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Fetal birthweight and maternal urinary incontinence in Chinese primiparas: a population-based study

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Abstract

Background Urinary incontinence (UI) is commonly linked to pregnancy and obstetric factors, but the association between fetal birthweight and maternal UI remains contentious. This study investigates the association between fetal birthweight and maternal UI and its subtypes in Chinese primiparas.

Methods Cross-sectional data from 54,346 women aged 20 years and above were obtained from the 2019–2021 National Urinary Incontinence Survey. Restricted cubic spline (RCS) regression analysis and threshold effect analysis were used to explore the association between fetal birthweight and urinary incontinence and its subtypes.

Results Among 19,365 primiparas, the prevalence of UI was 14.5%. Adjusted analyses revealed that each 1.0 kg increase in birthweight correlated with a 32% (95% CI: 1.21–1.44) increased risk of UI. Categorical analysis indicated that women in the highest birthweight tertile (3.4–6.0 kg) faced a higher risk of UI compared to those in the lowest tertile (0.5–3.0 kg) (adjusted OR, 1.42; 95% CI: 1.28–1.57). RCS regression highlighted non-linear associations between birthweight and the risk of any type of UI, urgency UI (UUI), and mixed UI (MUI), with a significant turning point at 3.9 kg for overall UI risk. Subgroup analyses revealed interactions between birthweight tertiles and modifiable risk factors like physical activity, as well as clinical risk factors like hypertension.

Conclusions These findings underscore the independent association between fetal birthweight and UI in Chinese primiparas, emphasizing the importance of considering various factors when assessing this relationship. A non-linear association exists between birthweight and any type of UI, UUI, and MUI, respectively. This study offers novel insights into the potential classification strategies for fetal birthweight and call for future research to validate and comprehend the clinical implications.

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Keywords Chinese primiparas, Urgency urinary incontinence, Mixed urinary incontinence, Modifiable risk factors

Background

According to the International Continence Society (ICS), urinary incontinence (UI) is defined as "complaint of any involuntary leakage of urine". It is a widespread health issue that mainly affects adult women of all ages and has a detrimental influence on their quality of life [1]. A large number of studies have shown that the prevalence of UI was observed to be 25–45% and increases with age [2]. UI symptoms are classified into three underlying symptomatic disorders, of which stress UI (SUI) and urgency UI (UUI) are the most common, with mixed UI (MUI) having more severe symptoms [3].

Different subtypes of UI have been shown to be linked to distinct underlying causes and varying degrees of severity [4]. Pregnancy and obstetric-related factors have been identified as the most significant risk factors to the development of female UI [5–7]. Anatomical and metabolic changes brought on by pregnancy itself would increase the risk of UI in the postpartum period [8], potentially triggering the onset of SUI as early as this stage [6]. Vaginal delivery had been suggested as the primary cause of UI [9] and SUI [10], likely due to the damaged sustained by the pelvic floor during the fetus' transit through the birth canal [11]. Evidence shows that among single-birth primiparas, women who give birth vaginally have a greater risk of UI when compared to nulliparous women, with cesarean sections coming in second [6]. SUI and UUI have been reported to be more common following vaginal birth than after cesarean section, though these differences tend to diminish [12]. Conversely, some studies suggest that cesarean sections may reduce the prevalence of UI [13]. Parity is a significant risk factor for SUI and MUI, with the first delivery being the most significant [5, 14]. However, mechanical damage from labor increases with parity [7].

Risk factors as age, ethnicity, height, current body mass index (BMI), physical activity, menopause, irritable bowel syndrome, neurological illnesses, hypertension, diabetes mellitus, urinary tract infections, constipation, and episiotomy have been linked to UI [2, 15–18]. The UR-CHOICE risk calculator, designed to predict future risk of UI after childbirth, includes eight factors, with birthweight being the only fetal factor [16]. However, conflicting findings on fetal birthweight have been obtained, with some research indicating an association between birthweight and UI [19, 20], while others do not support this link [21–23]. A methodological limitation in many studies is the relatively small sample size, often drawn from selective populations. Additionally, birthweight was often categorized arbitrarily without justification for the cut-off, and no data were available for stratified sub-analysis based on cesarean and vaginal deliveries, despite mode of delivery being a confounder likely influencing the association between birthweight and UI [19]. Given the impact of various factors on health outcomes reveals a non-linear relationship characterized by a threshold effect, further research is needed to understand the specific correlation between fetal birthweight and the risk of maternal UI and its subtypes. This study aimed to examine the associations between fetal birthweight and the risk of UI and its subtypes among women who had given birth to a single child through either vaginal delivery or cesarean section on a large, representative sample of the Chinese female population.

