Remission and Transition of Female Urinary Incontinence and Its Subtypes and the Impact of Body Mass Index on This Progression: A Nationwide Population-Based 4-Year Longitudinal Study in China

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Study Need and Importance: Knowledge of natural changes in urinary incontinence (UI) subtypes, ie stress UI (SUI), urgency UI (UUI) and mixed UI (MUI), is critical to the prevention and development of different clinical management and treatment strategies along the disease continuum. We aimed to estimate the remission and transition rates between UI subtypes in women with UI, and to evaluate the impact of body mass index (BMI) on this process.

What We Found: Analyses included 5,189 women, of whom 98.5% were parous. The median followup time was 4.0 years. Overall, the annual remission rate of UI was 12.7% among adult women. Regarding UI subtypes, the remission rates for UUI and SUI were similar, but higher than that for MUI. In total, 7.6% of SUI patients and 16.4% of UUI patients developed MUI, and 35.3% of MUI patients continued to report MUI after 4 years. For women aged ≥60 years with a BMI ≥24 kg/m² and MUI at onset, the predicted remission rate (95% CI) was only 0.32 (0.29–0.35), but the predicted probability of the MUI remaining reached 0.50 (0.46–0.54).

Limitations: The treatment and efficacy of UI were not fully investigated. Since risk factors for UI were not available at followup, we were unable to analysis the impact of changes in risk factors on UI and how its subtypes evolve over time. Finally, the frequency and volume of urine leakage and its impact on quality of life have not been measured, which makes it impossible to know the severity of UI and its impact on women.

Interpretation for Patient Care: UI is a highly dynamic condition, with periods of incidence and remission or transition from one subtype to another over time. This study indicated that high BMI impacts the prognosis of UI. As obesity is a modifiable risk factor, UI patients with a high BMI could be identified early, and targeting weight loss programs may help to prevent the transition to MUI.
Remission and Transition of Female Urinary Incontinence and Its Subtypes and the Impact of Body Mass Index on This Progression: A Nationwide Population-Based 4-Year Longitudinal Study in China

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Purpose: We estimated the remission and transition rate between urinary incontinence (UI) subtypes in women with UI and evaluated the impact of body mass index (BMI) on this process.

Materials and Methods: A Chinese population-based longitudinal study was conducted. Women aged ≥20 years were included using a multistage, stratified, cluster sampling method. Self-reported data on demographics, medical history, and physiological and anthropometric information were collected. UI was identified using 2 questions about any leaking symptom of stress UI (SUI) and urgency UI (UUI) in the past 6 months. Predicted probabilities of UI subtypes were calculated using multinomial logistic regression.

Results: Analyses included 5,189 women (mean age 52.6 years, mean BMI 23.8 kg/m²), of whom 98.5% were parous. The median followup time was 4.0 years. Overall, the annual remission rate of UI was 12.7% among adult women. Regarding UI subtypes, the remission rates for UUI and SUI were similar, but higher than that for mixed urinary incontinence (MUI; p <0.05). In total, 7.6% of SUI patients and 16.4% of UUI patients developed MUI, and 35.3% of MUI patients continued to report MUI after 4 years. For women aged ≥60 years with a BMI ≥24 kg/m² and

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Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.
Abbreviations and Acronyms

BMI = body mass index
MUI = mixed urinary incontinence
SUI = stress urinary incontinence
UI = urinary incontinence
UUI = urgency urinary incontinence
MUI at onset, the predicted remission rate (95% CI) was only 0.32 (0.29–0.35), but the predicted probability of the MUI remaining reached 0.50 (0.46–0.54).

**Conclusions:** The annual remission rate of UI was 12.7% among adult women. Women with a higher BMI had less remission and a higher predicted probability of MUI 4 years later.

**Key Words:** urinary incontinence; urinary incontinence, stress; urinary incontinence, urge

Urinary incontinence (UI) is a common condition, and has a significant impact on quality of life and results in high societal costs.\(^1\)–\(^5\) The International Continence Society defines UI as the complaint of any involuntary leakage of urine.\(^6\) UI is a dynamic phenomenon with periods of incidence and remission.\(^7\) The annual incidence of UI reportedly ranges from 1% to 11%, and the remission rate of UI ranges from 5% to 11%.\(^7\)–\(^12\) However, few large-scale studies quantifying the rates of progression and remission in Asia are available. Knowledge of natural changes in UI subtypes, ie stress UI (SUI), urgency UI (UUI) and mixed UI (MUI), is critical to the prevention and development of different clinical management and treatment strategies along the disease continuum.

