			52.7±5.5
Median (interquartile range)	53.0 (49.0–58.0)			53.1 (48.8–57.6)			52.7 (48.6–57.2)
Age category, n (%)							
<45 y	167 (12.7)			127 (9.6)			136 (10.4)
45–49.9 y	277 (21.0)			274 (20.8)			289 (22.0)
50–54.9 y	375 (28.5)			409 (31.0)			397 (30.3)
55–59.9 y	328 (24.9)			306 (23.2)			360 (27.4)
≥60 y	171 (13.9)			202 (15.3)			130 (9.9)
Body mass index units, kg/m^2		.71	0		.65	0.06	
Mean (standard deviation)	26.3±5.1			26.3±5.2			26.2±4.9
Median (interquartile range)	25.2 (22.6–28.7)			25.3 (22.7–29.0)			25.2 (22.6–28.7)
Body mass index category, n (%)							
<20 kg/m^2	66 (5.0)			74 (5.6)			56 (4.3)
20-24.9 kg/m^2	567 (43.0)			558 (42.3)			571 (43.5)
25-29.9 kg/m^2	422 (32.0)			406 (30.8)			427 (32.5)
30-34.9 kg/m^2	174 (13.2)			191 (14.5)			182 (13.9)
≥35 kg/m^2	89 (6.8)			89 (6.8)			76 (5.8)

[a] For comparison between groups; [b] Denotes the difference between means divided by the pooled standard deviations.
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calculated reduction of UI by CS was 30.0% (OR, 0.57; 95% CI, 0.49–0.67; *P*<.0001) with a reduction between 35% and 52% for more severe forms of UI (all with *P*<.0001; Figure 4). The prevalence of incontinence that had existed for >10 years was doubled from 2.3% in nulliparous women to 5.1% after CS (*P*=.004) and to 10.6% after VD (*P*<.0001; Table 2; Figure 3).

Principal findings

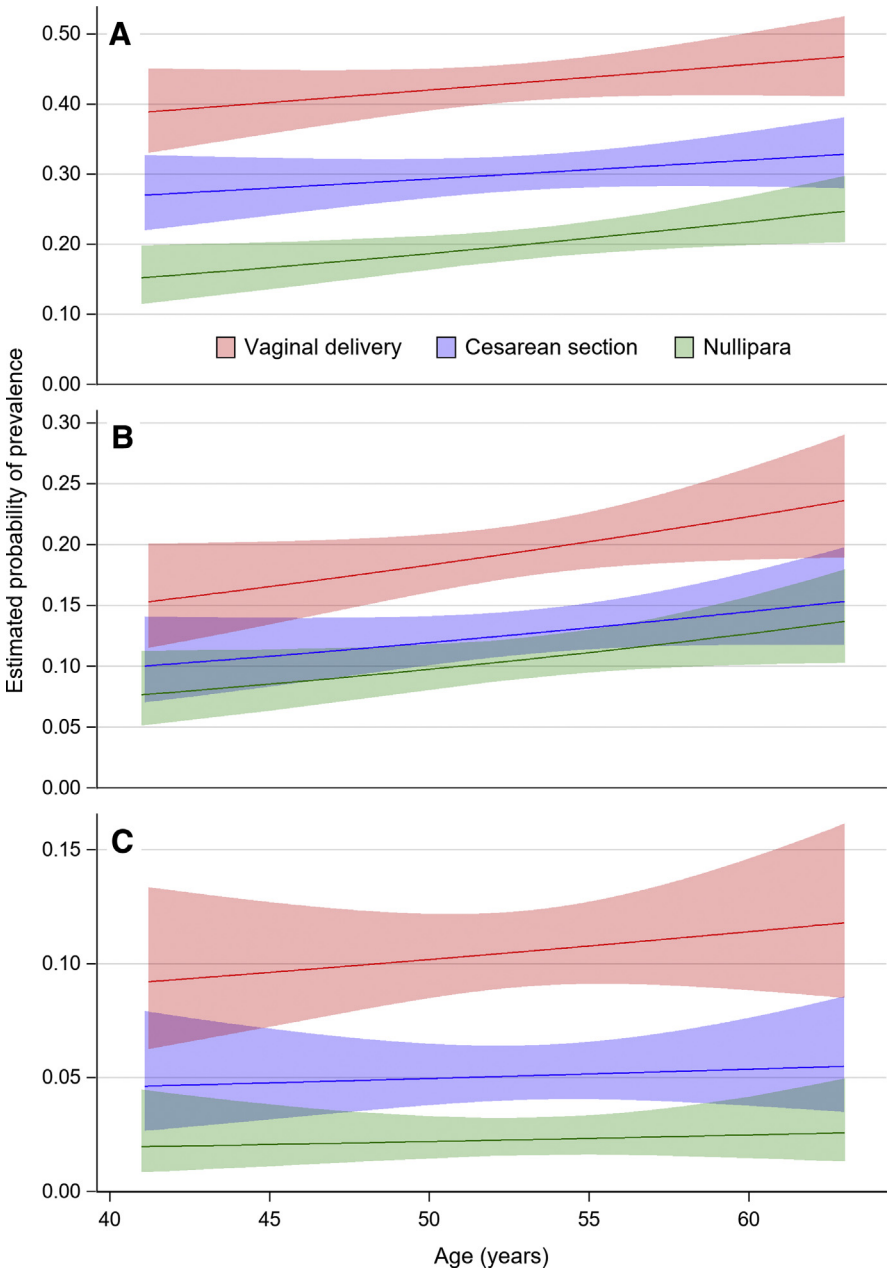
One pregnancy increased the prevalence of UI by 10 percentage points and 1 VD increased the prevalence further by 13 percentage points. Bypassing VD by CS was associated with a 30% lower prevalence of UI and 35–52% lower prevalence of more severe grades of UI. The age-related gap for UI between nulliparous and primiparous and cesarean and vaginally delivered women was constant between parallel trajectories that spanned the ages between 40 and 65 years. To estimate the effect of pregnancy on long-term UI, primiparous women delivered by CS were compared with women collected from a nationwide systematic survey of nulliparous women 25–64 years old.[8] Pregnancy alone, without the influence of VD, had a long-term effect on the future risk of UI.

