

Incidence and risk factors of female urinary incontinence: a 4-year longitudinal study among 24 985 adult women in China

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Accepted 25 June 2021. Published Online 17 October 2021.

Objective To estimate the incidence of urinary incontinence (UI), including its subtypes stress UI (SUI), urgency UI (UUI) and mixed UI (MUI), and to examine risk factors for de novo SUI and UUI in Chinese women.

Design Nationwide longitudinal study.

Setting Six geographic regions of China.

Participants Women aged ≥ 20 years old were included using a multistage, stratified, cluster sampling method.

Methods This study was conducted between May 2014 and March 2016, with follow up in 2018. Data on demographics, medical history, lifestyle and physiological and anthropometric information were collected.

Main outcome measurements Incidence, rate ratio (RR).

Results Analyses included 24 985 women (mean age 41.9 years). The follow-up response rate was 55.5%, median follow-up time was 3.7 years. The standardised incidences of UI, SUI, UUI and MUI were 21.2, 13.1, 3.0 and 5.1 per 1000 person-years, respectively. Risk factors for de novo SUI included delivery pattern (vaginal spontaneous delivery RR 2.12, 95% CI 1.62–2.78

and instrumental delivery RR 3.30, 95% CI 1.99–5.45), high body mass index (BMI) (overweight RR 1.52, 95% CI 1.33–1.74 and obesity RR 1.67, 95% CI 1.32–2.11), cigarette smoking (RR 1.54, 95% CI 1.12–2.12), chronic cough (RR 1.44, 95% CI 1.17–1.76), diabetes (RR 1.33, 95% CI 1.10–1.60) and older age (50–59 years RR 1.49, 95% CI 1.16–1.90 and 60–69 years RR 1.61, 95% CI 1.22–2.13). The risk factors significantly associated with de novo UUI were age (RR increased from 1.21, 95% CI 0.74–1.99, at 30–39 years to 6.3, 95% CI 3.85–10.30, at >70 years) and diabetes (RR 1.48, 95% CI 1.05–2.09).

Conclusions The incidence of female UI is 21.2 per 1000 person-years in China. Delivery (vaginal spontaneous delivery, instrumental delivery), high BMI, cigarette smoking, chronic cough, diabetes and older age were risk factors.

Keywords Female urinary incontinence, incidence rate, mixed urinary incontinence, risk factors, stress urinary incontinence, urgency urinary incontinence.

Tweetable abstract The incidence of female urinary incontinence was 21.2 per 1000 person-years in China. Delivery, BMI, diabetes and old age are risk factors.

Please cite this paper as: Pang H, Lv J, Xu T, Li Z, Gong J, Liu Q, Wang Y, Wang J, Xia Z, Li Z, Li L, Zhu L. Incidence and risk factors of female urinary incontinence: a 4-year longitudinal study among 24 985 adult women in China. BJOG 2022;129:580–589.

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Introduction

Urinary incontinence (UI) is defined as the complaint of any involuntary leakage of urine, according to the International Continence Society.¹ It is common in adult women, not life-threatening but seriously affecting quality of life.² The financial burden of UI is substantial, with estimated annual direct costs in the USA of \$19.5 billion in 2000.³ The cost of UI is expected to increase dramatically as the population continues to age.

Several epidemiological studies of female UI have been conducted in Western countries, with an estimated annual incidence varying from 1 to 11%,^{4–9} and prevalence varying from 5 to 69%.^{10–12} This variability is related to differences in the definitions of UI used, the populations studied and different measuring instruments.^{13,14} However, reliable estimation is required to plan effective clinical prevention and control. As China has a rapidly aging population, female UI is becoming an important public health concern. The available epidemiological evidence comes from cross-sectional studies that were conducted across six regions of China among women ≥ 20 years of age in 2006.^{15–17} The findings showed that the prevalence of UI and its subtypes, including stress urinary incontinence (SUI), urgency urinary incontinence (UUI) and mixed urinary incontinence (MUI), were 30.9, 18.9, 2.6 and 9.4%, respectively. However, the incidence rate of female UI is still unclear in China. Furthermore, a few longitudinal studies in Western women showed that the risk factors were different between UI subtypes, with educational level, body mass index (BMI), race and depression for SUI, and alcohol consumption and surgery for UUI.^{5,18} However, it remains unclear whether such associations hold among Chinese women.

We aimed to estimate the incidence rate of female UI and its subtypes, including SUI, UUI and MUI, in a large-scale population-based longitudinal study in China. We further examined potential risk factors for de novo SUI and UUI.

