GYNECOLOGY

The influence of pregnancy, parity, and mode of delivery on urinary incontinence and prolapse surgery—a national register study

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BACKGROUND: The long-term effects of vaginal delivery, parity, and pregnancy on the pelvic floor remain uncertain and controversial issues. In comparison with studies using self-reported symptoms, surgical register data may offer a more valid means for evaluating the relative influence of these risk factors.

OBJECTIVE: This study used data from 3 high-quality nationwide registers, namely the Swedish National Quality Register of Gynecological Surgery, the Swedish Medical Birth Register, and the Total Population Register, to evaluate the contribution of vaginal and cesarean delivery, parity, and factors not related to childbirth to the long-term risk for reconstructive urogential surgery.

STUDY DESIGN: This was a register-based linkage study among women aged ≥45 years who underwent urinary incontinence or prolapse surgery from 2010 to 2017. This surgical cohort was divided into nulliparous women, women with ≥1 cesarean deliveries only, those with ≥1 vaginal deliveries, and according to the number of births. A corresponding reference group was constructed based on women born in 1960 from the Total Population Register (n=2,309,765). The Swedish Medical Birth Register was used to determine the rate of women with cesarean and vaginal delivery and their respective parity. Absolute and relative risk were presented per 1000 women with 95% confidence intervals. Pairwise differences were analyzed with Fisher exact tests and the Mann-Whitney U test for dichotomous and continuous variables. The trend between ≥3 ordered categories of dichotomous variables was analyzed with Mantel-Haenszel statistics.

RESULTS: A total of 39,617 women underwent prolapse surgery and 20,488 underwent incontinence surgery. Among women with prolapse surgery, 97.8% had ≥1 vaginal delivery, 0.4% had ≥1 cesarean delivery only, and 1.9% were nullipara. Corresponding figures for those with incontinence surgery were 93.1%, 2.6%, and 4.3%, respectively. Women with vaginal deliveries were overrepresented in the prolapse surgery (relative risk, 1.23; 95% confidence interval, 1.22—1.24; P<.001) and incontinence surgery groups (relative risk, 1.17; 95% confidence interval, 1.15—1.19; P<.001). Nulliparous and cesarean delivered women were underrepresented in the prolapse surgery (relative risk, 0.14; 95% confidence interval, 0.13—0.15 and relative risk 0.055; 95% confidence interval, 0.046—0.065; all P<.001) and incontinence surgery groups (relative risk, 0.31; 95% confidence interval, 0.29—0.33 and relative risk, 0.40; 95% confidence interval, 0.36—0.43). The absolute risk for prolapse surgery was lowest after cesarean delivery (0.09 per 1000 women; 95% confidence interval, 0.08—0.11) and differed by a factor of 23 (absolute risk, 2.11 per 1000 women; 95% confidence interval, 2.09—2.13) from that after vaginal birth. The absolute risk for prolapse and incontinence surgery increased consistently with parity after vaginal births. This trend was not observed after cesarean delivery, which is on par with that of nulliparous women. The first vaginal birth contributed the highest increase in the absolute risk for pelvic organ prolapse surgery (6-fold) and stress urinary incontinence surgery (3-fold). The second vaginal birth contributed the lowest increase in the absolute risk for pelvic organ prolapse surgery (~1/3 of the first vaginal birth) and for stress urinary incontinence surgery (~1/10 of the first vaginal birth).

CONCLUSION: Surgery for urinary incontinence and prolapse was almost exclusively related to vaginal parity. The risk for prolapse surgery increased consistently with parity after vaginal births but not after cesarean delivery, whereas the risk associated with cesarean delivery was on par with that of nulliparous women. Thus, cesarean delivery seems to offer protection from the need for pelvic organ prolapse and stress urinary incontinence surgery later in life.

Key words: cesarean delivery, mode of delivery, pelvic floor disorders, pelvic organ prolapse, stress urinary incontinence, surgical outcomes, vaginal delivery

Introduction
Pelvic organ prolapse (POP) and stress urinary incontinence (SUI) are common female pelvic floor disorders (PFDs), which have a considerable impact on well-being and quality of life and cause both personal suffering and costs to society.1–3 Approximately every fourth woman reports one or more PFDs.4 Estimates of the lifetime risk for pelvic floor surgery is currently up to 1 in 5 women,5–8 but the actual need may be even higher.9 At present, the preponderance of evidence from epidemiologic and imaging studies suggests that vaginal delivery (VD) is the leading cause of SUI and POP,10–13 including the more surgical demanding forms of SUI and POP.14 Whether cesarean deliveries (CDs) can reduce the risk for PFDs later in life is controversial; 2 studies have indicated that the protective effect of CD on PFDs diminishes over time and even disappears after multiple deliveries.15,16 Most of the previous epidemiologic studies on POP and UI are based on patient reporting, which relies on women’s subjective perception and willingness to report. Another way to
assess the impact of pregnancy and childbirth is to study the epidemiology of surgical treatment of PFDs because reconstructive surgery presupposes an objectively confirmed condition and bothersome symptoms affecting quality of life. Nowadays, women in many countries have access to urogenital surgical treatment thanks to state-sponsored public healthcare systems that make it available at an affordable cost. Those who qualify for surgical treatment may offer insight into and serve as valid subjects to evaluate risk factors for PFDs.