Results in context

It seems reasonable to assume that some effect of pregnancy will persist in the long term, considering the dramatic physiologic changes and significant and extended remodeling of connective tissue that occurs during gestation.[11,12] Early in pregnancy, the distensibility of connective tissue that intertwines the components of the pelvic floor is increased. This process is considered to be associated with an increased bladder-neck mobility and descent and with decreased urethral resistance and pelvic floor contractility, which have been linked to stress UI.[13–15]

Earlier studies have shown that almost 100% of nulliparous women with UI continued to leak during and after pregnancy; among continent nulliparous women, the incidence

FIGURE 2
The age-related change of urinary incontinence parameters in nulliparous women and women who had cesarean and vaginal delivery



Panels show the results from 3 independent multivariate logistic regression analyzes for the predicted value (prevalence) of **A,** any urinary incontinence, **B,** moderate and severe urinary incontinence, and **C,** the duration of urinary incontinence >10 years in nulliparous and primiparous women and vaginally and cesarean delivered women from 40–65 years of age. The *shaded areas* show the 95% 2-tailed confidence intervals for the fitted estimated probability of urinary incontinence outcomes. (Parameter estimates from the logistic regressions are shown in Table S3).

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during pregnancy was about 1 in 5, and in more than every second instance, the onset occurred during the third trimester.[16,17] This indicates that gestational incontinence largely depends on distension exerted by intraabdominal pressure and is also supported by the observation that, after CS, postpartum UI and stress UI rapidly decreased towards prepregnancy rates.[18–20] A few studies have followed UI in primiparous women during the first year after childbirth and have found that UI and stress UI were relatively stable but higher after VD compared with CS.[21] There are no studies in primiparous women with follow up exceeding 1 year.

In a cross-sectional Chinese study of 19,024 women >20 years old, nulliparous women were compared with women after 1 CS.[22] Pregnancy was associated with an increase of stress UI (OR, 1.78; 95% CI, 1.22–2.59), which is similar to the results of the present study (OR, 1.71; 95% CI, 1.43–2.05). The EPINCONT study also compared nulliparous women with women after CS; however, the CS group was largely multiparous, with a mean number of pregnancies of 1.8. Pregnancy increased UI by an OR of 1.5 and stress UI by an OR of 1.4, which are in agreement with the results of the present study.[4]

The results of this study contradict several previous large cross-sectional epidemiologic studies that have reported that the protective effect of CS is temporary,[2,4] restricted to milder forms of UI,[23] or even nonexistent.[3,5] This, in turn, has led to the opinion that CS may not be "totally protective." However, according to the logic of causality, CS cannot prevent UI that existed before pregnancy or UI that started during and persisted after pregnancy. Therefore, to evaluate the scope and limits of the protective effect of CS, these groups of women should not have been included. There is still no general agreement on whether VD carries an additive risk of UI. The prospective multicenter study of McKinnie et al[5] and the survey of MacLennan et al[3] did not show any difference between CS and VD for any type of UI. The scientific evidence supporting these conclusions is weak and contradicts a wide range of data from functional and imaging studies that have demonstrated injuries and deteriorated function after vaginal birth in contrast to the lack of such changes in nulliparous women or in women after CS.[24,25]

