

# Natural History of Urinary Incontinence from First Childbirth to 30 Months Postpartum

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## Research Article

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# Abstract

**Purpose** The objectives of this study were to determine the incidence of UI in a large cohort of primiparous women before and during pregnancy and over the course of 30 months postpartum, and to identify risk factors for UI during and after pregnancy.

**Methods** Nulliparous women aged 18 to 35 years with singleton pregnancies were interviewed in their third trimester and asked about urinary incontinence before and during pregnancy (n = 3001). After delivery these women were interviewed at 1, 6, 12, 18, 24 and 30 months postpartum and asked about urinary incontinence occurring in the month prior to each interview. Multivariable logistic regression models identified risk factors for UI during pregnancy and during the follow-up period.

**Results** Overall, 4% reported having urinary incontinence before pregnancy and 36.8% during pregnancy. The strongest predictor of urinary incontinence during pregnancy was urinary incontinence before pregnancy (adjusted OR 13.11, 95% CI 7.43-23.13). Among the women with no subsequent pregnancies, the rate of urinary incontinence increased from 12.5% at 6 months postpartum to 27.4% at 30 months postpartum, 52.1% reported UI at one or more postpartum data collection stages, and the strongest predictors of postpartum UI were UI before pregnancy (adjusted OR 3.95 (95% CI 1.60-9.75) and during pregnancy (adjusted OR 4.36, 95% CI 3.24-5.87).

**Conclusion** Our findings suggest that primiparous women who report UI before and during pregnancy should be monitored for the continuation or worsening of UI over the course of the first 2-3 years postpartum, and treatment options discussed.

## Introduction

Urinary incontinence (UI) is defined as the symptom, sign, urodynamic finding, or diagnosis of involuntary urinary leakage [1]. In addition to tremendous economic costs, UI is a source of substantial physical and psychosocial morbidity resulting in substantial detriment to quality of life [2, 3]. Pregnancy, particularly the first delivery, not only has the largest effect on the urinary continence mechanism but is also associated with the highest incidence and risk of new-onset, long-lasting UI [4–8]. Epidemiological studies on UI during pregnancy provide numerous potential factors related to the development of UI postpartum [9–11]. While certain risk factors like age, race, fetal size/weight and medical morbidities may not be modifiable, others such as obesity, smoking, gestational weight gain, and route of delivery are indeed modifiable. By enhancing our knowledge regarding causative factors for UI, physicians can educate/advise patients to avoid modifiable risk factors prior to and during pregnancy and provide targeted intervention when necessary. Most studies addressing pregnancy related UI have limited follow up [9, 12, 13]; therefore, the objective of the present study was primarily to investigate UI in a large cohort of nulliparous women both in incidence and over the course of 30 months postpartum, and secondarily to identify maternal and obstetrical characteristics associated with gestational as well as persistent postpartum UI.

## Methods

The First Baby Study (FBS) was designed and statistically powered to investigate the association between mode of delivery at first childbirth and subsequent childbearing. Information about the study power calculations, sample representativeness, and flow diagram of participants have been reported elsewhere [14, 15]. The study participants were more likely to be white, college educated, married and to have private insurance than women in the state of Pennsylvania as a whole at first childbirth, but did not differ by mode of delivery [14, 15]. A planned secondary analysis of the FBS was to study the progression of urinary incontinence over the course of the study period. Nulliparous women residing in Pennsylvania aged 18 to 35 with singleton pregnancies were recruited through a variety of venues throughout the state in 2009 to 2011, including childbirth education classes, hospital tours, ultrasound centers, private obstetrician offices, low-income clinics, hospital intranet postings, newspaper and radio ads, and targeted mailings. Inclusion criteria were age 18 to 35, nulliparous, with a singleton pregnancy, no previous pregnancies of 20 weeks gestation or longer, English or Spanish speaking and planning to deliver at a hospital in Pennsylvania. Exclusion criteria included planning to have a tubal ligation during the delivery hospitalization, planning to deliver at home or in a birthing center not associated with a hospital, planning to have the child adopted and delivering before 34 weeks gestation. There were 3,080 women who were interviewed during pregnancy, among whom 6 had stillbirths and 68 dropped out of the study after the baseline interview, leaving 3,006 women who completed both the baseline and 1-month postpartum interviews. These participants delivered at 78 hospitals.

Study participants were interviewed by telephone by trained professional interviewers employed by the Penn State Center for Survey Research.