Materials and methods

Study design and data collection

From October 2019 to December 2021, a comprehensive national survey of UI among women was carried out covering 15 provinces, autonomous regions, or municipalities in China, which urbanization, economic development status, and geographic region were all taken into consideration [24]. Women who participated in this study were residents (staying in their current domicile for at least one year) and aged 20 years and above. Individuals with severe mental or physical illnesses, as well as pregnant women, were excluded from the study. To ensure the representativeness of the sample, a rigorous six-stage sampling strategy was employed, resulting in a required sample size of 51,915 women. This study was performed in line with the principles of the Declaration of Helsinki. Written informed consent was acquired from each participant and the study protocol received approval from the Ethical Review Committee of Peking Union Medical College Hospital (No. S-K970).

Flow diagram of the study population

We enrolled data from 54,346 female participants during the 2019–2021. Participants were excluded based on the following criteria: 333 had other types of UI, 34,467 were nulliparas or multiparas, 116 had instrumental delivery, and 65 had missing covariates. A total of 19,365 female participants with complete data who were primiparas on vaginal or cesarean delivery were comprised for the

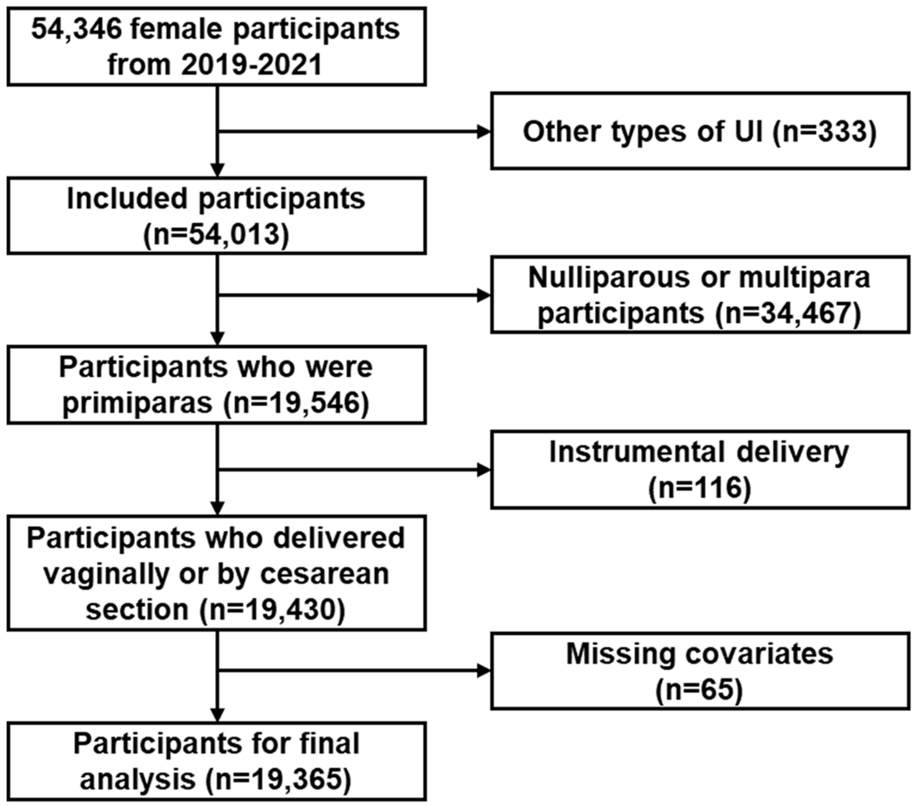

Fig. 1 Flow diagram of the study population. UI: urinary incontinence

final analytic sample (Fig. 1). Participants included and excluded differed substantially in terms of demographic and lifestyle characteristics due to variations in delivery types and UI subtypes (Supplementary Table S1).