There are still crucial and unresolved issues regarding the relative impact of pregnancy, VD, parity, and factors unrelated to childbirth on the long-term risk of PFDs. It is of particular interest and yet unknown whether the hormonally triggered changes during pregnancy are temporary and reversible during involution or if they persist, becoming aggravated with time. This study therefore, aimed to use data from 3 high-quality national registers, namely the Swedish National Quality Register of Gynecological Surgery (GynOp),17,18 the Swedish Medical Birth Register (MBR),19,20 and the Total Population Register (TPR),20,21 to analyze the relative contribution of VD and CD, parity, and factors not related to childbirth on the long-term relative and absolute risk for reconstructive urogenital surgery.

Materials and Methods
Ethical approval for the study was obtained from the Regional Ethical Review Board in Gothenburg, Sweden (reference number 345-17 approved on June 15, 2017 and October 12, 2018). All women gave their written consent to participate.

In this study, we used information from GynOp, which started in 1997.17 Several clinics have joined the register during the recent decade (increasing coverage from 60% in 2010 to >90% in 2017). Approximately 3500 SUI and 6000 POP procedures, either as day-care or inpatient procedures, are performed annually under local, regional, or general anesthesia. All women who qualified for surgery received information about GynOp and the possibility of declining participation or to opt-out at any time. Data were registered consecutively, including a preoperative evaluation (postal- or web-based questionnaires), hospital records from admission, surgery, discharge, and a questionnaire 1-year postoperatively. A total of 6% of all women declined participation or returned a blank or unusable form (2019).17 GynOp was intended for audit and research purposes. The County Council of Västerbotten, Umeå, Sweden, is the legal and responsible owner of the register. The section about POP and UI surgery has been in use since 2006. The Swedish Association of Local Authorities and Regions has reviewed and certified its content validity and measures patient-reported outcomes pre- and postoperatively (8 weeks and 12 months).18

All women ≥45 years who underwent SUI or POP surgery in 2010 to 2017 were eligible for inclusion in the study (n=59,415). The 3 study cohorts were designed to measure the risk for surgery after VD, after pregnancy separate from VD, and the sum effect of factors unrelated to childbirth (Supplemental Figure). Accordingly, the total study cohort was stratified into (1) nulliparous women, (2) women with first and all subsequent deliveries by CD, and (3) women with ≥1 VDs regardless of additional CDs (Figure 1, A; Supplemental Table). The number of births (0, 1, 2, 3, ≥4) was registered for all women (Figure 1, B). Information about parity in GynOp was cross-checked with the TPR.21 The TPR started in 1968, is updated every fourth week, and has 99.7% coverage. Its quality has been considered high.19,20,21 The highest number of births was chosen when parity information differed between GynOp and TPR (5%). The mode of delivery was cross-checked with the MBR.19 The MBR started in 1973 and includes information about pregnancy, delivery, and the infant of >97% of all births in Sweden. The register has been validated and considered to be of high quality.19

To calculate the relative risk (RR) and absolute risk (AR) of surgery, reference groups were constructed from data in the TPR of all women in Sweden born in 1960 (ie, 57 years of age in 2017; n=2,309,765, including those who had surgery). Since the 1930s, the rate of women in Sweden who remained nulliparous for life has been relatively constant (~13%).22 In 2017, the rate of nulliparous women in the reference group (≥45 years) was based on women born in 1960 and set to 13.8% (TPR). The remaining 86.2% (parous women) were subdivided into mode of delivery and parity as registered in the MBR (eg, 7.7% for ≥1 CD and 92.3% for ≥1 VD), which translated into 13.8% (nullipara), 79.6% (≥1 VD) and 6.6% (≥1 CD only).
A, The study population of women ≥45 years. B, Women having prolapse and incontinence surgery according to parity and mode of delivery. Superscript letter a denotes there were 4 women with uncertain parity, thus, the total number of women with known parity was 19,076. The superscript letter b denotes there were 11 women with uncertain parity, thus, the total number of women with known parity was 38,717. The superscript letter c denotes women with both incontinence and prolapse procedures were included in each treatment category. The superscript letter d denotes set according to the rate of nulliparous women aged ≥45 years in 2017 in the TPR. The superscript letter e denotes based on women born in 1960 recorded in the MBR. The rate of surgery for women with ≥1 CD and those with ≥1 VD was 7.7% vs 92.3%, and given the rate for nulliparous women, the final distribution was 13.8%, 79.6%, and 6.6%, respectively. From these percentages, the number of women in all cohorts according to mode of delivery and parity (0, 1, 2, 3, ≥4) was calculated from the total number of women in 2017 (n=2,309,765) down to the singular.