Birth certificate and hospital discharge data were obtained for each delivery as well.

This study was approved by the Penn State College of Medicine Institutional Review Board (IRB), as well as the IRB's of all hospitals and organizations involved with participant recruitment.

All participants provided signed informed consent.

This study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [16].

The baseline interview was conducted during pregnancy, at 30 weeks gestation or later, at a mean gestational age of 35.2 weeks (SD = 1.6). Questions about urinary incontinence were adapted from the Childbirth and Pelvic Symptoms Study[9], and can be seen in Appendix 1. In the baseline interview women were asked "During your pregnancy, how often have you experienced any amount of accidental urine loss?" The response options were "2 or more times a day", "Once a day", "2 or more times a week", "Once a week", "1-3 times a month", and "Never". They were also asked "Before you became pregnant, how often did you experience any amount of accidental urine loss?" with the same response options ("2 or more times a day" to "Never"). In the 1-month postpartum interview women were asked this question in reference to "Since your delivery" and at the 6-, 12-, 18-, 24- and 30-month postpartum interviews women

were asked this question in reference to “In the past month”. Among the 3,006 women who completed both the baseline and 1-month postpartum interviews, five answered “don’t know” in response to the questions asked about urinary incontinence before and during pregnancy and one woman answered “don’t know” in response to the urinary incontinence question asked in the 1-month postpartum interview. Information about maternal age, race, education, height, pre-pregnancy weight, gestational weight gain, smoking, mode of delivery and history of seasonal allergies and urinary tract infections were obtained from the interviews. Maternal age, race/ethnicity, education, height, pre-pregnancy weight, gestational weight gain and mode of delivery were verified in relation to the birth certificate and hospital discharge data.

Participants were asked about urinary incontinence 6 times after first childbirth: at 1, 6, 12, 18, 24 and 30 months postpartum. Over the course of the follow-up period from 6 to 30 months postpartum some participants were lost to follow-up, some skipped one or more interviews and small numbers answered “don’t know” in response to the questions about urinary incontinence. There were 2,911 women who participated in the 6-month interview and answered the question about urinary incontinence, 2,804 at the 12-month interview, 2,691 at the 18-month interview, 2,641 at the 24-month interview and 2,470 at the 30-month interview. There were a total of 2,473 women who participated in the 30-month interview (3 of whom answered “don’t know” in response to the urinary incontinence question), for a retention rate of 82.3% by 30 months postpartum. There were 2,301 women who participated in all 6 of the postpartum interviews and had no missing data on urinary incontinence, among whom 1,002 women had no pregnancies in this time period. At each of the postpartum data collection stages the participants were asked if they were currently pregnant and the outcomes of all pregnancies that had occurred since the previous interview. Based on these answers, women were classified as being pregnant or not at each of the postpartum interviews, and as having one or more pregnancies during the first 30 months after first childbirth.

## **Statistical analyses**

Statistical analyses were performed using IBM SPSS Statistics, Version 26. Pre-pregnancy body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and women were classified as underweight ( $< 18.5 \text{ kg/m}^2$ ), normal weight ( $18.5\text{--}24.9 \text{ kg/m}^2$ ), overweight ( $25.0\text{--}29.9 \text{ kg/m}^2$ ) and obese ( $\geq 30 \text{ kg/m}^2$ ). Women who were underweight and normal weight were combined due to small numbers of women who were underweight pre-pregnancy. Women were classified as gaining less than recommended during pregnancy, as recommended, or more than recommended based on the 2009 Institute of Medicine guidelines [17]. Women were stratified into two groups - those who reported experiencing urinary incontinence during the pregnancy and those who reported that they never did. The associations between urinary incontinence during pregnancy and maternal characteristics were measured using the  $\chi^2$  test for categorical variables. Multivariable logistic regression was used to calculate adjusted odds ratios (adjusted ORs) and 95% confidence intervals (CIs) to describe the associations between the maternal characteristics and the experience of urinary incontinence during pregnancy, controlling for the maternal characteristics that were significantly associated with urinary