Measures

Outcome measurement

The primary outcome was UI, defined by the ICS as any involuntary leakage of urine. Participants who self-reported symptoms of urine leakage were further evaluated for UI subtypes using the validated Chinese version of the International Consultation on Incontinence Questionnaire-Urinary Incontinence-Short Form (ICIQ-UI-SF) [25]. This tool categorizes UI into three main types: SUI, UUI, and MUI.

Exposure measurement

Fetal birthweight was self-reported and measured by the question "What is the maximum birthweight of the fetus?" Birthweight was recorded in grams and then converted to kilograms (kg), and categorized into three groups based on tertiles: Tertile 1 (≤ 3.0 kg), Tertile 2 (3.0–3.4 kg), and Tertile 3 (> 3.4 kg) [26]. Furthermore, birthweight was classified into percentiles using the growth curves established by the International Fetal and Newborn Growth Consortium for the twenty-first century (Intergrowth-21st). Newborns weighing above the 90th percentile were classified as LGA (large-for-gestational-age), while those below the 10th percentile were classified as SGA (small-for-gestational-age) [27]. Additionally, infants born weighing under 2,500 g were categorized as low birthweight, while those weighing 4,000 g or more were classified as macrosomia [28].

Covariates measurement

Demographic variables, including age, ethnicity (Han or Minority), education level (primary school and below, junior middle school, senior high school, college or above), and location (urban or rural). Maternal height was recorded as a continuous variable. BMI (calculated as weight/height^2, kg/m^2) was divided into underweight (< 18.5), normal (18.5–24.9), and overweight/obesity (≥ 25). Physical activity level (low, moderate, or high) was assessed using the Chinese version of the International Physical Activity Questionnaire Short Form (IPAQ-S-C), which has demonstrated adequate validity [29]. Reproductive history was reported as delivery type (vaginal spontaneous delivery or cesarean section) and menopausal status (yes/no). Comorbid conditions included hypertension, diabetes, gynecological diseases (i.e., those with pelvic inflammatory disease, pelvic pain, endometriosis, fibroids, gynecological malignant tumors, and pelvic organ prolapse), chronic cough (> 8 weeks), and chronic constipation (yes/no).

Statistical analyses

The descriptive statistical analysis outlined demographic characteristics and the prevalence of UI and its subtypes based on birthweight tertiles. Continuous variables were reported as mean ± SD (standard deviation), and categorical variables as frequencies (percentages). ANOVAT-tests were used for continuous data, and chi-square tests were applied for categorical data between groups. Initially, the association between birthweight and UI and its subtypes was assessed. Three logistic regression models were utilized to calculate odds ratios (ORs) and 95% confidence intervals (CIs) to explore the independent relationship between UI and continuous birthweight and its tertiles with varying adjustments for potential confounders. The unadjusted model included no covariates, while the partially adjusted model accounted for age, BMI, and fetal birthweight (continuous and categorical). The fully adjusted models additionally included ethnicity, education, location, maternal height, physical activity, delivery type, menopausal status, and five comorbidities (hypertension, diabetes, gynecological diseases, chronic constipation, and chronic coughing). *P* for trends were calculated using the median value as a quasi-continuous variable in the model. Additionally, restricted cubic spline (RCS) curves based on logistic regression models were used to explore potential non-linear relationships, provide a flexible method for modeling complex relationships and trends between continuous birthweight and UI. The number of knots was selected based on model fit, with knots placed at the 5th, 35th, 65th, and 95th percentiles of birthweight. Threshold effect analysis identified turning points using likelihood-ratio tests, and a two-piecewise linear model was constructed around these points. Subgroup analyses were performed within the fully adjusted model to account for potential effect modifications. Sensitivity analyses evaluated the impact of different birthweight cut-offs and delivery histories. To address confounding, additional sensitivity analyses excluded individuals with specific risk factors. Statistical analyses were performed with Stata version 17.0 and R version 4.2.2. All the tests were two-sided, and a *P* value < 0.05 was considered statistically significant.