TABLE 2
Prevalence of different aspects of urinary incontinence

Variable	Nulliparous women		Cesarean delivery		Vaginal delivery		Trend *P* value[a]
	n	% (95% Confidence interval)	n	% (95% Confidence interval)	n	% (95% Confidence interval)	
Any urinary incontinence[b]	265	20.1 (18.0–22.3)	397	30.1 (27.7–32.7)	564	43.0 (40.3–45.7)	<.0001
Bothersome	75	5.7 (4.5–7.1)	93	7.1 (5.8–8.6)	163	12.5 (10.7–14.4)	<.0001
Duration >10 y	30	2.3 (1.5–3.2)	67	5.1 (4.0–6.5)	138	10.6 (9.0–12.4)	<.0001
Treatment for incontinence[c]	11	0.8 (0.4–1.5)	30	2.3 (1.6–3.3)	50	3.8 (2.9–5.0)	<.0001
Subtypes of urinary incontinence							
Stress	105	8.0 (6.6–9.6)	157	12.1 (10.3–14.0)	221	17.1 (15.0–19.2)	<.0001
Urge	39	3.0 (2.1–4.0)	64	4.9 (3.8–6.2)	102	7.9 (6.5–9.5)	<.0001
Mixed	101	7.7 (6.3–9.3)	145	11.1 (9.5–13.0)	207	16.0 (14.0–18.1)	<.0001
Frequency of urinary incontinence							
Less than once a month	54	4.1 (3.1–5.3)	101	7.8 (6.4–9.4)	138	10.7 (9.0–12.5)	<.0001
Once or more per month	70	5.3 (4.2–6.7)	111	8.5 (7.1–10.2)	155	12.0 (10.2–13.9)	
Once or more per week	87	6.6 (5.3–8.1)	108	8.3 (6.9–9.9)	157	12.1 (10.4–14.0)	
Every day and/or night	54	4.1 (3.1–5.3)	60	4.6 (3.5–5.9)	98	7.6 (6.2–9.1)	
Weekly or more often	141	10.7 (9.1–12.5)	168	12.8 (11.0–14.7)	255	19.4 (17.4–21.7)	<.0001
Volume of urinary incontinence							
A few drops	162	12.3 (10.6–14.2)	268	20.5 (18.3–22.8)	377	28.8 (26.4–31.4)	<.0001
Small amounts	92	6.7 (5.7–8.5)	103	7.9 (6.5–9.5)	162	12.4 (10.7–14.3)	
Large amounts	9	0.7 (0.3–1.3)	16	1.2 (0.7–2.0)	21	1.6 (1.0–2.4)	
Small and large amounts	101	7.7 (6.3–9.3)	119	9.0 (7.6–10.7)	183	14.0 (12.1–16.0)	<.0001
Severity of incontinence according to Sandvik's index							
Slight	124	9.4 (7.9–11.2)	210	15.9 (14.0–18.0)	289	22.0 (19.8–24.4)	<.0001
Moderate	130	9.9 (8.3–11.6)	154	11.7 (10.0–13.6)	238	18.1 (16.1–20.4)	
Severe	9	0.7 (0.3–1.3)	13	1.0 (0.6–1.7)	18	1.4 (0.8–2.2)	
Moderate and severe[d]	139	10.6 (9.0–12.4)	167	12.7 (11.0–14.6)	256	19.5 (17.4–21.8)	<.0001

[a] The significance of trend was tested with Mantel–Haenszel statistics; [b] Any urinary incontinence is affirming the question "Do you have involuntary loss of urine?"; [c] Includes any type of treatment; [d] Considered to be more severe forms of urinary incontinence.
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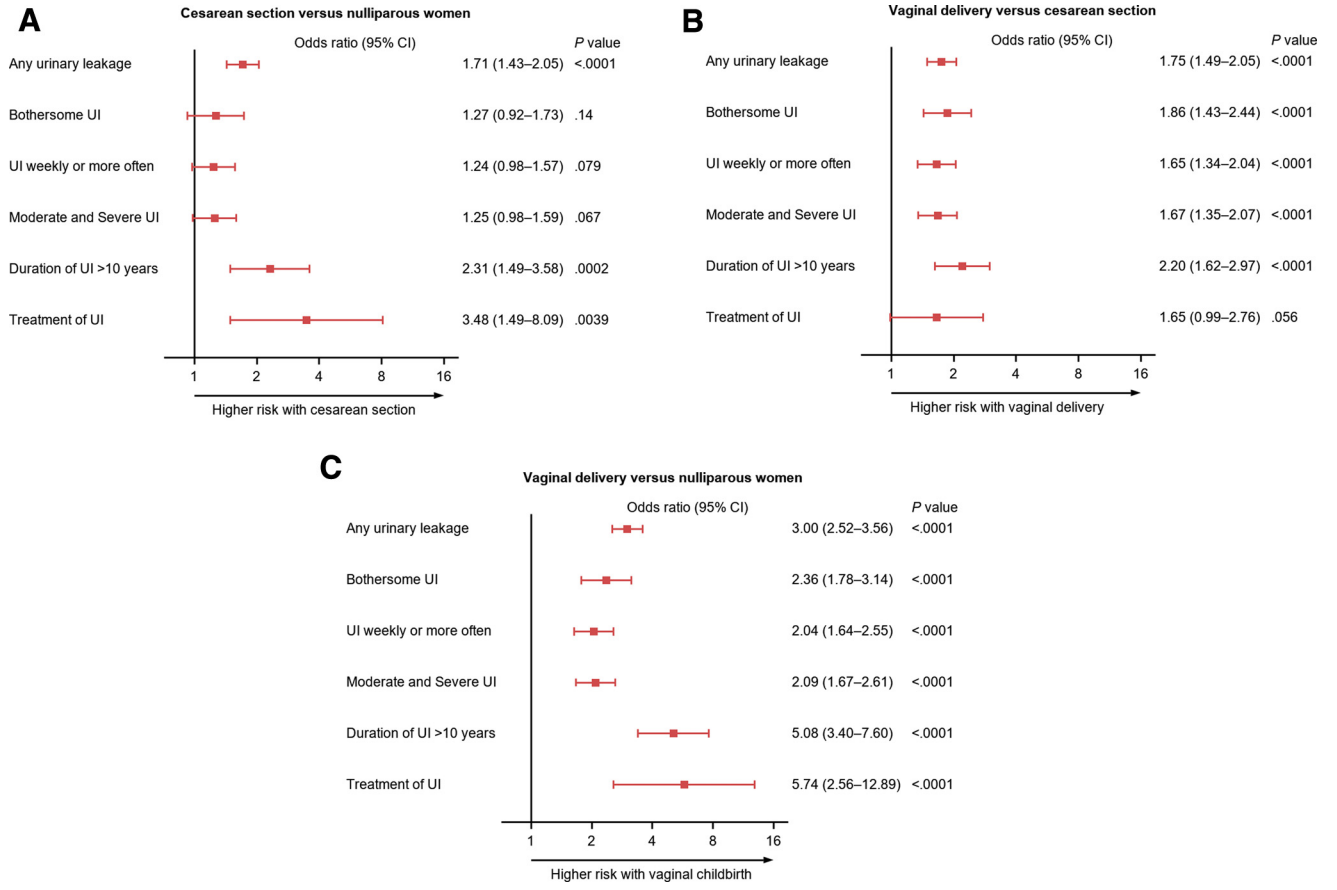
FIGURE 3
The effect of pregnancy and vaginal delivery on the risk and severity of urinary incontinence