incontinence in the  $\chi^2$  analyses. Race and gestational weight gain were dichotomized for the regression analyses because the subgroups were not significantly different from each other. For each of the 6 postpartum data collection stages women were stratified into two groups – those who reported experiencing urinary incontinence in the month prior to the interview and those who reported that they never did. The percent of the study participants who reported experiencing urinary incontinence at each of the postpartum interviews was calculated in several different ways. We calculated the percent of women reporting urinary incontinence at each interview among: 1.) all of the women who participated in that interview and answered the question about urinary incontinence, 2.) all of the women who participated in that interview, answered the question about urinary incontinence and were pregnant at that time, 3.) all of the women who participated in that interview, answered the question about urinary incontinence and were not pregnant at that time, 4.) all of the women who had no missing data on urinary incontinence, that is, they participated in all 6 of the postpartum interviews and answered the questions about urinary incontinence at all 6 of the postpartum interviews, and 5.) all of the women who had no missing data on urinary incontinence and no pregnancies, that is, they participated in all 6 of the postpartum interviews, answered the questions about urinary incontinence at all 6 of the postpartum interviews and were not pregnant at any time during the first 30 months after first childbirth. We counted the number of times women reported experiencing urinary incontinence across the 6 postpartum interviews among the women in groups 4 and 5 as described above. Finally, women in group 5 were stratified into two groups – those who reported experiencing urinary incontinence at any of the postpartum interviews and those who reported never experiencing urinary incontinence at any of the 6 postpartum interviews.

The associations between urinary incontinence after first childbirth pregnancy and maternal characteristics were measured using the  $\chi^2$  test for categorical variables. Multivariable logistic regression was used to calculate adjusted ORs and 95% CIs to describe the associations between the maternal characteristics and the outcome of experiencing urinary incontinence in the first 30 months after first childbirth among-women who had no subsequent pregnancies during this time, controlling for the maternal characteristics that were significantly associated with the outcome of experiencing urinary incontinence in the first 30 months after first childbirth in the  $\chi^2$  analyses. For this regression model we dichotomized race, gestational weight gain and mode of delivery because the subgroups were not significantly different from each other. We included both urinary incontinence before pregnancy and during pregnancy in this regression model because these variables were not so highly associated with each other as to be considered collinear (Spearman Rho = .230).

## Results

The participants in the First Baby Study were largely white (83.3%) and college educated (56.6%), as shown in Table 1. Of the 3,001 women who answered the questions about urinary incontinence in the baseline interview, 119 (4%) reported experiencing urinary incontinence before pregnancy and 1,104 (36.8%) reported experiencing urinary incontinence during their first-childbirth pregnancy. Urinary incontinence during pregnancy increased with increasing age, education, pre-pregnancy BMI, and

gestational weight gain, and was more common among the white non-Hispanic women (38.5%) than Black non-Hispanic women (25.5%), Hispanic women (32.5%) and women of other races (27.6%). Women who reported histories of seasonal allergies and UTIs were more likely to experience urinary incontinence during pregnancy as well. In the multivariable logistic regression model (Table 2) urinary incontinence before pregnancy was the factor most strongly associated with urinary incontinence during pregnancy (adjusted OR 13.11, 95% CI 7.43–23.13). Other factors that were significantly associated with urinary incontinence during pregnancy in the regression model were older maternal age, white race, obesity, gaining more than recommended in the pregnancy, history of seasonal allergies and history of UTI's (Table 2).

Table 1  
Maternal Characteristics and Urinary Incontinence during Pregnancy

Characteristic	Total (n = 3001)	Urinary Incontinence during Pregnancy		P value
		Yes	No	
Urinary incontinence before pregnancy				< 0.001
Yes	119 (4.0)	105 (88.2)	14 (11.8)	
No	2877 (96.0)	996 (34.6)	1881 (65.4)	
Age (y)				< 0.001
18–24	811 (27.0)	245 (30.2)	566 (69.8)	
25–29	1190 (39.7)	434 (36.5)	756 (63.6)	
30–35	1000 (33.3)	575 (57.5)	575 (57.5)	
Race and ethnicity				< 0.001
White non-Hispanic	2498 (83.3)	961 (38.5)	1537 (61.6)	
Black non-Hispanic	220 (7.3)	56 (25.5)	164 (74.5)	
Hispanic	166 (5.5)	54 (32.5)	112 (67.9)	
Other	116 (3.9)	32 (27.6)	84 (72.4)	
Education				< 0.001
High school degree or less	500 (16.7)	147 (29.4)	353 (70.9)	
Some college or technical	803 (26.8)	281 (35.0)	522 (65.0)	
College graduate or higher	1698 (56.6)	676 (39.8)	1022 (60.2)	
Pre-Pregnancy BMI (kg/m <sup>2</sup> )				0.003

BMI, body mass index; UTI, urinary tract infection; Data are n (%); P value ( $\chi^2$  test)