Results

Participant characteristics

Table 1 shows the characteristics of the study participants based on their tertiles (≤ 33rd, 33rd–66th, > 66th percentile) of fetal birthweight, with a mean (SD) birthweight of 3.24 (0.48) kg. The median (range) of birthweight across the total population and 1st–3rd tertiles were 3.2 (0.5–6.0) kg, 3.0 (0.5–3.0) kg, 3.2 (3.0–3.4) kg, and 3.6 (3.4–6.0) kg. In the total population (*n* = 19,365), the prevalence rates of UI and its subtypes were 14.5% for UI, 8.2% for SUI, 1.4% for UUI, and 4.9% for MUI. In terms of comorbidities, 10.3% of the participants reported current hypertension, 3.3% reported current diabetes, 9.1% had gynecological diseases, 2.1% experienced chronic cough lasting more than 8 weeks, and 3.7% suffered from chronic constipation.

Association between birthweight and incontinence subtypes

Table 2 provides a summary of the association between birthweight and UI and incontinence subtypes using logistic regression models. We found that birthweight, when treated as a continuous variable, was significantly and positively associated with UI across all models (unadjusted, OR = 1.22, 95% CI: 1.13–1.33, *P* < 0.001; partially adjusted, OR = 1.31, 95% CI: 1.20–1.42, *P* < 0.001; fully adjusted, OR = 1.32, 95% CI: 1.21–1.44, *P* < 0.001). Similar trends were also observed in the subtypes of UI with significant effects (all *P* values < 0.05), indicating that birthweight can be regarded as a risk factor for UI and its subtypes, and per 1 kg increase in fetal weight was associated with a higher risk of UI in the mother. When birthweight was treated as a categorical variable, participants in Tertile 3 (3.4–6.0 kg) had a higher risk of UI and its subtypes compared to those in Tertile 1 (0.5–3.0 kg) across all three models. Notably, participants in the Tertile 2 (3.0–3.4 kg) group showed a significantly higher risk of UI and SUI after adjusting for partial and all potential confounders, although similar results were not observed for UUI and MUI.

Dose–response relationship between birthweight and UI

The fully adjusted RCS regression with a knot of 4 showed the non-linear association between birthweight and UI, UUI, and MUI (*P* for nonlinearity was 0.021, 0.008, and 0.030, respectively) (Fig. 2). However, no such non-linear relationship was observed between birthweight and SUI (*P* for nonlinearity was 0.852). Threshold effect analysis identified turning points of 3.9 kg between birthweight and UI (*P* value for likelihood ratio test was 0.002), and 3.8 kg between birthweight and both UUI and MUI (*P* values for likelihood ratio test were 0.034 and 0.028, respectively) (Table 3). The results indicated that for birthweights less than 3.9 kg, there was a 1.48-fold increase in the risk of UI per 1 kg increase in birthweight (95% CI: 1.32–1.65). Conversely, for birthweights equal to

Table 1 Characteristics of participants among Chinese women in 2021 by birthweight