CD, cesarean delivery; MBR, Medical Birth Register; POP, pelvic organ prolapse; SUI, stress urinary incontinence; TPR, Total Population Register; VD, vaginal delivery.

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With these percentages of 2,309,765 women, the number of women at risk for surgery in each reference group was calculated (Figure 1).

**Statistics**

Descriptive data for continuous variables are presented as mean, standard deviation, 95% confidence interval (CI), and median and interquartile range. Categorical data are presented as number, percentage, and 95% CI. Fisher’s exact test was used for pairwise comparisons of categorical variables and the Mann-Whitney U test was used for continuous variables. Results were presented as the mean difference for continuous variables and as the difference in percentages for categorical variables, 95% CI, and P value. The trend between ≥3 independent groups of categorical variables was analyzed using Mantel-Haenszel statistics. The AR (per thousand women) of undergoing surgery was calculated by dividing the number of SUI or POP surgeries reported in GynOp by the number of women at risk in the reference female population aged ≥45 years and presented with a 95% CI. An observed/expected ratio was calculated, and the method of Ulm’s method was used to assess the CI of the RR when comparing proportions between groups in GynOp with the respective proportions in the general female population aged ≥45 years. Statistical significance was set at P<.05. Statistical analyses were performed using SAS version 9.4 (SAS Inc, Cary, NC).

**Results**

The baseline characteristics were almost similar between the parous groups. Nulliparous women were older than the parous groups, and, in addition, among

| Characteristics | Nullipara n=745 | All CD n=144 | At least 1 VD n=38,728 | Difference between cohortsa | P value |
|-----------------|-----------------|--------------|------------------------|---------------------------|---------|
| Age (y)         | 70.4 (9.7)      | 65.8 (10.8)  | 64.1 (9.7)             | CD only vs nullipara      | <.0001  |
|                 | 71 (65−77)      | 66 (58−73)   | 64 (57−71)             | VD vs nullipara           | <.0001  |
|                 | (69.7−71.1)     | (64.0−67.6)  | (64.0−64.2)            | VD vs CD only             | .063    |
| BMI (kg/m²)     | 25.8 (3.9)      | 26.6 (4.2)   | 26.2 (3.9)             |                           |         |
|                 | 25.2 (22.9−28)  | 26 (23.7−28.9)|                      |                           |         |
|                 | (25.4−26.1)     | (25.8−27.3)  | (26.2−26.3)            | .027                      | .0016   |
| BMI ≥30 (kg/m²) | 67/479          | 19/123       | 5176/32,986            |                           | .77     |
|                 | 14.0 (11.0−17.4)| 15.4 (9.6−23.1)|                     |                           | .34     |
|                 |                 | 15.7 (15.3−16.1) |                     |                           | 1.0     |
| Smoker ≥1 cigarette/d | 36/437 | 10/105       | 2751/29,535           |                           | .79     |
|                 | 8.2 (5.8−11.2)  | 9.5 (4.7−16.8)| 9.3 (9.0−9.7)        |                           | .50     |
|                 |                 |               |                       |                           | 1.0     |
| Estrogenb       | 200/427         | 56/100       | 13,437/29,090         |                           | .12     |
|                 | 46.8 (42.0−51.7)| 56.0 (45.7−65.9)|                     |                           | .83     |
|                 |                 | 46.2 (45.6−46.8) |                     |                           | .063    |
| Previous sterilizationc | 13/355 | 10/97        | 3935/26,596           |                           | .025    |
|                 | 3.7 (2.0−6.2)   | 10.3 (5.1−18.1)|                     |                           | <.0001  |
|                 |                 |               |                       |                           | .27     |
| Previous SUI surgeryc | 28/353 | 8/96         | 2719/26,250           |                           | 1.0     |
|                 | 7.9 (5.3−11.3)  | 8.3 (3.7−15.8)| 10.4 (10.0−10.7)     |                           | .15     |
|                 |                 |               |                       |                           | .65     |
| Previous POP surgeryc | 69/360 | 13/98        | 5863/26,289           |                           | .23     |
|                 | 19.2 (15.2−23.6)| 13.3 (7.3−21.6)|                     |                           | .17     |
|                 |                 | 22.3 (21.8−22.8) |                     |                           | .035    |
| Hysterectomyc   | 80/355          | 16/100       | 5178/26,119           |                           | .16     |
|                 | 22.5 (18.3−27.2)| 16.0 (9.4−24.7)|                     |                           | .20     |
|                 |                 | 19.8 (19.3−20.3) |                     |                           | .34     |
| SUI and POP surgeryc | 8745 | 5/144        | 677/38,728            |                           | .028    |
|                 | 1.1 (0.5−2.1)   | 3.5 (1.1−7.9)| 1.7 (1.6−1.9)        |                           | .16     |
|                 |                 |               |                       |                           | .12     |
| Preoperative UUI | 170/245         | 53/77        | 10,984/17,829        |                           | 1.0     |
| ≥1/wk           | 69.4 (63.2−75.1)| 68.8 (57.3−78.9)|                     |                           | .014    |
|                 |                 | 61.6 (60.9−62.3) |                     |                           | .23     |