<sup>a</sup>Based on IOM guidelines [17]

	<b>Total (n = 3001)</b>	<b>Urinary Incontinence during Pregnancy</b>		<b><i>P</i> value</b>
Normal/underweight ( $< 25.0$ )	1715 (57.2)	588 (34.3)	1127 (65.8)	
Overweight (25.0-29.9)	666 (22.2)	261 (39.2)	405 (60.9)	
Obese (30.0 or higher)	618 (20.6)	255 (41.3)	363 (58.8)	
Gestational weight gain <sup>a</sup>				0.004
Less than recommended	334 (11.2)	108 (32.3)	226 (67.7)	
As recommended	1041 (34.8)	355 (34.1)	686 (66.0)	
More than recommended	1617 (54.0)	638 (39.5)	979 (60.6)	
Smoker during pregnancy				0.621
Yes	314 (10.5)	111 (35.4)	203 (64.9)	
No	2687 (89.5)	993 (37.0)	1694 (63.1)	
History of seasonal allergies				$< 0.001$
Yes	1089 (36.3)	452 (41.5)	637 (58.5)	
No	1908 (63.7)	651 (34.1)	1257 (65.9)	
History of UTIs				$< 0.001$
Yes	1238 (41.3)	514 (41.5)	724 (58.5)	
No	1762 (58.7)	590 (33.5)	1172 (66.6)	
BMI, body mass index; UTI, urinary tract infection; Data are n (%); <i>P</i> value ( $\chi^2$ test)				
<sup>a</sup> Based on IOM guidelines [17]				

Table 2

Adjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) for Urinary Incontinence During Pregnancy

<b>Risk factor</b>	<b>OR<sup>a</sup> (95% CI)</b>	<b>P value</b>
Urinary incontinence before pregnancy	13.11 (7.43–23.13)	< 0.001
Maternal age (y)		
18–24		
25–29	1.05 (0.82–1.33)	0.706
30–35	1.32 (1.02–1.71)	0.034
White race	1.34 (1.06–1.69)	0.016
Education		
High school degree or less	Reference	
Some college or technical	1.13 (0.87–1.47)	0.368
College graduate or higher	1.30 (0.98–1.74)	0.068
Pre-Pregnancy BMI category (kg/m <sup>2</sup> )		
Normal and underweight (< 25.0)	Reference	
Overweight (25.0-29.9)	1.15 (0.94–1.40)	0.186
Obese (30.0 or higher)	1.26 (1.03–1.54)	0.028
Gestational weight-gain more than recommended <sup>b</sup>	1.19 (1.01–1.40)	0.041
Smoker during pregnancy	1.14 (0.87–1.50)	0.356
History of seasonal allergies	1.24 (1.06–1.46)	0.009
History of UTIs	1.31 (1.12–1.53)	0.001
<sup>a</sup> OR adjusted for all variables shown in table; <sup>b</sup> Based on IOM guidelines [17]; BMI, body mass index; UTI, urinary tract infection.		

The percent of women who experienced urinary incontinence in the month prior to a postpartum interview increased over time after first childbirth (Table 3). The lowest percent of women reporting urinary incontinence was at 6 months postpartum and it was higher at each subsequent data collection stage. While the women who were pregnant at any data collection stage were more likely to report experiencing urinary incontinence, the incidence of urinary incontinence more than doubled even among the women who had no pregnancies in the 30 months after first childbirth, from 12.5% at 6 months postpartum to 27.4% at 30 months postpartum. Among the 2,301 women who had no missing data on urinary

incontinence across the 6 data collection stages, 46.5% reported never experiencing urinary incontinence at all 6 of the postpartum data collection stages, 53.5% reported experiencing urinary incontinence at one or more of the 6 data collection stages, and 3.0% reported experiencing persistent urinary incontinence at all 6 of the data-collection stages (Table 4). Among the 1,002 women who had no missing data on urinary incontinence and no pregnancies during the 30-month follow-up period, we see similar results: 52.1% reported never experiencing urinary incontinence across all 6 of the postpartum interviews, 47.9% reported experiencing urinary incontinence at one or more of the postpartum interviews, and 2.1% reported experiencing urinary incontinence at all 6 of the postpartum interviews.