Variables, n (%)	Total	Birthweight tertiles			*P* value
		Tertile 1 (0.5–3.0 kg)	Tertile 2 (3.0–3.4 kg)	Tertile 3 (3.4–6.0 kg)	
Total number	19,365	7177	5881	6307	
Age group, years					
20–29	2333 (12.0)	766 (10.7)	797 (13.6)	770 (12.2)	< 0.001
30–39	4066 (21.0)	1304 (18.2)	1279 (21.7)	1483 (23.5)	
40–49	4586 (23.7)	1648 (23.0)	1417 (24.1)	1521 (24.1)	
50–59	4685 (24.2)	1846 (25.7)	1397 (23.8)	1442 (22.9)	
60–69	2994 (15.5)	1296 (18.1)	819 (13.9)	879 (13.9)	
≥ 70	701 (3.6)	317 (4.4)	172 (2.9)	212 (3.4)	
Ethnicity					
Han	18,329 (94.7)	6702 (93.4)	5624 (95.6)	6003 (95.2)	< 0.001
Minority	1036 (5.3)	475 (6.6)	257 (4.4)	304 (4.8)	
Education					
Primary school and below	2882 (14.9)	1359 (18.9)	738 (12.5)	785 (12.4)	< 0.001
Junior middle school	6327 (32.7)	2520 (35.1)	1889 (32.1)	1918 (30.4)	
Senior high school	4841 (25.0)	1671 (23.3)	1523 (25.9)	1647 (26.1)	
College or above	5315 (27.4)	1627 (22.7)	1731 (29.4)	1957 (31.0)	
Location					
Rural	6547 (33.8)	2523 (35.2)	2048 (34.8)	1976 (31.3)	< 0.001
Urban	12,818 (66.2)	4654 (64.8)	3833 (65.2)	4331 (68.7)	
Postmenopause	7348 (37.9)	3053 (42.5)	2094 (35.6)	2201 (34.9)	< 0.001
BMI, kg/m^2					
Underweight (< 18.5)	942 (4.9)	417 (5.8)	273 (4.6)	252 (4.0)	< 0.001
Normal (18.5–24.9)	13,849 (71.5)	5131 (71.5)	4341 (73.8)	4377 (69.4)	
Overweight (≥ 25)	4574 (23.6)	1629 (22.7)	1267 (21.5)	1678 (26.6)	
Physical activity level					
Low	5543 (28.6)	2125 (29.6)	1552 (26.4)	1866 (29.6)	< 0.001
Moderate	10,591 (54.7)	3836 (53.4)	3349 (56.9)	3406 (54.0)	
High	3231 (16.7)	1216 (16.9)	980 (16.7)	1035 (16.4)	
Delivery type					
Vaginal spontaneous delivery	15,294 (79.0)	6100 (85.0)	4697 (79.9)	4497 (71.3)	< 0.001
Cesarean section	4071 (21.0)	1077 (15.0)	1184 (20.1)	1810 (28.7)	
Comorbidity					
Hypertension	1986 (10.3)	867 (12.1)	508 (8.6)	611 (9.7)	< 0.001
Diabetes	639 (3.3)	246 (3.4)	165 (2.8)	228 (3.6)	0.033
Gynecological diseases	1754 (9.1)	591 (8.2)	521 (8.9)	642 (10.2)	< 0.001
Chronic cough (> 8 weeks)	400 (2.1)	162 (2.3)	110 (1.9)	128 (2.0)	0.290
Chronic constipation	707 (3.7)	228 (3.2)	210 (3.6)	269 (4.3)	0.003
Any type of UI	2805 (14.5)	962 (13.4)	807 (13.7)	1036 (16.4)	< 0.001
SUI	1585 (8.2)	550 (7.7)	477 (8.1)	558 (8.8)	< 0.001
UUI	274 (1.4)	84 (1.2)	74 (1.3)	116 (1.8)	
MUI	946 (4.9)	328 (4.6)	256 (4.4)	362 (5.7)	
Height, cm (mean, SD)	159.70 (5.07)	158.87 (5.17)	159.83 (4.85)	160.51 (5.01)	< 0.001
Birthweight, kg (mean, SD)	3.24 (0.48)	2.82 (0.29)	3.23 (0.11)	3.74 (0.39)	< 0.001

UI urinary incontinence, *SUI* stress urinary incontinence, *UUI* urgency urinary incontinence, *MUI* mixed urinary incontinence, *BMI* body mass index, *SD* standard deviation

Table 2 The linear association of birthweight with UI and its subtypes among Chinese women