Odds ratio and 95% confidence limits and *P* values were calculated from 3 separate logistic regression analyzes. **A,** The effect of pregnancy by comparing nulliparous women with women who delivered by cesarean delivery. **B,** The additive effect, above that from pregnancy alone, of vaginal delivery by a comparison of women delivered by vaginal delivery with women delivered by cesarean delivery. **C,** The sum effect of vaginal childbirth (ie, pregnancy followed by vaginal birth, by comparing nulliparous women with women delivered by vaginal delivery).

CI, confidence interval; *UI*, urinary incontinence.

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The EPINCONT study reported a 1.7-fold increased risk of UI after ≥1 vaginal deliveries compared with ≥1 CS. The prevalence of UI was 21.0% after VD and 15.9% after CS.[4] The results at the 12-year follow up in the ProLong study showed that vaginal birth was associated with a higher UI prevalence compared with CS (39.4% vs 24.3%).[26] Schytt et al[27] followed primiparous women for 1 year and found an increased risk of stress UI for VD (OR, 2.0; 95% CI, 1.11−2.05) compared with an OR of 1.49 (95% CI, 1.20−1.89) in the present study.

It has been reported that the preventive effect of CS dissipates around the menopause.[2,4] This is contradicted by the findings of the current study that show a persistent effect of both pregnancy and VD during an age interval of 25−65 years of age. The cross-sectional study design is sometimes not optimal for age-related changes because some groups of older individuals may be too small resulting in a lack of power, which has led to the erroneous acceptance of no difference between VD and CS.

Research implications

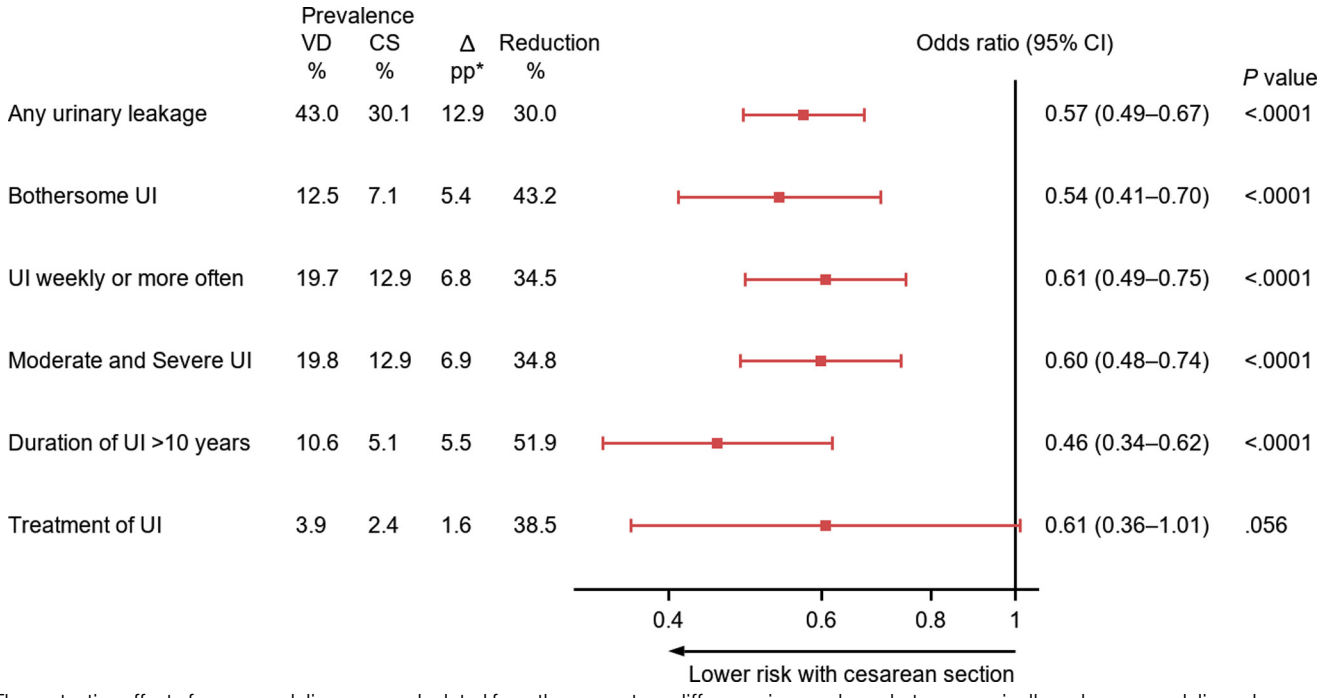
The results of the present study refer to the effect of 1 pregnancy and 1 VD in Nordic women up to 65 years of age. In coming decades, women worldwide will live longer, and a majority of women will give birth to 2 children. This is the reason that it is important to include elderly and multiparous women of different ethnicity.