Table 3

Percent of Women Who Reported Experiencing Urinary Incontinence in the Baseline Interview and in the 6 Interviews after First Childbirth

	<b>Overall</b>	<b>Women Who Were Pregnant at Interview</b>	<b>Women Who Were Not Pregnant at Interview</b>	<b>Women Who Had No Missing Data on Urinary Incontinence (Pregnant and Nonpregnant)</b>	<b>Women Who Had No Missing Data on Urinary Incontinence and No Pregnancies</b>
Baseline					
Before pregnancy	119/3001 (4.0)				
During pregnancy	1104/3001 (36.8)				
After first childbirth					
1 month	526/3005 (17.5)	NA	NA	442/2301 (19.2)	184/1002 (18.4)
6 months	394/2911 (13.5)	10/46 (21.7)	384/2865 (13.4)	325/2301 (14.1)	125/1002 (12.5)
12 months	523/2804 (18.7)	68/237 (28.7)	455/2567 (17.7)	434/2301 (18.9)	182/1002 (18.2)
18 months	617/2691 (22.9)	190/530 (35.8)	427/2161 (19.8)	555/2301 (24.1)	211/1002 (21.1)
24 months	731/2641 (27.7)	225/521 (43.2)	506/2120 (23.9)	658/2301 (28.6)	246/1002 (24.6)
30 months	746/2470 (30.2)	184/442 (41.6)	1466/2028 (27.7)	697/2301 (30.3)	275/1002 (27.4)
Data are numerator/denominator (%)					

Table 4

Count of Number of Times Women Reported Urinary Incontinence across 6 Postpartum Interviews from 1 Month to 30 Months Postpartum

<b>Number of times urinary incontinence was reported across postpartum interviews</b>	<b>Women who had no missing data on urinary incontinence from 1 to 30 months postpartum (n = 2301)</b>	<b>Women who had no missing data on urinary incontinence from 1 to 30 months postpartum and no pregnancies (n = 1002)</b>
None	1070 (46.5)	522 (52.1)
1	463 (20.1)	187 (18.7)
2	241 (10.5)	73 (7.3)
3	197 (8.5)	82 (8.2)
4	143 (6.2)	67 (6.7)
5	119 (5.2)	50 (5.0)
6	68 (3.0)	21 (2.1)
Data are n (%).		

As seen in Fig. 1, women who reported urinary incontinence before pregnancy and during pregnancy were highly likely (89.6%) to report urinary incontinence at least once across the 6 postpartum interviews, and the mean (SD) number of times reported was 3.7 (1.7). Even among the women who reported no UI before or during pregnancy, a third (33.1%) reported experiencing UI at least once across the 6 postpartum interviews, and the mean (SD) number of times reported among these women was 2.1 (1.3). The overall one-way ANOVA comparing the mean number of times that UI was reported across the four groups shown in the far-right column of Fig. 1 was significant at  $p < .001$ ,  $F = 17.22$ .

Factors that were associated with the experience of urinary incontinence after first childbirth in the  $\chi^2$  analyses (Table 5) were older maternal age, pre-pregnancy BMI, gestational weight gain, history of urinary tract infections and mode of delivery. In the multivariable logistic regression model (Table 6) the two factors most strongly associated with experiencing urinary incontinence in the postpartum period were the experience of urinary incontinence before pregnancy (adjusted OR 3.95, 95% CI 1.60–9.75) and during pregnancy (adjusted OR 4.36, 95% CI 3.24–5.87). Women who delivered their first child vaginally were more likely to experience urinary incontinence in the first 30 months after first childbirth than those who delivered by cesarean (adjusted OR 2.07, 95% CI 1.53–2.81).

Table 5

Participant Characteristics in Relation to Urinary Incontinence Reported at any Time Postpartum among Women who Had No Missing Data on Urinary Incontinence from 1 to 30 Months Postpartum and No Pregnancies (n = 1002)

	Urinary incontinence reported postpartum n (%)		P value
	Yes	No	
	480 (47.9)	522 (52.1)	
Urinary incontinence before pregnancy			< 0.001
Yes	47 (88.7)	6 (11.3)	
No	431 (45.6)	515 (54.4)	
Urinary incontinence during pregnancy			< 0.001
Yes	268 (72.2)	103 (27.8)	
No	211 (33.5)	418 (66.5)	
Maternal age (years)			< 0.001
18–24	97 (40.6)	142 (59.4)	
25–29	176 (44.8)	217 (55.2)	
30–35	207 (55.9)	163 (44.1)	
Race/ethnicity			0.167
White non-Hispanic	421 (49.2)	435 (50.8)	
Black non-Hispanic	24 (40.0)	36 (60.0)	
Hispanic	17 (35.4)	31 (64.6)	
Other	18 (47.4)	20 (52.6)	
Education			0.361
High school degree or less	66 (46.5)	76 (53.5)	
Some college or technical	140 (45.0)	171 (55.0)	
College graduate or higher	274 (49.9)	275 (50.1)	
Pre-Pregnancy BMI (kg/m <sup>2</sup> )			0.025
Normal and underweight (< 25.0)	229 (43.9)	293 (56.1)	