BMI, body mass index; CD, cesarean delivery; CI, confidence interval; IQR, interquartile range; POP, pelvic organ prolapse; SD, standard deviation; SUI, stress urinary incontinence; UUI, urgency urinary incontinence; VD, vaginal delivery.

a The Mann-Whitney U test was used for comparisons between groups of continuous variables and Fisher’s Exact test (lowest 1-sided P value multiplied by 2) was used for dichotomous variables. A P value of <.05 was considered as statistically significant; b Both systemic and vaginal treatments; c Previous surgery as reported in the questionnaire.

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TABLE 2
Characteristics of cohort who underwent surgery for stress urinary incontinence

| Characteristics          | Nullipara n=873 | All CD n=535 | At least 1 VD n=19,080 | Difference between cohortsa | P-value |
|--------------------------|-----------------|--------------|------------------------|----------------------------|---------|
| Age (y)                  | 62.6 (10.9)     | 56.6 (8.6)   | 56.9 (9.9)             | .23                        | .0003   |
| BMI (kg/m²)              | 27.3 (4.8)      | 27.5 (4.6)   | 26.5 (4.3)             | .05                        | .0015   | .0003 |
| n/N % (95% CI)           | 30.1 (57.3)     | 27.1 (5.9)   | 26.4 (5.7)             | .0001                      | <.0001  | .60   |
| Smoker ≥1 cigarette/d    | 56/506 (11.1)   | 118/431 (27.4) | 3084/15,445 (20.0) | .55                        | .0015   | .0003 |
| Estrogenb                | 259/488 (53.1)  | 136/310 (43.9) | 4772/12,524 (38.1)    | .014                       | <.0001  | .046  |
| Previous sterilizationc  | 18/391 (4.6)    | 58/297 (19.5) | 2010/11,017 (18.2)    | <.0001                     | <.0001  | .62   |
| Previous SUI surgeryd    | 88/394 (22.3)   | 49/300 (16.3) | 1736/10,900 (15.9)    | .060                       | .0014   | .90   |
| Previous POP surgerye    | 10/388 (2.6)    | 2/300 (0.7)  | 663/10,838 (6.1)      | .10                        | <.0001  | <.0001 |
| Hysterectomyf            | 134/400 (33.5)  | 64/298 (21.5) | 2055/11,015 (18.7)    | <.0005                     | <.0001  | .22   |
| SUI and POP surgeryd     | 8/873 (0.9)     | 5/535 (0.9)  | 677/19,080 (3.5)      | .97                        | <.0001  | .0011 |
| Preoperative UI ≥1/wk    | 403/590 (68.3)  | 261/423 (61.7) | 8340/15,085 (55.3)    | .035                       | <.0001  | .0098 |

BMI, body mass index; CD, cesarean delivery; CI, confidence interval; IQR, interquartile range; MBR, Swedish Medical Birth Register; POP, pelvic organ prolapse; SD, standard deviation; SUI, stress urinary incontinence; UUI, urgency urinary incontinence; VD, vaginal delivery.

* The Mann-Whitney U test was used for comparisons between groups of continuous variables and Fisher Exact test (lowest 1-sided P-value multiplied by 2) was used for dichotomous variables. A P value of < .05 was considered as statistically significant; bBoth systemic and vaginal treatments; cPrevious surgery as reported in the questionnaire; dConcomitant POP and SUI surgery. The rate of vacuum extraction—assisted vaginal deliveries reported in the Swedish National Quality Register of Gynecological Surgery (GynOp) among single parous women (one and no subsequent VDs) was 17.1% compared with 14.1% reported in the MBR in 1973 to 2017. Conversely, among women with 2 VDs, the rate of vacuum extraction reported in GynOp was 10.8% compared with 13.8% in the MBR. The overall rate of forceps delivery was < 0.8% of all vaginal deliveries.

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The nulliparous women were also more often hysterectomized, taking estrogen, and reported preoperative urge UI more often (Table 1 and 2). A total of 39,617 women underwent POP surgery, and 20,488 underwent SUI surgery (690 women [1.2%] had concomitant procedures). In the study population, 57,131 had ≥1 VD, 674 had ≥1 CD, and 1610 were nulliparous (Figure 1). Of those who underwent SUI surgery, 93.1% had ≥1 VDs, 2.6% had ≥1 CD only, and 4.3% were nulliparous. Among those who underwent POP surgery, 97.8% had ≥1 VDs, 0.4% had ≥1 CD only, and 1.9% were nulliparous (Figure 2).