Methods

Study design and participants

This study was 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, baseline recruitment and data collection have been described previously.¹⁹ In brief, six provinces of China, which represent six major geographic regions of great socio-economic and cultural diversity, were randomly selected as study regions. These provinces were Gansu in the northwest, Guizhou in the southwest, Shanxi in central China, Liaoning in the northeast, Jiangsu in the east and Guangdong in the southeast. Three counties and three

cities, which were stratified by levels of economic development and urbanisation, were randomly selected from each province. The target population was all eligible adult female residents according to the updated census lists from the community registry offices. The inclusion criteria were women ≥ 20 years old in the general population who had lived in the registered regions for at least 5 years before the study. Individuals with severe mental or physical illness and pregnant females were excluded. A total of 55 477 women aged ≥ 20 years participated in the baseline survey (central China: 9104, the northwest: 9723, the east: 9078, the southwest: 8774, the southeast: 9803, and the northeast: 8995).

From June to December in 2018, we contacted 55 190 women who had complete baseline data for a telephone follow up, and 30 658 (55.5%) participants completed the follow-up survey. We compared the baseline sociodemographic characteristics between responders and non-responders (Table S1). Non-responders were older and comprised a higher proportion of urban population compared with responders. After excluding 5675 participants who had UI detected at baseline or had missing data, a total of 24 985 women were eligible for final analysis. The study flowchart is shown in Figure 1.

Ethical approval for the research protocol was obtained from the Institutional Review Board of Peking Union Medical College Hospital. Approval in the form of written informed consent was obtained from all participants.

Assessment of UI

Trained interviewers used the same self-developed questionnaire in the baseline and follow-up surveys. 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 exercise?' (no or yes); 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?' (no or yes).

The International Continence Society defines UI as the complaint of any involuntary leakage of urine.¹ Women who answered yes for question (1) were categorised as having SUI (i.e. involuntary leakage on effort, exertion, sneezing or coughing). Women who answered yes for question (2) were categorised as having UUI (i.e. involuntary urine leakage accompanied by, or immediately preceded by, urgency). Women who answered yes for both questions were categorised as having MUI. Women with any of SUI, UUI or MUI were categorised as having UI.

Assessment of other variables

An interviewer-administered questionnaire was also used to collect information on sociodemographic characteristics,

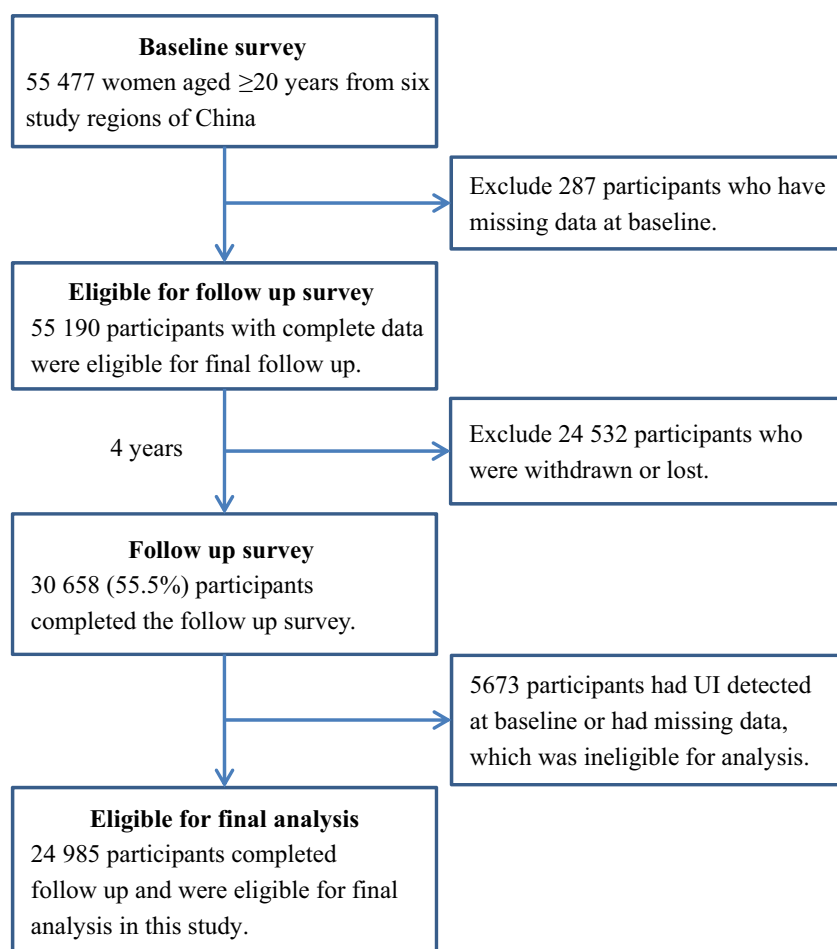


Figure 1. Study flowchart.

physiological data, reproductive health, personal medical history, lifestyle behaviours and anthropometric data. Sociodemographic characteristics included birth year, ethnicity, marital status and education level. Information on reproductive health included menstruation, postmenopausal hormone replacement therapy and childbearing history. Medical history included doctor-diagnosed chronic diseases (diabetes and cancers) and gynaecological diseases (pelvic inflammatory disease, pelvic pain, endometriosis, fibroids, gynaecological malignant tumours, pelvic organ prolapse). Lifestyle behaviours included smoking and alcohol drinking.¹⁹ Anthropometric data included weight and height.