Several prospective studies have identified positive associations between a higher body mass index (BMI) and the risk of de novo UI.\(^13\)–\(^15\) Studies have also shown that adiposity and weight gain increase the risk of developing UI.\(^16\) However, whether BMI is associated with the transition between UI subtypes is unknown. More recently, evidence from the Nurses Health Studies has shown that obese women are less likely to have mixed urinary incontinence (MUI) remission.\(^17\) However, whether this conclusion applies to Asian women needs to be determined.

Therefore, we aimed to estimate the remission and transition rates among UI subtypes in women with UI at baseline and to evaluate the impact of BMI on this process by means of a large-scale population-based 4-year longitudinal study in China.

**METHOD**

**Study Design and Participants**

This is a population-based prospective study. A baseline survey with a multistage stratified cluster sampling design was conducted between May 2014 and January 2016. Details of the sampling technique, recruitment and data collection have been described previously.\(^18\) Briefly, 6 provinces of China (Jiangsu in the east, Guangdong in the southeast, Shanxi in central China, Gansu in the northwest, Guizhou in the southwest and LiaoNing in the northeast), which represent 6 major geographic regions of great socioeconomic and cultural diversity, were randomly selected as study regions. Three counties and 3 cities, which were stratified by levels of economic development and urbanization, were randomly selected from each province. The inclusion criteria were women aged ≥20 years who had lived in the registered regions for at least 5 years. Individuals with severe mental or physical illness and pregnant females were excluded. A total of 55,477 women participated in the baseline survey.

From June to December 2018, we conducted a followup survey. A total of 55,190 women who had complete baseline data were contacted by telephone, and 30,658 (55.5%) of them completed the followup. We compared the baseline sociodemographic characteristics between responders and nonresponders (see supplementary Table, https://www.jurology.com). The group of nonrespondents was older and had a higher proportion of urban participants than the responder group. The mean BMI was similar in responders and nonresponders (22.6 vs 22.7 kg/m\(^2\)). After exclusion of 24,985 participants who were continent at baseline and 484 participants who had missing data, a total of 5,189 women who had UI detected at baseline and completed followup were eligible for final analysis in this study (Fig. 1).

Ethical approval for the research protocol was obtained from the Institutional Review Board of Peking Union Medical College Hospital (IRB No. S-689). Approval in the form of written informed consent was obtained from all participants.

**Assessment of UI Symptoms**

The participants were asked the following questions: 1) “During the last 6 months, did you leak urine when you were performing some physical activity, such as coughing, sneezing, lifting, or exercising?” (yes or no), and 2) “During the last 6 months, did you leak urine when you had the urge or the feeling that you needed to empty your bladder, but you could not get to the toilet fast enough?” (yes or no). UI is defined by the International Continence Society as the complaint of any involuntary leakage of urine.\(^5\) Women who answered “yes” to question 1 were categorized as having SUI (ie involuntary leakage on effort, exertion, sneezing or coughing). Women who answered “yes” to question 2 were categorized as having UUI (ie involuntary urine leakage accompanied by, or immediately preceded by, urgency). Women who answered “yes” to both questions were categorized as having MUI. Women with any SUI, UUI or MUI were categorized as having UI. Women who answered “no” to both questions during followup were considered in remission.

**Assessment of Other Information**

An interviewer-administered questionnaire was also used to collect baseline information on sociodemographic characteristics, physiological data, reproductive health, personal medical history, lifestyle behaviors and anthropometric data. Sociodemographic characteristics included birth year, race, marital status and educational level. Anthropometric data included weight and height. Information on reproductive health included childbearing history and delivery pattern. Medical history included doctor-diagnosed chronic diseases and gynecologic diseases. Lifestyle behaviors...
Included smoking and alcohol drinking. Surgical treatment of UI was assessed at followup.

**Statistical Analysis**

The remission rates were standardized by age and region using the population composition of those aged ≥20 years from the 2010 Chinese census population. To evaluate changes in UI subtype over time, we calculated predicted probabilities and 95% confidence intervals using the multinomial logistic regression model. The dependent variable of the model was UI symptoms at followup: SUI, UUI, MUI and no UI. The independent variables were measured at baseline: UI subtypes, age, BMI (underweight: <18.5 kg/m²; normal weight: 18.5–23.9 kg/m²; overweight: 24.0–27.9 kg/m²; obese: ≥28.0 kg/m²) and parity. Although the models accounted for all of the variables mentioned, for ease of presentation in the results, we chose to focus on contrasts in age (ie age <60 years vs ≥60 years) as well as in BMI (ie BMI <24 kg/m² vs BMI ≥24 kg/m²) among UI subtypes, as they are commonly measured factors in clinical practice. Statistical significance for each variable in the model was analyzed by means of the Wald test.