Compared with the proportions among females aged ≥45 years in the general population (n=1,837,883), the VD group was overrepresented in GynOp (RR, 1.17; 95% CI, 1.15–1.19) for SUI surgery and for POP surgery (RR, 1.23; 95% CI, 1.22–1.24; both P<.0001). The expected number of surgeries for POP in the VD group was 31,535, whereas the number in GynOp was 38,728 (18% increase) (Table 3; Figure 2). The reverse applied to the nulliparous and CD groups, which were similarly underrepresented by an RR of 0.31 (95% CI, 0.29–0.33) and an RR of 0.40 (95% CI, 0.36–0.43; both P<.0001), respectively, for SUI surgery and by an RR of 0.14 (95% CI,
0.13–0.15) and an RR of 0.055 (95% CI, 0.046–0.065; both P < 0.0001), respectively, for POP surgery. The expected number of POP procedures was reduced by 94% in the CD group and by 88% in the nulliparous group, and for SUI surgery, the expected number was reduced by 60% and 69%, respectively (Table 3). The AR for POP surgery, that is, the number of surgeries in GynOp divided by the number of women at risk in the reference population aged ≥ 45 years, was lowest for women who only delivered by CD (CD) (AR, 0.09 per 1000 women; 95% CI, 0.08–0.11). In comparison, the AR for POP surgery in the VD group differed with a factor of 23 (AR, 2.3 per 1000 women; 95% CI, 2.2–2.5) in the nulliparous group and increased 17-fold to 38.7 per 1000 women (95% CI, 37.8–39.8) with ≥ 4 or VDs. The increase in the AR for SUI surgery was consistent but less pronounced than for POP surgery among women with VDs from an AR of 2.7 per 1000 women (95% CI, 2.6–2.9) among nullipara to 14.5 per 1000 women (95% CI, 13.9–15.1) after ≥ 4 vaginal births (5-fold increase) (Table 4 and 5). There were significant trends in the AR for surgery according to parity in the CD group (a positive trend for SUI and a negative trend for POP surgery, both P < 0.0001) (Table 4 and 5; Figure 3), but the effect was small and on par with that of nulliparous women. The first vaginal birth contributed the highest risk increase to both POP (AR difference, 11.5 per 1000 women; 95% CI, 11.1–11.9; P < 0.0001) and SUI surgeries (AR difference, 6.2 per 1000 women; 95% CI, 5.8–6.5; P < 0.0001), higher than for all subsequent births (Table 4 and 5; Figure 3). The second vaginal birth contributed the lowest additional risk increase to both POP (AR difference, 4.4 per 1000 women; 95% CI, 3.9–4.9; P < 0.0001) and SUI surgeries (AR difference, 0.6 per 1000 women; 95% CI, 0.3–1.0; P = 0.011). This pattern was more pronounced for SUI surgery (second birth added 10% of that in the first birth) than for POP surgery (second birth added 38% of that in the first birth) (Table 4 and 5).

**Comments**

**Principal findings**

VD was the sole dominant risk factor for subsequent urogenital surgery and was overrepresented, whereas nulliparous women and those who delivered exclusively by CD were underrepresented. After one or more pregnancies among women who delivered by CD, the AR for POP and SUI surgery was negligible and on par with that of nulliparous women. An increasing number of vaginal births was associated with a cumulative increase in the AR of surgery for POP and SUI. The first vaginal birth contributed the largest and the second vaginal birth the smallest additive AR for POP and SUI surgery.

**Results in context**

The crucial contribution to this study was the inclusion of a large group of nulliparous women who had undergone urogenital surgery and the possibility of identifying a corresponding reference group of at-risk women in the total female population aged ≥ 45 years. Known parity and mode of delivery made it possible to calculate the relative and AR for surgery for all cohorts. In addition, a...
### TABLE 3
The relative risk for surgery