	Birthweight (kg)		Birthweight tertiles OR (95% CI)			
	OR (95% CI)	*P* value	Tertile 1 (0.5–3.0 kg)	Tertile 2 (3.0–3.4 kg)	Tertile 3 (3.4–6.0 kg)	*P* for trend
Any type of UI						
Unadjusted	1.22 (1.13—1.33)	< 0.001	Reference	1.03 (0.93—1.14)	1.27 (1.15—1.40)	< 0.001
Partially adjusted	1.31 (1.20—1.42)	< 0.001	Reference	1.15 (1.04—1.28)	1.41 (1.28—1.56)	< 0.001
Fully adjusted	1.32 (1.21—1.44)	< 0.001	Reference	1.16 (1.04—1.29)	1.42 (1.28—1.57)	< 0.001
SUI						
Unadjusted	1.17 (1.05—1.29)	0.004	Reference	1.06 (0.94—1.21)	1.17 (1.03—1.32)	0.012
Partially adjusted	1.21 (1.09—1.34)	< 0.001	Reference	1.16 (1.02—1.32)	1.25 (1.11—1.42)	0.001
Fully adjusted	1.21 (1.09—1.35)	< 0.001	Reference	1.15 (1.01—1.31)	1.24 (1.09—1.41)	0.002
UUI						
Unadjusted	1.41 (1.12—1.76)	0.003	Reference	1.08 (0.79—1.47)	1.58 (1.19—2.10)	0.001
Partially adjusted	1.46 (1.18—1.82)	0.001	Reference	1.19 (0.87—1.64)	1.73 (1.30—2.30)	< 0.001
Fully adjusted	1.52 (1.22—1.90)	< 0.001	Reference	1.25 (0.91—1.72)	1.81 (1.35—2.42)	< 0.001
MUI						
Unadjusted	1.20 (1.05—1.36)	0.007	Reference	0.95 (0.80—1.12)	1.27 (1.09—1.48)	0.001
Partially adjusted	1.28 (1.13—1.46)	< 0.001	Reference	1.07 (0.91—1.27)	1.43 (1.22—1.67)	< 0.001
Fully adjusted	1.28 (1.13—1.46)	< 0.001	Reference	1.09 (0.92—1.30)	1.42 (1.21—1.67)	< 0.001

ORs and 95% CIs were calculated from the binary logistic regression model

P values for trend were estimated using the birthweight tertile median as a continuous variable

Partially adjusted models include age, BMI, and birthweight (continuous/categorical)

Fully adjusted models include age, ethnicity, education, location, maternal height, BMI, physical activities, delivery type, menopause status, five types of comorbidities (hypertension, diabetes, gynecological diseases, chronic coughing and chronic constipation), and birthweight (continuous/categorical)

UI urinary incontinence, *SUI* stress urinary incontinence, *UUI* urgency urinary incontinence, *MUI* mixed urinary incontinence, *BMI* body mass index, *OR* odds ratio, *CI* confidence interval

or greater than 3.9 kg, each 1 kg increase in birthweight was associated with a reduced risk of UI (OR = 0.97; 95% CI: 0.76–1.21). No significant turning point was found between birthweight and SUI (*P* value for likelihood ratio test was 0.127).

Subgroup analysis

Subgroup analyses were performed to examine the association between birthweight tertiles and UI, while accounting for all baseline latent covariates (Supplementary Table S2-S5). As shown in Supplementary Table S2, there was no significant interaction between birthweight tertiles and any type of UI (all *P* for interactions > 0.05). However, significant interactions were observed between modifiable risk factors, such as physical activity level, and birthweight tertiles in relation to SUI, UUI, and MUI (*P* for interactions were 0.040, 0.039, and 0.027, respectively). In terms of clinical risk factors, an interaction between hypertension and birthweight tertiles was noted in SUI (*P* for interaction was 0.049). Further subgroup analyses were conducted based on continuous birthweight (Supplementary Figure S1-S4). The results revealed clinically significant interactions of hypertension with continuous birthweight in SUI (*P* for interaction was 0.009), and chronic constipation with birthweight in UUI (*P* for interaction was 0.037). Additionally, non-modifiable risk factors (e.g., age group and education level) were observed to interact with birthweight in MUI (*P* for interactions were 0.044 and 0.027, respectively).

Exploratory subgroup analyses were also performed to evaluate the association between birthweight and the risk of any type of UI in two participant groups divided at the turning point of 3.9 kg (Supplementary Figure S5). In group A (birthweight < 3.9 kg), an interaction between the clinical risk factor hypertension and continuous birthweight was observed (*P* for interaction was 0.042), while interactions existed among modifiable risk factors, specifically activity level (*P* for interaction was 0.001), as well as clinical risk factors, namely delivery type and diabetes (*P* for interactions were 0.049 and 0.020, respectively), and continuous birthweight in group B (birthweight ≥ 3.9 kg). Supplementary Figure S6 showed the association between birthweight and the risk of any type