Statistical analysis

Normally distributed continuous data are expressed as mean \pm SD and non-normally distributed continuous data are expressed as the median (25th centile, 75th centile). A test for normality was performed by the Shapiro–Wilk test. Categorical variables are presented as the number and

proportion. Incidence rates per 1000 person-years were obtained by dividing the total number of incident cases over the follow-up period by the total observed person-years and multiplying by 1000. The incidence rates were standardised by age and region using the population composition of those aged ≥ 20 years from the 2010 Chinese census population. We conducted tests for the linear trend of incidence rate across categories of age group.

The multivariable Poisson regression model was used to assess the relationship between de novo SUI/UII and potential risk factors of baseline and to estimate the rate ratio (RR) and 95% CI. We first performed univariate analysis to select statistically significant risk factors. We then combined these risk factors with clinical considerations for the multivariable model. Statistical significance for each variable in the model was analysed by the Wald test. All *P* values are two-sided, with the significance level set at 0.1 for univariate analysis and 0.05 for other statistical tests. Data processing and statistical analyses were performed using SAS Version 9.3 (SAS, Cary, NC, USA).

Results

Among the 24 985 participants included in the analysis, the age distribution ranged from 20 to 96 years, and the median (25th centile, 75th centile) follow up was 3.7 (3.1, 4.1) years. The mean (\pm SD) age was 41.9 ± 15.0 years and mean BMI was 22.5 ± 3.0 kg/m². Overall, 12 994 (52.0%) participants were from urban areas. With regard to the delivery pattern, there were 15 736 (63.4%) vaginal spontaneous deliveries, 4331 (17.4%) caesarean sections, and 212 (0.9%) instrument-assisted deliveries. Sociodemographic characteristics, physiological and pathological conditions, and health behaviour of study participants at baseline and follow up are shown in Table 1.

Overall, the crude incidence rate of UI was 19.6 (95% CI 18.7–20.5) per 1000 person-years among women aged ≥ 20 years (Table 2). The age-specific incidence rate of UI rose significantly with age ($P_{\text{trend}} < 0.0001$ for urban and rural areas) from 10.2 per 1000 person-years in the 20–30 years group to 43.0 per 1000 person-years in the >70 years group. The crude incidence rate was significantly higher in rural than in urban areas (21.0, 95% CI 19.6–22.3 versus 18.2, 95% CI 16.9–19.4 per 1000 person-years, $P < 0.0001$). The standardised incidence rate of UI was 21.2 per 1000 person-years for all women, and 19.5 and 23.0 per 1000 person-years for urban and rural women, respectively.

For subtypes of UI, the crude incidence rates of female SUI, UII and MUI were 12.4 (95% CI 11.7–13.2), 2.7 (95% CI 2.4–3.0) and 4.4 (95% CI 4.0–4.9) per 1000 person-years, respectively. The trend of the incidence rates of SUI, UII and MUI with age is shown in Figure S1. For SUI, the crude incidence initially increased and then decreased with age, and peaked at 60–69 years (Table 3). The crude incidence of UII and MUI monotonically increased with age, especially in the age group of >70 years, which was much higher than other age groups ($P < 0.0001$). This pattern was found in urban ($P < 0.0001$) and rural areas ($P < 0.0001$) (Table 3). With regard to different delivery patterns, the incidence rates of SUI in women who were nulliparous, and in those who had vaginal spontaneous delivery, instrumental delivery and caesarean section were 5.9, 15.1, 27.7 and 8.9 per 1000 person-years, respectively. The incidence rates of UI, SUI and UII increased with BMI ($P_{\text{trend}} < 0.05$) (Figure 2). The standardised incidence rates of SUI, UII and MUI were 13.1, 3.0 and 5.1 per 1000 person-years, respectively.