| Study cohorts                  | A. Performed procedures | B. Expected procedures | The difference between A and B | The relative risk for surgery |
|--------------------------------|-------------------------|------------------------|-------------------------------|-------------------------------|
|                               | n                       | %                      | n                             | %                            | RR (95% CI)                 | P value       |
| Pelvic organ prolapse surgery |                         |                        |                               |                              |                            |              |
| ≥1 vaginal births             | 38,728                  | 97.8                   | 31,535                        | 79.6                         | +7193 (+18.2)               | 1.228 (1.216–1.240) | <.0001        |
|                               | 1 cesarean deliveries only | 144                   | 2615                          | 6.6                          | −2471 (−6.2)                | 0.055 (0.046–0.065) | <.0001        |
| Nulliparous women             | 745                     | 1.9                    | 5467                          | 13.8                         | −4722 (−11.9)               | 0.136 (0.127–0.146) | <.0001        |
| Total                         | 39,617                  | 100.0                  | 39,617                        | 100.0                        | 0                           | 0                           |              |
| Stress urinary incontinence surgery |                   |                        |                               |                              |                            |                            |              |
| ≥1 vaginal births             | 19,080                  | 93.1                   | 16,308                        | 79.6                         | +2772 (+13.5)               | 1.170 (1.153–1.187) | <.0001        |
|                               | 1 cesarean deliveries only | 535                   | 1352                          | 6.6                          | −817 (−4.0)                  | 0.396 (0.363–0.431) | <.0001        |
| Nulliparous women             | 873                     | 4.3                    | 2827                          | 13.8                         | −1954 (−9.5)                | 0.309 (0.289–0.330) | <.0001        |
| Total                         | 20,488                  | 100.0                  | 20,488                        | 100.0                        | 0                           | 0                           |              |

CI, confidence interval; RR, relative risk.

* Denotes the number of procedures that would have been performed providing the same rate of surgery as in the Swedish National Quality Register of Gynecological Surgery but based on the distribution of the study groups in the general female population ≥45 years of age. The 95% confidence limits of the relative risk of surgery were calculated according to the method of Ulm. Larsudd-Kåverud. Mode of delivery and parity and the absolute risk of urogenital surgery. Am J Obstet Gynecol 2023.

### TABLE 4
The absolute risk of surgery according to mode of delivery and the number of births for vaginal delivery

| Parity of VD | Procedures | Reference | Absolute risk per 1000 women (95% CI) | Stepwise change in absolute risk of surgery | Absolute risk difference per 1000 women (95% CI) | p valuea |
|--------------|------------|-----------|-------------------------------------|---------------------------------------------|-------------------------------------------------|---------|
| POP surgery  |            |           |                                     |                                             |                                                 |         |
| 0            | 745        | 318,559   | 2.34 (2.17–2.51)                    |                                             |                                                 |         |
| 1            | 4479       | 323,467   | 13.85 (13.45–14.26)                 | 1 vs 0                                      | 11.51 (11.07–11.94)                             | <.0001  |
| 2            | 17,609     | 964,889   | 18.25 (17.98–18.52)                 | 2 vs 1                                      | 4.40 (3.92–4.89)                                | <.0001  |
| 3            | 11,146     | 408,010   | 27.32 (26.82–27.82)                 | 3 vs 2                                      | 9.07 (8.50–9.64)                                | <.0001  |
| ≥4           | 5483       | 141,517   | 38.74 (37.75–39.76)                 | ≥4 vs 3                                     | 11.43 (10.30–12.55)                             | <.0001  |
| 1 to ≥4      | 38,728     | 1,837,883 | 21.07 (20.9–21.3)                   | Trend 0 to ≥4                               |                                                 | <.0001  |
| SUI surgery  |            |           |                                     |                                             |                                                 |         |
| 0            | 873        | 318,559   | 2.74 (2.56–2.93)                    |                                             |                                                 |         |
| 1            | 2878       | 323,467   | 8.90 (8.58–9.23)                    | 1 vs 0                                      | 6.16 (5.79–6.53)                               | <.0001  |
| 2            | 9199       | 964,889   | 9.53 (9.34–9.73)                    | 2 vs 1                                      | 0.64 (0.26–1.01)                               | .0011   |
| 3            | 4946       | 408,010   | 12.12 (11.79–12.46)                 | 3 vs 2                                      | 2.59 (2.20–2.98)                               | <.0001  |
| ≥4           | 2053       | 141,517   | 14.5 (13.89–15.14)                  | ≥4 vs 3                                     | 2.38 (1.68–3.09)                               | <.0001  |
| 1 to ≥4      | 19,080     | 1,837,883 | 10.38 (10.2–10.5)                   | Trend 0 to ≥4                               |                                                 | <.0001  |

CD, cesarean delivery; CI, confidence interval; POP, pelvic organ prolapse; SUI, stress urinary incontinence; VD, vaginal delivery.

a For pairwise comparisons between parity groups the Fisher exact test was used. The trend 0 to ≥4 was analyzed with Mantel-Haenszel chi-square statistics. Larsudd-Kåverud. Mode of delivery and parity and the absolute risk of urogenital surgery. Am J Obstet Gynecol 2023.
nulliparous cohort allowed assessment of the combined effect of factors unrelated to childbirth in evaluating the long-term effect of pregnancy, separate from VD, and to measure the additive AR of term effect of pregnancy, separate from the additive AR of term effect of childbirth in evaluating the long-term effect of factors unrelated to childbirth. Some studies have shown a strong association between the number of vaginal births a woman underwent and the risk for surgery for UI or POP, largely consistent with the present study. Mant et al showed that, compared with a few nulliparous women, those with 1, 2, and ≥4 VDs were 4, 8, and 11 times more likely to undergo surgery for POP. A recent review stated that it remains controversial whether an elective CD is protective against surgery for PFDs when compared with the long-term effect of pregnancy.