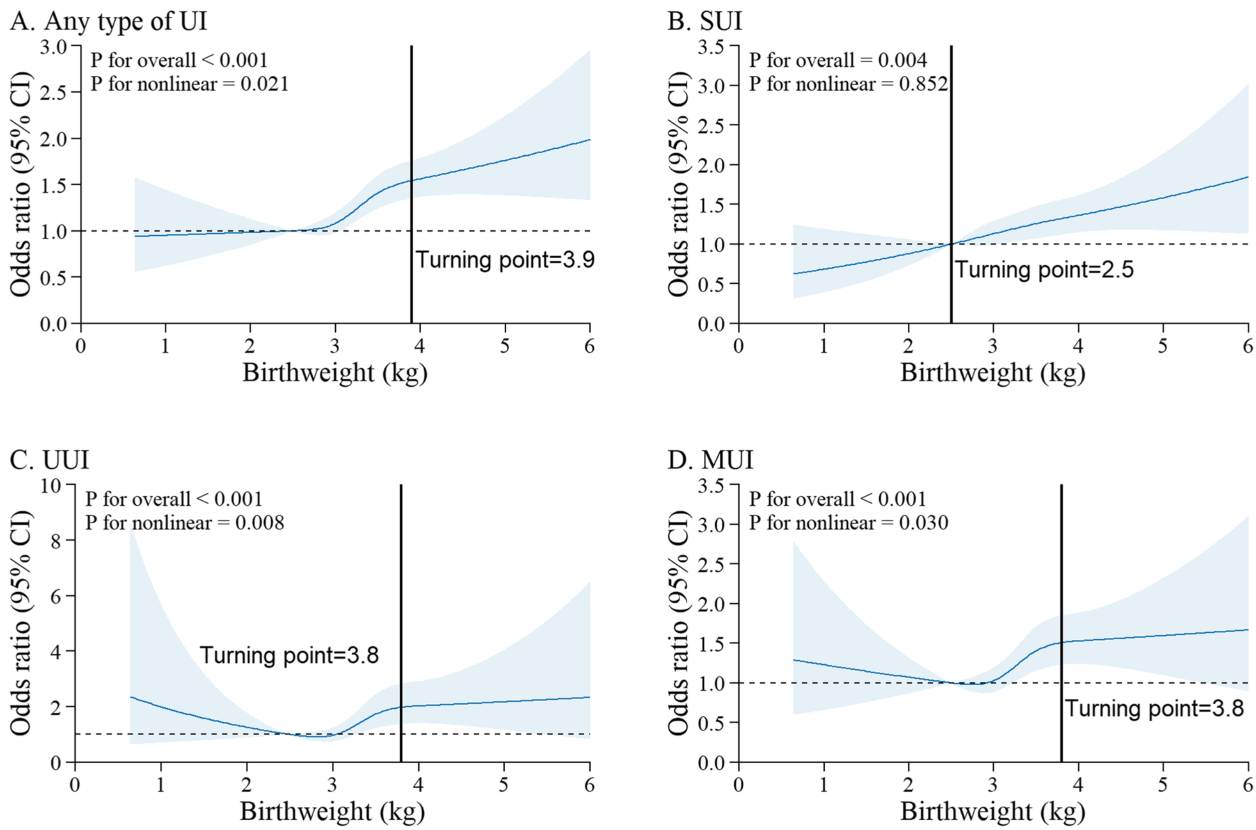

Fig. 2 Non-linear relationship between birthweight and UI and its subtypes using a restricted cubic spline regression model. Relationship between birthweight and any type of UI (**A**), SUI (**B**), UUI (**C**), and MUI (**D**). Adjusted for age, ethnicity, education, location, maternal height, BMI, physical activities, delivery type, menopause status, five types of comorbidities (hypertension, diabetes, gynecological diseases, chronic coughing and chronic constipation), and birthweight (continuous/categorical). Data were fitted by a logistic regression model, and the model was conducted with 4 knots at the 5th, 35th, 65th, 95th percentiles of birthweight (reference is the 5th percentile). Solid lines indicate OR, and shadow shape indicate 95% CI. UI: urinary incontinence; SUI: stress urinary incontinence; UUI: urgency urinary incontinence; MUI: mixed urinary incontinence; BMI: body mass index; OR: odds ratio; CI: confidence interval

of UI in two groups divided by delivery type. In group B (cesarean section), interactions were observed between non-modifiable such as age group and modifiable risk factors, namely physical activity level, and continuous birthweight (*P* for interactions were 0.006 and 0.003, respectively).