Comment

Strengths and limitations

In practice, there is no perfect study designed to investigate the long−term effects of childbirth. A longitudinal follow-up study, which theoretically would be the optimum solution, has its weaknesses, such as the workload and costs over an extended time period, confounding by further births, bias because of loss of follow-up and power,

FIGURE 4
Prevalence and risk reduction for different aspects of urinary incontinence by cesarean delivery in primiparous women



The protective effect of cesarean delivery was calculated from the percentage difference in prevalence between vaginally and cesarean delivered women. Odds ratio and 95% confidence limits and probability values were calculated by use of a logistic regression analysis. The *asterisk* indicates the difference in percentage points.

CI, confidence interval; *CS*, cesarean delivery; *UI*, urinary incontinence; *VD*, vaginal delivery.

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and having to await years and decades for the final results. Cohort studies are biased by time-dependent intergenerational differences that are caused by changes in characteristics and experiences rather than pure age-related changes. Large studies, with robust epidemiologic and statistical techniques (such as a matched cohort study), however, are considered capable of providing good estimates of interindividual variability in each age group and changes with age/time.[28,29]

The findings of this study are generalizable to women after their first and only birth. Women in this study were furthermore predominantly white, which is the reason that results should be interpreted with caution for diverse ethnic groups. The validity of outcome parameters, which are based on self-report, depends on the participants willingness and ability to perceive, evaluate, and report correctly, which also may change with aging. The prevalence of UI in this study may seem to be high. However, "any urinary incontinence" has been defined by the International Urogynecological Association /International Continence Society.[10] By this definition, crude prevalence estimates of UI in general populations ranged from 5−69%, with most studies reporting a prevalence of incontinence of 25−45%.[1] That the prevalence in this study is in the upper segment of this range may also be explained by the fact that women were 40−64 years of age.

Nulliparous women ≥40 years of age probably do not represent normality ideally as compared with women who give birth. Being finally nulliparous is considered to be multifactorial including infertility, personal preferences, health issues, or social circumstances. Some women with chronic conditions may have concerns regarding the negative effects of pregnancy on their illness, the risk of passing on the disease, and concerns about being able to raise a child in spite of the disease burden, which might also involve pelvic floor status.[29] Provided that such an effect exists, it would lead to an underestimation of the effect of pregnancy.

The main strengths of this study were the large, national, randomly selected cohorts that were restricted to nulliparous and primiparous women, with the exclusion of multifetal and ongoing pregnancies. Women >64 years were excluded to avoid confounding by multiple illnesses. Parous women who gave birth during a limited period of time (1985−1988) and who were all evaluated 20 years later were included. They represented approximately 25% of all women who gave birth during that time period and who remained primiparous. The surveys were conducted within a time period of 6 years. Three independent control stations were used for the

crucial variables of parity and mode of delivery. The Swedish Medical Birth Register at the National Board of Health and Welfare collects information on >98% of all births from antenatal clinics and obstetric units. The quality of this national database has been shown to be good and suitable for population studies of this type. An evaluation of this register has been published by the National Board of Health and Welfare and is available at http://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/10655/2003-112-3_20031123.pdf (accessed February 7, 2019). Births are registered continuously and updated every 6 weeks by Statistics Sweden. The question regarding ongoing pregnancy and previous births was also included in the questionnaire. Data about aspects of UI were based on a subjective evaluation and not confirmed objectively. A self-administered questionnaire is considered to be the most feasible tool for gathering information about sensitive issues from large populations, which applies to incontinence.[30]

Conclusion

The present study has added estimates and comparisons of the effect size of 1 pregnancy, 1 VD, and the derived protective effect of CS for different aspects of UI in women 40−64 years old. These results make it reasonable to assume that the burden of UI after childbirth most probably does not subside with ageing. More likely it persists and contributes to an earlier onset of UI throughout life. Hence, the protective effect of CS in women after 1 birth also persists up to age 65 years and should therefore, with advancing age, contribute to maintaining continence and postpone the onset of UI. ■

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Supplementary Materials

Description of the source cohorts

The 3 matched cohorts (nulliparous women and vaginal and cesarean delivered women) were drawn from 3 national randomly selected cohorts. The origin of these large source cohorts is described in more details.