When exploring the epidemiology of PFDs, accessing a sufficiently large group of nulliparas has been a substantial problem. In a cross-sectional survey from Norway, only 1 of 252 nulliparas was identified as having self-reported POP surgery among 1123 surgical procedures. In the register study on married women by Mant et al, 5 nulliparous women, had surgery for POP, and in the case-control study by Carley et al., 13 of 480 women with urogenital surgery and 27 of 150 controls were nulliparous. Such small numbers for the outcome variable in the study groups carry a high risk for selection bias and imprecise analyses. In this study, 1610 nulliparous women aged ≥45 years underwent surgery. The corresponding cohort at risk in the general population was 318,559. Our finding that nulliparous women, aged ≥45 years, underwent POP or SUI surgery marginally more often than women who exclusively delivered by CD may indicate the presence of additional health-related mechanisms for PFDs that may also influence fecundity in these women.

Five, large, register-based studies have demonstrated that vaginally delivered women were dominant among those with reconstructive urogenital surgery. This is what one would expect, because most women (80% of the total female population aged ≥45 years in this study) had at least 1 vaginal birth. By analyzing the RR for surgery, we demonstrated that the VD group had an excess risk beyond what was expected for this proportion of the total population. In contrast, a reduced risk for surgery, that is, fewer women than expected, was observed for nulliparous and cesarean delivered women.

Table 5: The absolute risk of surgery according to mode of delivery and the number of births for cesarean delivery

| Parity of CD | Procedures | Reference | Absolute risk per 1000 women (95% CI) | Stepwise change in absolute risk of surgery | Absolute risk difference per 1000 women (95% CI) | P valuea |
|-------------|------------|-----------|-------------------------------------|---------------------------------------------|-----------------------------------------------|---------|
| POP surgery | 1          | 93        | 64,396                              | 1.44 (1.17–1.77)                            | 1 vs 0                                        | −0.89 (−1.23 to −0.56) | <.0001  |
|             | 2          | 42        | 57,803                              | 0.73 (0.52−0.98)                            | 2 vs 1                                        | −0.72 (−1.08 to −0.35) | .0002   |
|             | 3          | 7         | 23,305                              | 0.30 (0.12−0.62)                            | 3 vs 2                                        | −0.43 (−0.74 to −0.11) | .0262   |
|             | ≥4         | 2         | 7819                                | 0.26 (0.03−0.92)                            | ≥4 vs 3                                       | −0.04 (−0.46 to 0.37) | 1.0000  |
| 1 to ≥4     | 144        | 153,323   |                                     |                                              | Trend 0 to ≥4                                 | <.0001  |
| SUI surgery | 0          | 873       | 318,559                             | 2.74 (2.56–2.93)                            |                                                |                     |
|             | 1          | 223       | 64,396                              | 3.46 (3.02–3.95)                            | 1 vs 0                                        | 0.72 (0.23–1.21)      | .0024   |
|             | 2          | 223       | 57,803                              | 3.86 (3.37–4.40)                            | 2 vs 1                                        | 0.40 (0.28 to 1.07)   | .2546   |
|             | 3          | 73        | 23,305                              | 3.13 (2.46–3.94)                            | 3 vs 2                                        | −0.73 (−1.60 to 0.15) | .1230   |
|             | ≥4         | 16        | 7819                                | 2.05 (1.17 to −3.32)                        | ≥4 vs 3                                       | −1.09 (−2.32 to 0.15) | .1414   |
| 1 to ≥4     | 535        | 153,323   | 3.49 (3.20–3.80)                    | Trend 0 to ≥4                                |                                                | <.0001  |

CD, cesarean delivery; CI, confidence interval; POP, pelvic organ prolapse; SUI, stress urinary incontinence; VD, vaginal delivery.

a For pairwise comparisons between parity groups the Fisher exact test was used. The trend 0 to ≥4 was analyzed with Mantel-Haenszel chi-square statistics.
term effects of VD.32 Our results regarding the long-term effects of one or more pregnancies unequivocally showed that ≥1 CD was protective when compared with ≥1 VD against the cumulative excess risk for POP and SUI surgery, which increased with the number of vaginal births. We could not find any substantial difference in the risk for prolapse and incontinence surgery between truly nulliparous women and those who had all their deliveries by acute or elective CDs.

A remaining unresolved issue remains the risk for surgery for POP and SUI according to the order of vaginal births. In this study, the first vaginal birth was associated with the lowest AR increase for both POP and SUI surgery, followed by a subsequent biphasic AR increase. This does not harmonize with the linear increase found in studies that did not use nulliparous women as reference for SUI,28 POP,29 and UI and POP surgeries.14 However, some previous population- and register-based studies presented prevalence data demonstrating a strong effect of the first birth on the prevalence of UI,33 SUI,34, and POP surgeries,35 as well as an overall biphasic pattern with increasing vaginal parity, all of which used nulliparous women as reference. Introducing nulliparous women as baseline references for these comparisons is pivotal and may explain why the results differ between studies.