Univariate and multivariable analyses of the risk factors of developing SUI are shown in Table 4. In multivariable analysis, middle and older age, higher BMI, race, higher education, vaginal spontaneous delivery, instrumental delivery, chronic cough, diabetes and cigarette smoking were identified as risk factors for de novo SUI ($P < 0.05$). Our

Table 1. Sociodemographic characteristics, physiological and pathological conditions, and health behaviour of the study participants at baseline and follow up

Characteristic	Baseline <i>n</i> = 24 985	Follow up <i>n</i> = 24 985
Age (years), mean \pm SD	41.9 \pm 15.0	45.4 \pm 14.9
20–29	6521 (26.1)	3869 (15.5)
30–39	6517 (26.1)	6795 (27.2)
40–49	5244 (21.0)	5945 (23.8)
50–59	3010 (12.1)	3890 (15.6)
60–69	1998 (8.0)	2410 (9.7)
≥ 70	1695 (6.8)	2076 (8.3)
Race		
Han	24 436 (97.9)	24 436 (97.9)
Minority	521 (2.1)	521 (2.1)
Education		
Primary school and below	5454 (21.8)	5605 (22.4)
Junior middle school	6540 (26.2)	5988 (24.0)
Senior school	5663 (22.7)	5734 (23.0)
College or above	7318 (29.3)	7648 (30.6)
Marital status		
Couple	21 614 (86.9)	22 352 (90.2)
Single	2382 (9.6)	1390 (5.6)
Divorce/Widowed	874 (3.5)	1041 (4.2)
Cigarette smoking	441 (1.8)	272 (1.09)
Alcohol consumption	151 (0.6)	263 (1.06)
BMI (kg/m ²), mean \pm SD	22.5 \pm 3.0	22.6 \pm 3.0
Underweight (<18.5)	1747 (7.0)	1429 (5.8)
Normal (18.5–23.9)	16 523 (66.1)	16 538 (66.5)
Overweight (24–27.9)	5537 (22.2)	5707 (23.0)
Obese (≥ 28)	1175 (4.7)	1192 (4.8)
Parity		
Nulliparous	4560 (18.3)	2334 (9.3)
Primiparous (1)	11 312 (45.5)	11 536 (46.2)
Multiparous (2)	5959 (24.0)	7595 (30.4)
Multiparous (≥ 3)	3034 (12.2)	3513 (14.1)
Delivery pattern		
Nulliparous	4560 (18.4)	2334 (9.4)
Vaginal spontaneous delivery	15 736 (63.4)	17 254 (69.5)
Instrumental deliverer	212 (0.9)	215 (0.9)
Caesarean section	4331 (17.4)	5032 (20.3)
Gynaecological disease*	5975 (24.0)	3238 (13.04)
Premenopausal	15 688 (71.8)	14 174 (64.9)
Cough (>3 weeks)	1385 (5.6)	994 (4.0)
Diabetes	2159 (8.7)	2505 (10.1)
Pelvic surgery	7606 (30.5)	9973 (40.0)
Spinal surgery	79 (0.3)	116 (0.5)

Data are shown as mean \pm SD or *n* (%).

*Gynaecological diseases included myoma, pelvic inflammatory disease, chronic pelvic pain and endometriosis.

study showed a higher risk of SUI in middle-aged and older-aged women (RR 1.49, 95% CI 1.16–1.90 for 50–59 years, RR 1.61, 95% CI 1.22–2.13 for 60–69 years) compared with young women (20–29 years). Women who were

Table 2. Incidence rate of female UI over 4 years by region and age*

	Person-years	Cases	IR (95% CI)	Standardised IR (%)**,*
All	89 790	1757	19.6 (18.7–20.5)	21.2
20–29	22 596	230	10.2 (8.9–11.5)	
30–39	23 821	333	14.0 (12.5–15.5)	
40–49	19 908	410	20.6 (18.6–22.6)	
50–59	11 094	308	27.8 (24.7–30.9)	
60–69	6805	237	34.8 (30.3–39.3)	
≥70	5564	239	43.0 (37.5–48.4)	
Urban	45 147	820	18.2 (16.9–19.4)	19.5
20–29	12 003	104	8.7 (7.0–10.3)	
30–39	12 657	161	12.7 (10.8–14.7)	
40–49	9583	189	19.7 (16.9–22.5)	
50–59	4923	151	30.7 (25.8–35.6)	
60–69	3409	116	34.0 (27.8–40.2)	
≥70	2573	99	38.5 (30.9–46.1)	
Rural	44 643	937	21.0 (19.6–22.3)	23.0
20–29	10 593	126	11.9 (9.8–14.0)	
30–39	11 164	172	15.4 (13.1–17.7)	
40–49	10 326	221	21.4 (18.6–24.2)	
50–59	6171	157	25.4 (21.5–29.4)	
60–69	3397	121	35.6 (29.3–42.0)	
≥70	2991	140	46.8 (39.1–54.6)	

*Incidence rate (IR) per 1000 person-years.

**Standardised incidence rate: the incidence rates were standardised by age and region based on the 2010 Chinese census.

overweight (RR 1.52, 95% CI 1.33–1.74) and with obesity (RR 1.67, 95% CI 1.32–2.11) were more likely to have SUI than women with a normal BMI. With regard to delivery pattern, women with vaginal spontaneous delivery (RR 2.12, 95% CI 1.62–2.78) and instrumental delivery (RR 3.30, 95% CI 1.99–5.45) were more likely to have SUI than nulliparous women.