P value ( $\chi^2$  test); BMI, body mass index; UTI, urinary tract infection

<sup>a</sup>Based on IOM guidelines [17]

	Urinary incontinence reported postpartum n (%)		
Overweight (25.0-29.9)	118 (51.8)	110 (48.2)	
Obese (30.0+)	133 (53.0)	118 (47.0)	
Gestational weight-gain <sup>a</sup>			0.001
Less than recommended	44 (40.4)	65 (59.6)	
As recommended	134 (41.2)	191 (58.8)	
More than recommended	302 (53.4)	264 (46.6)	
Smoker during pregnancy			0.832
Yes	45 (46.9)	51 (53.1)	
No	435 (48.0)	471 (52.0)	
History of seasonal allergies			0.088
Yes	199 (51.3)	189 (48.7)	
No	281 (45.8)	333 (54.2)	
History of UTIs			0.008
Yes	223 (52.8)	199 (47.2)	
No	257 (44.4)	322 (55.6)	
Mode of delivery			0.006
Spontaneous vaginal	305 (52.1)	280 (47.9)	
Instrumental vaginal	36 (47.4)	40 (52.6)	
Planned cesarean	33 (46.5)	38 (53.5)	
Unplanned cesarean	106 (39.3)	164 (60.7)	
<i>P</i> value ( $\chi^2$ test); BMI, body mass index; UTI, urinary tract infection			
<sup>a</sup> Based on IOM guidelines [17]			

Table 6

Adjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) for Risk of Postpartum Urinary Incontinence among Women who Had No Missing Data on Urinary Incontinence from 1 to 30 Months Postpartum and No Pregnancies (n = 1002)

Risk factor	OR <sup>a</sup> (95% CI)	P value
Urinary incontinence before pregnancy	3.95 (1.60–9.75)	0.003
Urinary incontinence during pregnancy	4.36 (3.24–5.87)	< 0.001
Maternal age (years)		
18–24	1.0 (Reference)	
25–29	1.20 (0.83–1.73)	0.342
30–35	1.92 (1.31–2.81)	0.001
White race	0.89 (0.59–1.34)	0.567
Pre-Pregnancy BMI (kg/m <sup>2</sup> )		
Normal and underweight (< 25.0)	1.0 (Reference)	
Overweight (25.0-29.9)	1.14 (0.79–1.65)	0.475
Obese (30.0+)	1.49 (1.05–2.13)	0.026
Gestational weight-gain more than recommended <sup>b</sup>	1.57 (1.16–2.11)	0.003
Vaginal delivery	2.07 (1.52–2.81)	< 0.001
History of seasonal allergies	1.10 (0.83–1.47)	0.510
History of UTIs	1.30 (0.98–1.72)	0.073
<sup>a</sup> OR adjusted for all variables shown in table; <sup>b</sup> Based on IOM guidelines [17]; BMI, body mass index; UTI, urinary tract infection		

## Discussion

This study's strength lies in its prospective longitudinal design along with its extended follow-up time with queries assessing UI at seven distinct time-points amongst first time mothers. Findings from our study build on observations from previous work yet offer a more complete description of the cumulative incidence of UI prior to pregnancy, during pregnancy and over the course of 30-months postpartum, as well as factors associated with the persistence of postpartum UI.

Perhaps the present study's most compelling finding may be that the rate of UI increased over time after the first childbirth. While previous studies [18, 19] have assessed the prevalence of UI after a set period

postpartum, we measured the incidence of UI across several time points – and thus – examined the natural history of UI after first childbirth. In one of the few other large prospective longitudinal studies designed to describe the long-term pattern of UI following first delivery, authors described a similar increasing incidence of UI [11]. One possible hypothesis for this progression is the increasing weight of the first child over the course of time. The average weight of a newborn is 7.5 pounds, but by 30 months-old the average child weighs nearly 30 pounds. Lifting and carrying a 30-pound child many times a day likely increases the strain on women’s pelvic floor musculature.