SWEPOP-1 (vaginal and cesarean delivered women)

This national survey of pelvic floor dysfunction, the SWEPOP (SWEdish Pregnancy, Obesity and Pelvic floor) study was conducted in 2008 and assessed pelvic floor function in women 20 years after 1 single pregnancy that terminated in either a vaginal or a surgical delivery.

The population studied and their obstetric data were obtained from the Swedish Medical Birth Register (MBR). The MBR, which was started in 1973, is a national register that includes >98% of all births in Sweden. Data from all antenatal clinics and all obstetric units are sent to the MBR at the National Board of Health and Welfare.

The quality of this national database has been shown to be good and suitable for population studies of this type. A description of the MBR in English can be found at http://www.socialstyrelsen.se/register/halsodataregister/medicinskafodelseregistret/inenglish. An evaluation of the MBR has been performed by Cnattingius et al[1] and by the National Board of Health and Welfare and is available at www.socialstyrelsen.se/publikationer2002/2002-112-4.

Restricting the admission criteria for individuals to be included in a study is the most effective method of preventing confounding of known risk factors.[2] We therefore used restriction as far as possible in the design of the study. Furthermore, many birth-related pelvic floor disorders have a long latency period before symptoms appear and develop.[3,4]

On this basis, we chose a conservative study design according to the following criteria: only primiparae who had 1 and no further births, with the exclusion of multifetal pregnancies (avoiding multiparity, mixed modes of delivery, and new or repeated obstetric events). The period of recruitment was short (1985−1988), and the long-term follow-up was fixed to 20 years.

The questionnaire was sent to 9423 women who were asked to provide written, informed consent to participate and to complete a questionnaire. On the basis of the answers in the questionnaire, women were excluded from the study if they affirmed multiparity (the misdiagnosis of "parity" is predominantly related to immigration, because the first birth in Sweden is sometimes assumed to be the first birth ever) or a multifetal or current pregnancy.

The questionnaire was returned by 65.2% of 9423 women.

Characteristics of responders and nonresponders (SWEPOP -1)

The proportion of missing data varied between 0.0% for age and 15.9% for hysterectomy in the population cohort. There was little difference in the proportions of missing data between groups (eg, the proportion of missing data for hysterectomy, which had the greatest proportion of missing data, was 15.5% [620/3995 women] in the vaginal delivery group and 17% [205/1204 women] in the CS group). The nonresponders were 1.6 years younger (49.6±5.9 vs 51.2±5.9 years; $P<.001$), were more often overweight or obese (37% vs 27%; $P<.001$), and had an infant whose birthweight was <4000 g (43% vs 48%; $P=.003$) compared with the responders.

SWEPOP-0 (nulliparous women)

Nulliparous women generally are considered to be the proper control group for measuring the effects of pregnancy because it reflects the natural, age-dependent change of pelvic floor anatomy and function. A systematic survey of pelvic floor disorders in nulliparous women, however, has not been presented previously, which is probably due to the fact that it is difficult to identify a large group of randomly selected nulliparous women of different ages.

SWEPOP-0 was a national postal and World Wide Web−based questionnaire survey that was conducted in 2014. The potential study population was identified by the Survey Division at the Central Bureau of Statistics from the Total Population Register and comprised women registered in Sweden who had not given birth and were 25−64 years old.

The lower limit of the age span was set to 25 years because studies of adolescent girls and young women indicate that the prevalence of urinary incontinence seems to stabilize at a minimum during the third decade.[5] The upper limit was set to 65 years because confounding age-dependent comorbidities potentially influence the prevalence of urinary incontinence, which is known to increase rapidly from the seventh decade.

A total of 20,000 women from the total number of eligible nulliparous women (625,810). were invited randomly to participate. The 20,000 participants comprised 4 independent, random samples, that were stratified by decades of age with oversampling of the 2 youngest age groups for a subsequent longitudinal follow up.

A letter about the study, which included log-in credentials to a World Wide Web form, that requested them to give their written informed consent was sent to all women. The introductory letter was followed by postal questionnaires.

The questionnaire (Internet-based and postal versions) was returned by 10,187 women after 3 mailing cycles during a 4-month period. The web form was used by 52% of the women.

The answers revealed that 194 women were pregnant, that 525 women were parous, and that a further 264 women declined participation or returned an unusable form. These women were excluded, plus another 7, because of missing information about parity. Misdiagnosis of parity was related to immigration (337/525 women). The final study population thus comprised 9197 women.

The response rate varied between 43.3% in the youngest age group (25−29 years) and increased incrementally and consistently to 62.7% in the oldest group

(60−64 years). Of the respondents, 52% completed the questionnaire in web form, and 48% completed the postal questionnaire. Of the respondents, 1576 were postmenopausal; 358 had undergone a hysterectomy, and 175 were taking estrogens.

Characteristics of responders and nonresponders (SWEPOP -0)

Responders and nonresponders were compared with the use of information from the Total Population Register, which was available for 99.9% of the total sample. Nonresponders were younger (56.7% of the age group 25−29 years compared with 37.3% of the age group 60−64 years), more likely to be immigrants (63.7%), non-Swedish citizens (67.8%), unmarried (51.2%), living in suburban or commuting municipalities (53.7%), and in a lower income bracket and had lower level of education (59.1% of those with $\leq$3 years of secondary education compared with 40.9% of those with >3 years secondary education and higher).