Univariate and multivariable analyses of the risk factors of developing UUI are shown in Table 5. The risk factors that were positively associated with de novo UUI were older age and diabetes. The RR of UUI increased with age, from 1.96 (95% CI 1.24–3.12) in the 40–49 years group to 6.30 (95% CI 3.85–10.30) in the >70 years group compared with the 20–29 years group.

Discussion

Main findings

The current nationwide longitudinal survey included 24 985 women. We found that standardised incidence rates of UI, SUI, UUI and MUI were 21.2, 13.1, 3.0 and 5.1 per 1000 person-years, respectively, among adult women in China. Delivery (vaginal spontaneous delivery, instrumental

delivery), high BMI, cigarette smoking, chronic cough, diabetes, middle and older age, and living in rural areas increase the risk of SUI. Older age and diabetes increase the risk of UUI.

Strengths and limitations

The strengths of this study are that it included a large population of women, which enabled us to accurately estimate the incidence of UI in each subgroup. Furthermore, for the first time, the incidence rate of female UI and its subtypes has been reported in the general population in China, especially for young women. Finally, several controllable risk factors were identified for de novo SUI and UUI.

Our study has several limitations. First, because 44.5% participants did not respond in the follow-up survey, selection bias due to loss to follow up was inevitable. However, the distributions of baseline characteristics between the responders and the non-responders were similar. Although the differences were significant in this large sample, the absolute differences were small, so we believe that loss to follow up did not have a great impact on the estimation of incidence rate. Second, all information was obtained through self-reporting of responders. Therefore, information bias might have affected the accuracy of the data. Third, UI is a dynamic process and not necessarily progressive, and some people may have recovered before follow up. Therefore, the incidence of UI may have been underestimated. Finally, the frequency and volume of urine leakage and its impact on quality of life were not measured, which makes it impossible to know the severity of UI and the bother it causes to women. A certain proportion of women with symptoms of urine leakage may never require treatment. Further evidence on the severity of UI in women of different ages is needed in future studies.

Interpretation

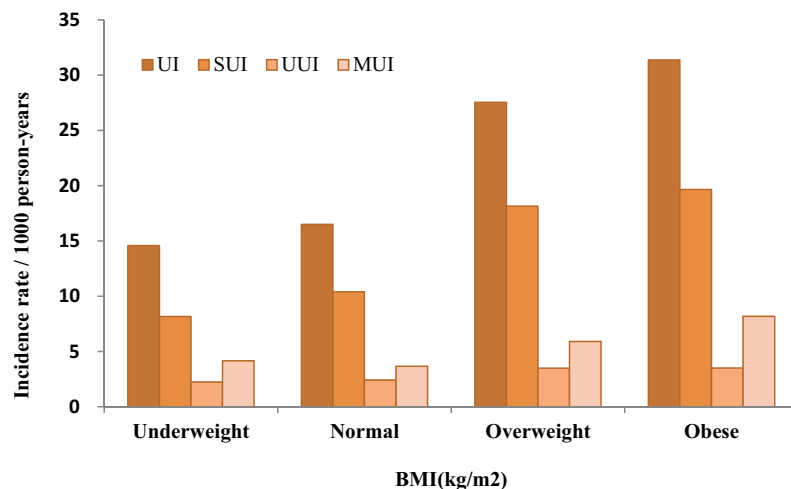
This study showed that the standardised incidence of UI was 21.2 per 1000 person-years, which approaches the lower range of estimates from other studies, which ranged from 1 to 11%.⁵ Our results of incidence in people aged >60 years are similar to that of the SABE STUDY,²⁰ which showed the incidence of UI was 39.3 per 1000 person-years among a relatively small sample size of 864 Brazilian older women (individuals aged ≥60 years). An analysis of the Nurses' Health Study cohort,⁷ which included 852 Asian women aged 37–79 years in the USA, showed that the incidence of UI in Asian women was 5.7 per 100 person-years. This number is higher than that of our result in women aged >40 years, perhaps because the participants of the Nurses' Health Study cohort are specifically a highly educated population. Additionally, our result is lower than that of Espuna-Pons et al.'s study,⁶ which showed that the 1-year incidence of female UI was 5.3% in the age group of 18–91 years in