According to previous studies, the prevalence of UI is maximal at the end of pregnancy and diminishes during the early postpartum period [20]. This dynamic short-term postpartum remission of UI may be attributed to partial healing [21], compensation that might restore continence despite persistence of the injuries, or resolution of hormonal and metabolic changes associated with pregnancy [20, 22]. Long-term, postpartum UI relapse – and thus the increasing cumulative incidence of UI over time – could potentially be explained by factors such as tissue aging, weakening pelvic floor muscle force, and aggravation in cases of multiple exposures to pregnancy [20]. Although slightly more than half of the women reported experiencing UI at least once across the six postpartum data collection stages, only 2–3% reported experiencing UI at all six of the postpartum data collection stages. These results indicate that among women in their childbearing years, UI is more likely to be episodic rather than chronic.

Analogous to prior work by others, the present study reports a significantly higher risk of both gestational UI and long-term, postpartum UI amongst women reporting prior incontinence and for women of advanced maternal age [12, 23–28]. This finding is postulated to be due to inherently reduced collagen, weakened connective tissue, loss of nerve function, and decrease in the total number of striated muscle fibers of the urethral sphincter which occurs with aging [29, 30]. These women are therefore intrinsically more susceptible to UI during pregnancy as well as persistent postpartum UI [31, 32]. Women who develop gestational UI may undergo similar biological changes, and in our study had the strongest associated risk of long-term, postpartum UI. Notably, we found that women who become pregnant 6 to 30 months postpartum were also at a heightened risk of developing UI. UI is often also a symptom of urinary tract infection (UTI) [33], and prior investigations – including the present – have noted previous UTI to be associated with UI in both pregnant [34, 35] and postmenopausal women [36]. While the mechanism behind this association between UI and UTI is largely unknown, one hypothesis suggests UTI to be a cause of UI as a result of inflammation and irritability of smooth muscle of the bladder wall [37, 38] along with the involuntary stimulation of detrusor muscle contractions. [34] Interestingly, the present study also found history of seasonal allergies to be highly associated with UI during pregnancy. This finding may be related to the increased coughing or sneezing brought on by seasonal allergies, which in turn could strain pelvic floor support. While not modifiable risk factors, presence of previous incontinence, advanced age, gestational incontinence, short pregnancy intervals (within 6 to 30 months postpartum), previous UTI, and history of seasonal allergies can allow physicians to target a specific subset of women with early behavioral interventions, such as timed voiding, avoidance of bladder irritants [39], and pelvic floor muscle training [40, 41] to prevent development or lessen the impact of UI during and after pregnancy.

While several studies have investigated obesity and high prenatal BMI as major risk factors for UI during pregnancy [12, 23–25, 42], only a few – including the present study – have documented an association between obesity and the development of long term, postpartum UI [43]. Unlike obesity, the association of excessive gestational weight gain with UI is a topic of debate. While some studies [13, 44] – including the present – have demonstrated excessive weight gain during pregnancy to be a risk factor for gestational UI, others [45, 46] were unable to find any such association. This association of UI with obesity and more than recommended gestational weight gain is plausibly caused by the added tension on the pelvic floor due to increased intra-abdominal pressure [47] along with impairment of blood flow and nerve innervation to the bladder/urethra [47, 48]. Postpartum weight loss may reduce intra-abdominal pressure, possibly explaining why excessive gestational weight gain is not consistently found to be associated with postpartum UI, as in the present study. Since pre-pregnancy BMI and gestational weight gain are modifiable risk factors, interventions involving diet and weight control/loss [49] may be targeted to prevent gestational and long-term UI in these populations.

Though vaginal delivery is generally considered to be the optimal mode of delivery, numerous studies – including the present – have noted its association with development of long-term, postpartum UI [11, 50–54]. Consistently in these studies, women with both spontaneous and operative vaginal deliveries are more prone to developing UI later in life possibly due to perineal trauma and denervation encountered during childbirth [55]. Therefore, intervention with previously specified techniques may be beneficial to offer to women following vaginal delivery to prevent postpartum UI development.

The present study does have limitations that must be addressed. Most notably, we did not solicit details to suggest the type of UI, nor the bother of the patients' symptoms. Additionally, all of the information was collected through self-report rather than confirmatory testing or exam. The population of women recruited for this study were predominantly white, college-educated, insured women, which may not confer generalizability to other populations. Finally, UI in females is a condition with various factors contributing to its development, advancement, and regression. The dynamic nature of UI presents as a limitation to understanding the true development of problematic UI in this population.