All p values are 2-sided, with the significance level set at 0.05 for statistical tests. Data processing and statistical analyses were performed using SAS® version 9.4 (SAS, Cary, North Carolina).

**RESULTS**

Among the 5,189 participants included in the analysis, the median (25th percentile, 75th percentile) followup time was 4.0 years (3.4, 4.2). The characteristics of participants at baseline are as follows: the mean±SD age was 52.6±13.8 years, and the mean BMI was 23.8±3.2 kg/m². Overall, 2,461 (47.4%) participants were from urban areas. A total
of 5,098 (98.2%) women had a history of childbirth. The sociodemographic characteristics of participants at baseline are shown in Table 1.

Overall, the crude remission rate (95% CI) of UI was 50.8% (49.4–52.2) among women aged ≥20 years (Table 2), corresponding to a mean annual remission rate of 12.7%. The age-specific remission rate of UI first increased and then decreased with age (the trend was the same in urban and rural areas), and this rate in the 40–49 age group reached a peak of 60.9% (58.3–63.5). After adjustments for age, the standardized remission rates of UI were 51.7% for all women, and 52.1% and 51.6% for urban and rural women, respectively. The remission rate of women <60 years old was higher than that of women ≥60 years old (p < 0.05).

The transition of UI subtypes over 4 years is shown in Figure 2. In total, 34.9% reported the same UI subtype as that at baseline at the 4-year followup. Among women with SUI at onset, 90% continued to have SUI and 7.6% developed MUI 4 years later. Of those women who had UUI at onset, 16.0% continued to have UUI and 16.4% developed MUI 4 years later. Among women with MUI at onset, 35.3% continued to report MUI 4 years later. The remission rates for UUI and SUI were similar (53.1% and 52.9%, respectively) but higher than that for MUI (46.4%, p < 0.05).

The natural progression of female UI subtypes among women with different BMIs is shown in Figure 3. We found that women with a higher BMI at baseline had a lower remission rate of UI 4 years later. For example, among women with SUI at onset, the highest remission rate was observed for underweight women (62.9%), followed by women with a normal BMI (56.2%), while the remission rate for overweight and obese women was relatively low (48.1% and 48.4%, respectively). A similar pattern was observed for women with UI at baseline. It is worth noting that among obese women with MUI at baseline, more than half (55.6%) reported MUI 4 years later, and only 28.1% recovered.

We next modeled different patient profiles based on age and BMI to predict patterns of UI symptom progression. Table 3 shows the predicted probabilities of UI modeled with parity ≥1. We found that women with a BMI ≥24 kg/m² had a lower remission rate 4 years later than women with a BMI <24 kg/m², regardless of age and onset of UI subtype. Among women with any UI subtype at onset, women with a BMI ≥24 kg/m² had a higher predicted probability of MUI 4 years later than women with a BMI <24 kg/m². Moreover, the prediction probability showed that women who were older and had a higher BMI had less remission from UI. For example, among women aged ≥60 years with a BMI ≥24 kg/m² and MUI at onset, the predicted remission rate (95% CI) was only 0.32 (0.29–0.35) but the predicted probability of continuing to have MUI reached 0.50 (0.46–0.54).

**DISCUSSION**

In this nationwide longitudinal survey, we found a mean annual remission rate of 12.7%. Among UI subtypes, the remission rates for UUI and SUI were similar, but higher than that for MUI. Women with a higher BMI at baseline had less remission and a higher predicted probability of MUI 4 years later.

UI is a highly dynamic condition, with periods of incidence and remission or transition from one subtype to another over time. The annual remission rate of UI we found in China is slightly higher than that reported in previous studies, which ranges from 5% to 11% in Western countries. The reason for the difference may be as follows. First, this study is a general population-based epidemiology study with a mean patient age of 52.6 years and a proportion of young women (aged ≤40 years) of nearly 20%. Our
study shows that the remission rate of young women is higher than that of middle-aged and older women. However, most of the previous studies were based on middle-aged or older women.7,8,10 Second, the definition of UI (any leakage in past 6 months) used in this study may result in some women with UI having milder UI, which is more likely to remit.