Table 3. Incidence rates of female UI subtypes over 4 years by region and age*

Region	Person-years	SUI			UII			MUI		
		Cases	IR (95% CI)	Standardised IR (%)**	Cases	IR (95% CI)	Standardised IR (%)**	Cases	IR (95% CI)	Standardised IR (%)**
All	89 790	1117	12.4 (11.7–13.2)	13.1	243	2.7 (2.4–3.0)	3.0	397	4.4 (4.0–4.9)	5.1
20–29	22 596	178	7.9 (6.7–9.0)		28	1.2 (0.8–1.7)		24	1.1 (0.6–1.5)	
30–39	23 821	245	10.3 (9.0–11.6)		36	1.5 (1.0–2.0)		52	2.2 (1.6–2.8)	
40–49	19 908	272	13.7 (12.0–15.3)		50	2.5 (1.8–3.2)		88	4.4 (3.5–5.3)	
50–59	11 094	195	17.6 (15.1–20.0)		42	3.8 (2.6–4.9)		71	6.4 (4.9–7.9)	
60–69	6805	135	19.8 (16.5–23.2)		34	5.0 (3.3–6.7)		68	10.0 (7.6–12.4)	
≥70	5564	92	16.5 (13.2–19.9)		53	9.5 (7.0–12.1)		94	16.9 (13.5–20.3)	
Urban	45 147	543	12.0 (11.0–13.0)	12.6	107	2.4 (1.9–2.8)	2.6	170	3.8 (3.2–4.3)	4.2
20–29	12 003	83	6.9 (5.4–8.4)		14	1.2 (0.6–1.8)		7	0.6 (0.2–1.0)	
30–39	12 657	124	9.8 (8.1–11.5)		14	1.1 (0.5–1.7)		23	1.8 (1.1–2.6)	
40–49	9583	133	13.9 (11.5–16.2)		20	2.1 (1.2–3.0)		36	3.8 (2.5–5.0)	
50–59	4923	97	19.7 (15.8–23.6)		19	3.9 (2.1–5.6)		35	7.1 (4.8–9.5)	
60–69	3409	70	20.5 (15.7–25.3)		16	4.7 (2.4–7.0)		30	8.8 (5.7–11.9)	
≥70	2573	36	14.0 (9.4–18.6)		24	9.3 (5.6–13.1)		39	15.2 (10.4–19.9)	
Rural	44 643	574	12.9 (11.8–13.9)	13.6	136	3.0 (2.5–3.6)	3.5	227	5.1 (4.4–5.7)	6.0
20–29	10 593	95	9.0 (7.2–10.8)		14	1.3 (0.6–2.0)		17	1.6 (0.8–2.4)	
30–39	11 164	121	10.8 (8.9–12.8)		22	2.0 (1.1–2.8)		29	2.6 (1.7–3.5)	
40–49	10 326	139	13.5 (11.2–15.7)		30	2.9 (1.9–3.9)		52	5.0 (3.7–6.4)	
50–59	6171	98	15.9 (12.7–19.0)		23	3.7 (2.2–5.3)		36	5.8 (3.9–7.7)	
60–69	3397	65	19.1 (14.5–23.8)		18	5.3 (2.9–7.7)		38	11.2 (7.6–14.7)	
≥70	2991	56	18.7 (13.8–23.6)		29	9.7 (6.2–13.2)		55	18.4 (13.5–23.2)	

*Incidence rate (IR)/1000 person-years.

**Standardised incidence rate: the incidence rates were standardised by age and region based on the 2010 Chinese census.

Trend test: UI: $p < 0.0001$; SUI: $p < 0.0001$; UII: $p = 0.011$; MUI: $p < 0.0001$.

BMI = body-mass index; UI = urinary incontinence; SUI = stress urinary incontinence;

UII = urgency urinary incontinence; MUI = mixed urinary incontinence.

Figure 2. BMI-specific incidence rate of UI and its subtypes. Trend test: UI: $P < 0.0001$; SUI: $P < 0.0001$; UII: $P = 0.011$; MUI: $P < 0.0001$.

Table 4. Univariate and multivariable adjusted rate ratios (95% CI) for the risk of developing SUI