Supplementary References

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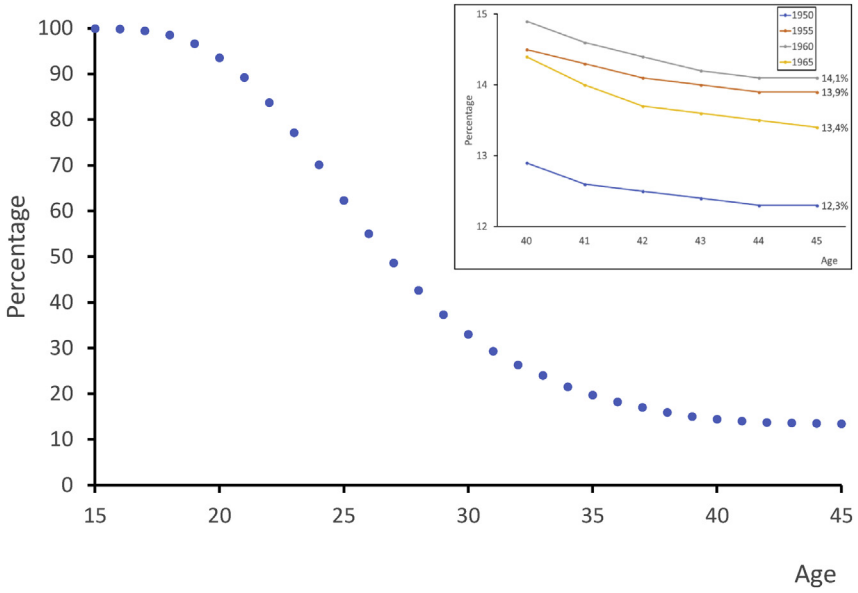
SUPPLEMENTARY FIGURE

The rate of nulliparity across ages 15–45 years for women born in Sweden in 1950, 1955, 1960, and 1965



Source: Statistics Sweden: Demographic reports (2011;3:68-70); childbearing patterns of different generations; proportion of women born in Sweden in 1965 who had at least 1 child by age and year of birth. This publication is only available in electronic form on www.scb.se

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TABLE S1

Missing values

Variable	Nulliparous women (n=1318), n (%)	Cesarean delivery (n=1318), n (%)	Vaginal delivery (n=1312), n (%)	All (N=3948)
Urinary incontinence				
Bothersome	0	8 (0.6)	5 (0.4)	13 (0.3)
Duration >10 y	0	7 (0.5)	8 (0.6)	15 (0.4)
Treatment	1 (0.1)	2 (0.2)	2 (0.2)	5 (0.1)
Subtypes	20 (1.5)	31 (2.4)	34 (2.6)	85 (2.2)
Frequency	0	17 (1.3)	16 (1.2)	33 (0.8)
Volume of leakage	2 (0.2)	10 (0.8)	4 (0.3)	16 (0.4)
Sandvik's severity index	2 (0.2)	20 (1.55)	19 (1.5)	41 (1.0)
Total	25 (0.3)	95 (1.0)	88 (1.0)	208 (0.8)

NOTE: The large number of missing data for subtypes of urinary incontinence was probably due to the fact that an approved response was based on the requirement to either affirm both stress and urge (mixed urinary incontinence) or to negate 1 and at the same time also affirm the other or vice versa (stress urinary incontinence or urge urinary incontinence). For example, in women who were delivered by cesarean delivery, 31 women were excluded; 15 women were excluded because both stress and urge symptoms were negated; 16 women were excluded because of missing response to 1 (n = 12) or both (n = 4) questions about stress and urge incontinence. Nulliparous women answered a postal questionnaire only, whereas 52% of nulliparous women opted for a worldwide web-based questionnaire. Online forms might be more beneficial for obtaining complete answers and may attract a group of keener women.

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TABLE S2
Postmatching distribution of characteristics

Variable	A. Nulliparous women (n=1318) n	%	A vs B *P* value	B. Cesarean delivery (n=1318) n	%	B vs C *P* value	C. Vaginal delivery (n=1312) n	%
Hysterectomy	124	9.4	0.14	102	7.7	0.13	81	6.2
Postmenopausal	606	46.0	.038	552	41.9	0.65	562	42.8
Estrogen treatment	41	3.1	<.0001	115	8.7	0.37	101	7.7

NOTE: The difference in estrogen treatment between nulliparous and primiparous women probably reflects a change in attitude towards hormone treatment during the study period of 2008 and 2014. For differences between groups, the Fisher's exact test (lowest 1-sided *P* value multiplied by 2) was used.