Clinical implications
The long-term effect of 1 or more CDs on the risk for reconstructive urogenital surgery, representing the effect of 1 or more pregnancies, was similar to that among nulliparous women who are unaffected by childbirth. This is crucial information for healthcare economic calculations and women’s autonomous decision regarding their preferred mode of delivery.

Research implications
This study contributes valuable information to the Life Span Study approach to determining the epidemiology and healthcare economics of PFDs.36,37 The costs of a first CD at maternal request vs a first planned vaginal birth have been calculated to be $14,259 and $13,283, respectively, in the United States.38 Decades later, costs arise for reconstructive surgery of POP and SUI, which are almost exclusively attributable to VD. In the intervening time, there are additional costs for other birth-related PFDs, such as fecal incontinence, after sphincter injury and many years of suffering, expenses, inconvenience, and impairment of quality of life. In future research, this life span approach should be more widely applied, and the results must be communicated to all women antenatally and should guide clinical practice and policy.

Strengths and limitations
The strengths of this study include the large cohorts based on prospective data from national registers considered to be of high quality. It is a major strength to include a reference group of nulliparous women to specifically evaluate the long-term effect of pregnancy in the CD group. There was no risk of recall bias concerning obstetrical history because information on parity and mode of delivery was cross-checked with national registers. Furthermore, the Swedish public healthcare system is state-sponsored, and medical assessment and surgery are available to all citizens at an affordable cost, reducing the risk of bias owing to socio-economic factors.

It may be considered a limitation that some obstetrical information that may contribute to the risk for pelvic floor...
surgery, such as the length of the second stage of labor and information about postnatal pelvic floor exercises, were not available for the reference group. The rate of women only delivering by CD was estimated from the rate among women born in 1960 in the reference group. This might be considered a limitation because of the changes in mean parity and the increase in CD rates over time, leading to a higher rate of CDs in younger compared with older women in the population in 2017. Nulliparous women aged ≥45 years may truly represent women unaffected by childbirth, but they are most probably, at the same time and to some degree, a group with a negative health bias compared with parous women. For example, they were more often hysterectomized than parous women (28% compared with 20%). The health effect may have led to an overestimation of the AR for surgery for POP and UI in the nulliparous cohort in this study.

Conclusion
We found no evidence, based on the results of this study, that pregnancy alone or the additive effect of multiple pregnancies increased the risk for surgery for POP or UI over and above the risk observed in nulliparous women. Giving birth exclusively by CD seemed to maintain the nulliparous state of the pelvic floor support in the long term. Therefore, healthcare resources used for urogenital surgery could be attributed to the negative consequences of VD. However, this is only one part of women’s total reproductive burden.

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Supplemental Appendix
This appendix has been provided by the authors to give readers additional information about their work.

Supplement to: J.L.K., J.G., S.A., M.M., I.M., A.W., M.G. The influence of pregnancy, parity, and mode of delivery for urinary incontinence and prolapse surgery—a national register study.

SUPPLEMENTAL FIGURE
Causal components for genital prolapse and stress urinary incontinence surgery

Larsudd-Kårnud. Mode of delivery and parity and the absolute risk of urogenital surgery. Am J Obstet Gynecol 2023.
# SUPPLEMENTAL TABLE

The rate of women with additional cesarean births according to vaginal parity

| Vaginal parity | POP surgery | SUI surgery |
|----------------|-------------|-------------|
|                | n = 38,728  | n = 19,080  |
| All women in each VD parity group | Women with additional CD | All women in each VD parity group | Women with additional CD |
| n | n | % | n | n | % |
| 1 | 4479 | 690 | 15.4 | 2878 | 818 | 28.4 |
| 2 | 17,609 | 606 | 3.4 | 9199 | 517 | 5.6 |
| 3 | 11,146 | 291 | 2.6 | 4946 | 180 | 3.6 |
| ≥4 | 5483 | 175 | 3.2 | 2053 | 63 | 3.1 |

CD, cesarean delivery; POP, pelvic organ prolapse; SUI, stress urinary incontinence; VD, vaginal delivery.

Regardless of the number of CDs. The number and location of previous, subsequent, or intermediate cesarean births may vary considerably. The number of vaginal births is fixed in each parity group, but the location may differ (e.g., ≥1 CD followed by 1 VD with ≥1 subsequent CD = VD parity 1 with additional CD). There were 11 women with missing information about vaginal parity in the POP surgery group and 4 in the SUI surgery group.

Larsudd-Kåverud. Mode of delivery and parity and the absolute risk of urogenital surgery. Am J Obstet Gynecol 2023.