Variables	Univariate analysis		Multivariable analysis	
	RR (95% CI)	P value	RR (95% CI)	P value
Age (years)				
20–29	Reference		Reference	
30–39	1.31 (1.08–1.58)	0.007	0.99 (0.79–1.23)	0.930
40–49	1.73 (1.44–2.10)	<0.0001	1.22 (0.97–1.54)	0.083
50–59	2.23 (1.82–2.73)	<0.0001	1.49 (1.16–1.90)	0.002
60–69	2.52 (2.01–3.15)	<0.0001	1.61 (1.22–2.13)	0.001
≥70	2.10 (1.63–2.70)	<0.0001	1.33 (0.98–1.82)	0.069
Region				
Urban	Reference		—	—
Rural	1.07 (0.95–1.20)	0.265	—	—
Race				
Han	Reference		Reference	
Minority	0.41 (0.21–0.79)	0.007	0.46 (0.24–0.89)	0.022
Education				
Primary school and below	Reference		Reference	
Junior middle school	1.28 (1.08–1.51)	0.004	1.66 (1.40–1.98)	<0.0001
Senior school	1.01 (0.84–1.21)	0.920	1.59 (1.30–1.94)	<0.0001
College or above	0.99 (0.83–1.18)	0.910	2.05 (1.68–2.52)	<0.0001
Cigarette smoking	2.05 (1.50–2.80)	<0.0001	1.54 (1.12–2.12)	0.007
Alcohol consumption	0.43 (0.14–1.34)	0.146	—	—
BMI (kg/m ²)				
Underweight (<18.5)	0.79 (0.59–1.04)	0.097	0.90 (0.67–1.20)	0.470
Normal (18.5–23.9)	Reference		Reference	
Overweight (24.0–27.9)	1.75 (1.53–1.99)	<0.0001	1.52 (1.33–1.74)	<0.0001
Obese (≥28.0)	1.89 (1.50–2.37)	<0.0001	1.67 (1.32–2.11)	<0.0001
Marital status				
Couple	Reference		—	—
Single	0.37 (0.27–0.51)	<0.0001	—	—
Divorce/Widowed	1.40 (1.07–1.82)	0.01	—	—
Delivery pattern				
Nulliparous	Reference		Reference	
Vaginal spontaneous delivery	2.54 (2.05–3.14)	<0.0001	2.12 (1.62–2.78)	<0.0001
Instrumental delivery	4.67 (2.91–7.50)	<0.0001	3.30 (1.99–5.45)	<0.0001
Caesarean section	1.49 (1.15–1.94)	0.003	1.28 (0.95–1.71)	0.107
Gynaecological disease*,*	1.09 (0.95–1.23)	0.253	—	—
Premenopausal	1.45 (1.28–1.64)	<0.0001	—	—
Cough (>3 weeks)	1.64 (1.34–2.01)	<0.0001	1.44 (1.17–1.76)	0.001
Diabetes	1.98 (1.68–2.33)	<0.0001	1.33 (1.10–1.60)	0.003
Pelvic surgery	0.87 (0.77–0.99)	0.039	—	—
Spinal surgery	0.55 (0.14–2.20)	0.397	—	—

*Gynaecological diseases included myoma, pelvic inflammatory disease, chronic pelvic pain and endometriosis.

patients seeking care for different gynaecological problems in Spain. Although the participants came from the clinical population, the incidence of female UI may have been higher than that in the general population. The French GAZEL cohort study⁸ recruited 4127 middle-aged (47–52 years old at baseline) women over 18 years (1990–2008), and reported an annual incidence of 3.3% for UI, which is higher than that of our result in women aged 40–60 years.

Although several studies have reported the incidence of female UI in various populations, these earlier findings are not comparable because of the small sample size or non-representative samples or clinical patients.^{5,6,21,22}

Identifying risk factors is important for clinical prevention and decision-making. Because MUI is a combination of SUI and UUI, and MUI pathophysiology may be different from that of pure SUI and pure UUI combined

Table 5. Univariate and multivariable adjusted rate ratios (95% CI) for the risk of developing UUI

Variables	Univariate analysis		Multivariable analysis	
	RR (95% CI)	P value	RR (95% CI)	P value
Age (years)				
20–29	Reference		Reference	
30–39	1.22 (0.74–2.00)	0.431	1.21 (0.74–1.99)	0.442
40–49	2.03 (1.28–3.22)	0.003	1.96 (1.24–3.12)	0.004
50–59	3.06 (1.89–4.93)	<0.0001	2.81 (1.73–4.56)	<0.0001
60–69	4.03 (2.44–6.65)	<0.0001	3.47 (2.06–5.84)	<0.0001
≥70	7.69 (4.86–12.15)	<0.0001	6.30 (3.85–10.30)	<0.0001
Region				
Urban	Reference		—	—
Rural	1.28 (1.00–1.66)	0.052	—	—
Race				
Han	Reference		—	—
Minority	1.27 (0.57–2.86)	0.561	—	—
Education				
Primary school and below	Reference		—	—
Junior middle school	0.74 (0.54–1.01)	0.061	—	—
Senior school	0.64 (0.46–0.91)	0.013	—	—
College or above	0.28 (0.18–0.42)	<0.0001	—	—
Cigarette smoking	0.67 (0.21–2.09)	0.491	—	—
Alcohol consumption	1.33 (0.33–5.33)	0.692	—	—
BMI (kg/m ²)				
Underweight (<18.5)	0.92 (0.53–1.60)	0.778	—	—
Normal (18.5–23.9)	Reference		—	—
Overweight (24.0–27.9)	1.44 (1.08–1.91)	0.012	—	—
Obese (≥28.0)	1.45 (0.85–2.46)	0.173	—	—
Marital status				
Couple	Reference		—	—
Single	0.35 (0.17–0.72)	0.004	—	—
Divorce/Widowed	2.28 (1.44–3.60)	<0.0001	—	—
Delivery pattern				
Nulliparous	Reference		—	—
Vaginal spontaneous delivery	3.65 (2.12–6.28)	<0.0001	—	—
Instrumental delivery	4.38 (1.26–15.35)	0.020	—	—
Caesarean section	2.48 (1.34–4.61)	0.004	—	—
Gynaecological disease**	1.09 (0.82–1.45)	0.556	—	—
Premenopausal	3.78 (2.87–4.99)	<0.0001	—	—
Cough (>3 weeks)	0.82 (0.46–1.46)	0.499	—	—
Diabetes	3.14 (2.33–4.24)	<0.0001	1.48 (1.05–2.09)	0.026
Pelvic surgery	1.00 (0.76–1.30)	0.972	—	—
Spinal surgery	2.53 (0.63–10.19)	0.190	—	—