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TABLE S3
Estimates of the effect of age from the logistic regressions of different aspects of urinary incontinence by parity and mode of delivery

	Aspects of urinary incontinence								
	Any urinary incontinence			Moderate and severe incontinence			Duration of Urinary incontinence>10 y		
Variable	$ß_0$	$ß_1$	*P* value[a]	$ß_0$	$ß_1$	*P* value[a]	$ß_0$	$ß_1$	*P* value[a]
Vaginal delivery	−1.0626	0.0148	.14	−2.7970	0.0260	.04	−2.8125	0.0127	.44
Cesarean delivery	−1.5180	0.0127	.22	−3.1902	0.0236	.10	−3.3709	0.0083	.70
Nulliparous women	−2.8514	0.0275	.02	−3.6612	0.0285	.07	−4.4342	0.0126	.69

NOTE: To convert the results from the logistic regression to probabilities of urinary incontinence outcomes for any specific age between 40 and 64 years the following formula can be used: $P(Y)=1/1+e^{-(ß_0+ß_1 \times age)}$, where P=probability of urinary incontinence variables, $ß_0$=intercept, and $ß_1$=age.

[a] Denotes the significance of the estimate of $ß_1$ (ie, of the effect of age on the prevalence of urinary incontinence outcomes).

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Questionnaire

Q1	How tall are you?	cm
Q2	How much do you weigh?	kg
Q3	Have you given birth?	Yes If so how many children have you had? _____ No, I have not given birth
Q4	Do you still have menstrual periods?	Yes/No If yes, go to Q6
Q5	If you have no menstrual periods, what is the cause?	
a	Are you pregnant?	Yes/No
b	Has your uterus been removed?	Yes/No
c	Do you use an intrauterine hormone device?	Yes/No
d	Are you in the menopause?	Yes/No
e	Do you use estrogen?	Yes/No
f	Other causes?	Yes/No
Symptoms from the urinary tract		
Q6	How many times do you urinate during the daytime, on average?	_____
Q7	Do you have to urinate during the night?	Yes If yes, how many times? ____ No
Q8	Do you have urinary urgency with a sudden and strong urge to void that is hard to postpone?	Yes No, if no go to Q10
Q9	How does your urinary urgency affect you?	No problem A minor nuisance Some bother Much bother A major problem
Q10	Do you take any medication for urinary urgency?	Yes/no
Q11	Were you a bed wetter during childhood, (involuntary loss of urine while sleeping)?	Yes If yes, at what age did it stop? No
Q12	Do you have involuntary loss of urine?	Yes/no If no, go to Q21
Q13	How often do you have involuntary loss of urine?	Less than once a month Once or more per month Once or more per week Every day and/or night
Q14	How much urine do you leak each time?	A few drops Small amounts Large amounts
Q15	Do you have involuntary loss of urine in connection with coughing, sneezing, laughing, or lifting heavy items?	Yes/no
Q16	Do you have involuntary loss of urine in connection with a sudden and strong urge to void?	Yes/no
Q17	For how long have you had involuntary loss of urine?	0–5 years 5–10 years More than 10 years

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Questionnaire *(continued)*

Q18	Have you consulted a doctor because of involuntary loss of urine?	Yes/no
Q19	How does your urinary leakage affect you?	No problem A minor nuisance Some bother Much bother A major problem
Q20	If you have given birth, did you have urinary leakage even before the first pregnancy?	Yes/no
Q21	Have you had any surgery for a urinary incontinence?	Yes/no
Q22	Do you take any medication for urinary incontinence?	Yes/no
Q23	Has your mother suffered from urinary leakage?	Yes/no/do not know
Symptoms from the vagina		
Q24	Do you have a sensation of tissue protrusion (a vaginal bulge) from your vagina?	Often Sometimes Infrequently Never
Q25	Do you suffer from a chafing/a rubbing feeling in your vagina/vulva?	Often Sometimes Infrequently Never
Q26	Do you have to lift the front vaginal wall to start or complete voiding?	Often Sometimes Infrequently Never
	If you have no discomforts from your vagina, proceed to Q29.	
Q27	Are your symptoms worse during straining, for example, during heavy lifting?	Unchanged Better Worse
Q28	How do these vaginal symptoms affect you?	No problem A minor nuisance Some bother Much bother A major problem
Q29	Have you received (any) treatment for a prolapse?	Yes/no
Q30	Have you had any surgery for a prolapse?	Yes/no
Q31	Has your mother suffered from prolapse?	Yes/no/do not know
Symptoms from your back passage		
Q32	Do you leak solid feces involuntarily?	Never Less than once a month Several times a month, but less than once a week Once a week or more Once a day or more
Q33	Do you leak liquid feces involuntarily?	Never Less than once a month Several times a month but less than once a week Once a week or more Once a day or more

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Questionnaire *(continued)*

Q34	Do you leak flatus/gas involuntarily?	Never Less than once a month Several times a month but less than once a week Once a week or more Once a day or more
Q35	Do you use a protective product/pad because of involuntary leakage from the back passage?	Never Less than once a month Several times a month but less than once a week Once a week or more Once a day or more
Q36	Is your daily life style affected by involuntary leakage from your back passage?	Never Less than once a month Several times a month but less than once a week Once a week or more Once a day or more
Q37	How do your bowel symptoms affect you?	No problem A minor nuisance Some bother Much bother A major problem
Q38	Have you received (any) treatment for leakage of flatus/gas or feces?	Yes/no
Q39	Has your mother suffered from leakage of flatus/gas or feces?	Yes/no/do not know
Q40	On the lines below, there is room for your own comments regarding this questionnaire.	……..

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