In conclusion, we have investigated both the incidence and natural history of UI during pregnancy and over the course of time to 30 months postpartum. We have also confirmed several modifiable (pre-pregnancy BMI, more than recommended gestational weight gain, and route of delivery) and nonmodifiable (presence of previous incontinence, advanced age, gestational incontinence, short pregnancy intervals, previous UTI, and history of seasonal allergies) risk factors associated with UI both during and following first pregnancy. The impact of several characteristics, such as genetic predisposition, were not evaluated and may warrant further investigations. Awareness of all the aforementioned risk factors may allow for preventative strategies including individualized counseling, lifestyle modification, and targeted treatment to reduce the risk of persistent UI. Further studies addressing the success of such interventions are an avenue of future research.

## Abbreviations

Urinary incontinence (UI)

First Baby Study (FBS)

Urinary tract infection (UTI)

Odds ratio (OR)

Confidence interval (CI)

## Declarations

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**Conflicts of interest** The authors declare that they have no conflicts of interest

**Availability of data and material** The First Baby Study datasets are available from the principal investigator, Kristen Kjerulff, [khk2@psu.edu](mailto:khk2@psu.edu).

**Code availability:** Not applicable

**Author's contributions** KP: Manuscript writing. JL: Manuscript writing, editing. SB: Manuscript editing. KK: protocol/project development, data collection, data analysis, manuscript writing

**Ethics approval** This study received all required approvals from the Penn State College of Medicine Institutional Review Board (IRB), as well as the IRB's of all hospitals and organizations involved with participant recruitment

**Consent to participate** Written and signed informed consent was obtained from all individual participants included in this study

**Consent for publication:** Not applicable

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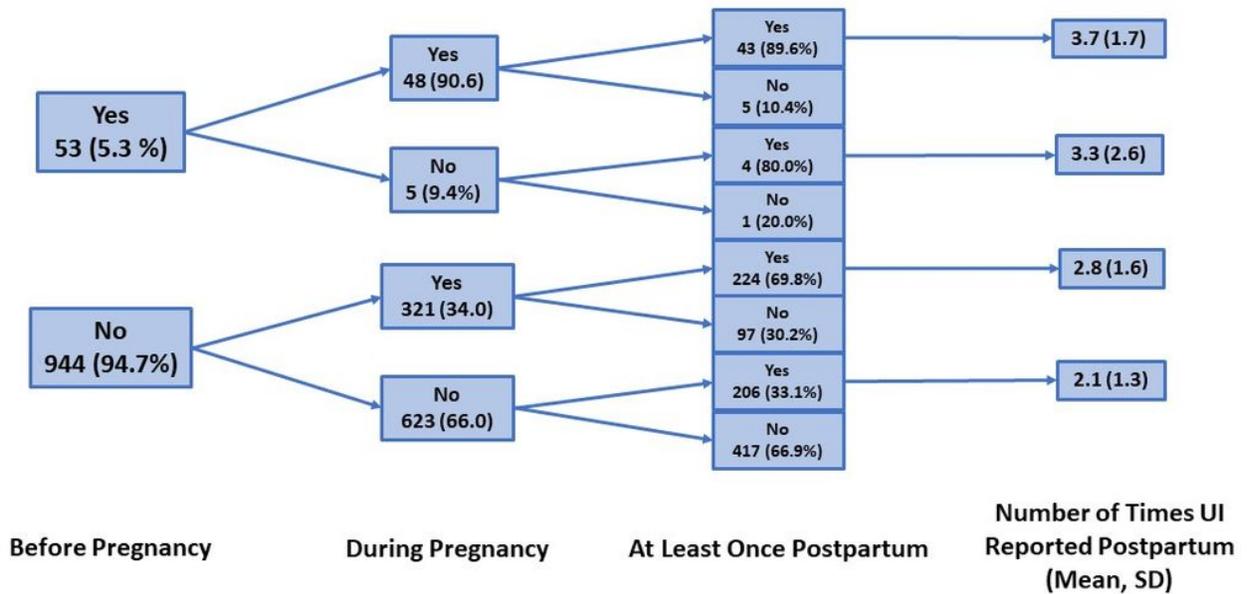
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## Figures



**Figure 1**

Urinary incontinence before pregnancy, during third trimester, and at least once across 6 postpartum data collection stages, 1-30 months postpartum (n = 997)

## Supplementary Files

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- [Appendix1.pdf](#)