SUI is the most prevalent type of UI among young and middle-aged women, but data on the transition from SUI to other UI subtypes are sparse in the literature. Accordingly, over an 8-year period, the data from the GAZEL cohort of women at midlife showed that the remission rates of SUI were 37.9%, that 47.2% of women with SUI were invariant, that

Table 2. The crude remission rates of female UI over 4 years by region and age

| Pt Age (yrs) | No. UI at Baseline | No. Remission at Followup | Remission Rate (%) (95% CI) | Standardized Remission Rate (%)* |
|--------------|---------------------|---------------------------|-----------------------------|----------------------------------|
| All pts:     | 5,189               | 2,636                     | 50.8 (49.4–52.2)            | 51.7                             |
| 20—29        | 163                 | 83                        | 50.9 (43.3–58.6)            |                                  |
| 30—39        | 790                 | 404                       | 51.1 (47.7–54.6)            |                                  |
| 40—49        | 1,386               | 844                       | 60.9 (58.3–63.5)            |                                  |
| 50—59        | 1,199               | 630                       | 52.5 (50.0–55.4)            |                                  |
| 60—69        | 859                 | 384                       | 44.7 (41.4–48.0)            |                                  |
| ≥70          | 792                 | 291                       | 36.7 (33.4–40.1)            |                                  |
| Urban pts:   | 2,461               | 1,201                     | 48.8 (46.6–50.8)            | 52.1                             |
| 20—29        | 88                  | 46                        | 52.3 (41.8–62.7)            |                                  |
| 30—39        | 379                 | 216                       | 57.0 (52.0–62.0)            |                                  |
| 40—49        | 602                 | 347                       | 57.6 (53.7–62.6)            |                                  |
| 50—59        | 508                 | 250                       | 49.2 (44.9–53.6)            |                                  |
| 60—69        | 401                 | 178                       | 44.4 (39.5–49.3)            |                                  |
| ≥70          | 483                 | 164                       | 34.0 (29.7–38.2)            |                                  |
| Rural pts:   | 2,728               | 1,435                     | 52.6 (50.7–54.5)            | 51.6                             |
| 20—29        | 75                  | 37                        | 49.3 (38.0–60.7)            |                                  |
| 30—39        | 411                 | 188                       | 45.7 (40.9–50.6)            |                                  |
| 40—49        | 784                 | 497                       | 63.4 (60.0–66.8)            |                                  |
| 50—59        | 691                 | 380                       | 55.0 (51.3–58.7)            |                                  |
| 60—69        | 458                 | 206                       | 49.0 (40.4–49.5)            |                                  |
| ≥70          | 309                 | 127                       | 41.1 (35.6–46.8)            |                                  |

* The remission rate was standardized by age and region based on the 2010 Chinese census.

Figure 2. The remission and development of UI subtypes over 4 years.
3.2% of women with SUI converted to UUI and that 10.8% women with SUI converted to MUI. Our results show that the transition mode was consistent with that of the GAZEL cohort, but the remission rate of SUI was approximately 15% higher, which may be due to the difference in the age distribution of participants and length of follow-up.

MUI is associated with more severe symptoms; however, the potential reasons are poorly understood. The current analysis indicated a possible way that UI may develop from the transition of stress or urgency to MUI. MUI is the most persistent subtype and least likely to transition compared with SUI and UUI, which is consistent with a previous study. This may be due to variation by severity, pathophysiology or other mechanisms making MUI least likely to resolve. Based on these findings, it may be important in future research to explore these differing trajectories to the development of MUI and further develop strategies to prevent or slow this transition process.

This study indicated that high BMI impacts the prognosis of UI. We found that women with higher BMI at baseline had less remission of UI 4 years later. Moreover, women who were older and had a higher BMI had a higher predicted probability of remaining with or progressing to MUI, which was consistent with the Nurses’ Health Studies. As obesity is a modifiable risk factor, UI patients with a high BMI could be identified early, and targeting weight loss programs may help to prevent the transition to MUI.

Our findings have important clinical and public health and socioeconomic implications because of the growing obesity epidemic worldwide. They also add to a range of adverse health effects that have already been identified as being associated with excess weight. Together with previous evidence from randomized trials showing that weight loss may decrease the prevalence or number of episodes of UI, the current findings provide further evidence that a higher BMI may be an important target for clinical intervention in patients with UI in the future.

One of the strengths of this study is its being the first report of the remission and transition rates of
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