*Gynaecological diseases included myoma, pelvic inflammatory disease, chronic pelvic pain and endometriosis.

together, we focused on analysing the risk factors of SUI and UUI. Our findings suggested that vaginal spontaneous delivery and instrumental delivery significantly increased the risk of SUI, which is consistent with previous studies.^{23,24} Vaginal delivery is correlated with development of SUI, probably via injury of pelvic floor structures, such as muscles, nerves, organs and the extracellular matrix responsible for continence.²⁵ Tahtinen et al. showed that instrumental delivery, especially forceps delivery, is

associated with significant increased long-term risk of SUI compared with other vaginal deliveries for women aged ≤50 years.²⁴ More attention needs to be paid to women after childbirth, and early prevention and rehabilitation strategies for SUI are required.

Our study showed that BMI at baseline was significantly associated with SUI. These data confirm the associations found between weight gain and UI in clinical patients.²⁶ However, we did not find an association between BMI and

UUI. BMI is a risk factor that can have intervention, and moderate weight reduction may be beneficial for treatment and prevention of SUI.

Age is an established risk factor for SUI and UUI.^{4,10,27} Our findings further confirmed that the risk of SUI and UUI increased with age in the general population. In each age group, although the risk of UUI was higher than that of SUI, the prevalence of SUI was higher. Therefore, the absolute number involved in SUI was more than that of UUI. The incidence of UI subtypes in women aged >60 years is increasing rapidly, which requires more investment in clinical treatment.

We also found a significant association between diabetes and the incidence of SUI and UUI. Although diabetes was identified as a risk factor for UI in a previous cross-sectional study,²⁸ our results indicated its causal association by time in our prospective study. Our study suggests that health management of chronic diseases, such as obesity and diabetes, may help to reduce the risk of SUI and UUI.

Our study findings have important public health implications. We calculated the absolute numbers of people with SUI based on the number of Chinese women from the 2018 Chinese Statistics Yearbook.²⁹ The estimated total number of individuals aged ≥ 20 years with de novo UI was 14.46 million in China, including 8.93 million SUIs, 2.05 million UUIs and 3.48 million MUIs. With rapid entry into an aging society, the number of affected people and the burden of UI are anticipated to continue to increase in China. Our findings suggest the need for national policies and programmes for prevention and early detection of UI. Information about UI should be disseminated to the Chinese public to assure proper clinical treatment in the future.

Conclusion

Our study shows that the incidence of de novo female UI is 21.2/1000 person-years in China. Delivery (vaginal spontaneous delivery, instrumental delivery), high BMI, cigarette smoking, chronic cough, diabetes, middle and older age, and living in rural areas increase the risk of SUI. Older age and diabetes increase the risk of UUI. Our findings may aid in identifying populations at risk, and help clinical early prevention, and intervention of UI.

Disclosure of interests

None declared. Completed disclosure of interest forms are available to view online as supporting information.

Contribution to authorship

LZ contributed to the study conception, design, analysis and interpretation of the data, and reviewed and approved the final manuscript. HP contributed to the study concept and design, analysis and interpretation of the data, and

drafting of the manuscript. JL contributed to analysis and made critical revision of the manuscript. TX contributed to study concept and design. Zhaoai Li, JG, QL, YW, JW, ZX, and Zhiyi Li contributed to acquisition of data. LL made critical revision of the manuscript for important intellectual content.

Details of ethics approval

The study protocol was approved by the institutional review board of Peking Union Medical College Hospital (Number: S-689, Date: 15 May 2014). The study protocol was approved (<http://www.chictr.org>, ChiCTR-OCH-14004675), and written informed consent was obtained from each participant before data collection.

Funding

This study was funded by the National Key R&D Programme of China (2018YFC2002201), the National Natural Science Foundation of China (72104247), the CAMS Initiative for Innovative Medicine (2017-I2M-1-002) and the National Natural Science Foundation of China (81830043).

Acknowledgements

We thank all patients who participated in the study. We thank Ellen Knapp for editing the English text of a draft of this manuscript.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Baseline description of responders and non-responders.

Figure S1. Trend of the incidence rates of SUI, UUI and MUI with age. ■

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