Sensitive analysis

The linear association between birthweight and UI remained robust when using various birthweight cut-offs (e.g., 3.5 kg, 4.0 kg, 4.5 kg, SGA and LGA, and low birthweight and macrosomia) instead of birthweight tertiles (Supplementary Table S6). Furthermore, the exclusion of postmenopausal participants, and those with hypertension, diabetes, gynecological diseases, chronic coughing, and chronic constipation did not significantly alter the observed association between birthweight and UI (both *P* values and *P* for trends were < 0.05; Model 1–6 in Supplementary Table S7). Additionally, after further adjusting for delivery history (e.g., multiparas, and the population characteristics were described in Supplementary Table S8), a sensitivity analysis was conducted including individuals who were multiparas rather than primiparas, and the association remained statistically significant (Model 7 in Supplementary Table S7).

Discussion

Main findings

This national cross-sectional study, involving data from 19,365 primiparas, identified a significant association between higher fetal birthweight and the risk of developing UI and its subtypes. The analysis revealed that every 1 kg increase in fetal birthweight was associated with a 32% higher risk of UI among primiparas. Notably, primiparas in Tertile 3 (3.4–6.0 kg) had the highest

Table 3 Threshold effect analysis of relationship between birthweight and UI among Chinese women in 2021

Birthweight (kg)	OR (95% CI)	*P* value	*P* value for likelihood ratio test
Any type of UI			
< 3.9	1.48 (1.32—1.65)	< 0.001	0.002
> 3.9	0.97 (0.76—1.21)	0.775	
SUI			
< 2.5	2.09 (1.05—4.96)	0.061	0.127
> 2.5	1.18 (1.05—1.32)	0.005	
UUI			
< 3.8	2.01 (1.42—2.86)	< 0.001	0.034
> 3.8	0.93 (0.47—1.56)	0.808	
MUI			
< 3.8	1.48 (1.23—1.79)	< 0.001	0.028
> 3.8	0.94 (0.65—1.28)	0.702	

Adjusted for age, ethnicity, education, location, maternal height, BMI, physical activities, delivery type, menopause status, five types of comorbidities (hypertension, diabetes, gynecological diseases, chronic coughing and chronic constipation), and birthweight (continuous/categorical)

UI urinary incontinence, *UUI* urgency urinary incontinence, *MUI* mixed urinary incontinence, *OR* odds ratio, *CI* confidence interval

risk, with a 42% increased likelihood of developing UI compared to those in Tertile 1 (0.5–3.0 kg). Additionally, the analysis uncovered a non-linear relationship between the risk of any type of UI, UUI, and MUI and birthweight. To our knowledge, this study is the first epidemiological inquiry to systematically explore the relationship between both continuous and categorical birthweight and UI in primiparas. These findings enhance and broaden existing knowledge regarding the correlation of birthweight with the risk of UI, highlighting the importance of early identification of risk factors for UI and timely intervention for populations at elevated risk.

The non-linear associations between birthweight and UI

Previous studies had focused on the linear relationship between birthweight and the risk of UI, often without a scientifically established cutoff for birthweight [19]. Using RCS and threshold effect analysis, we found that the relationship between birthweight and any type of UI, UUI, and MUI follows a non-linear pattern, with the exception of SUI. Our study identified 3.9 kg as a potential turning point for birthweight, indicating a threshold associated with a significant change in the risk of UI. While the standard definition of macrosomia (> 4000 g) aids in identifying increased risks of labor and newborn complications, it may not be the optimal threshold for assessing UI risk [30]. In clinical practice, it is essential to consider the relationship between infant birthweight and other adverse maternal and fetal outcomes [31]. Birthweight is a key indicator of neonatal health outcomes, with both underweight and excessive weight at birth linked to higher infant mortality rates [32]. Therefore, caution is advised in interpreting these results, and further research is needed to validate the findings.

The selection of birthweight groups

Our study confirmed a significant association between birthweight tertiles and the risk of UI among primiparas, including its specific subtypes. Categorizing birthweight into tertiles provides a more nuanced and representative method compared to traditional classifications such as SGA and LGA. This approach not only helps identify potential turning points but also highlights how the impact of birthweight on maternal UI risk varies within specific weight ranges. The selection of birthweight groups and reference groups can influence the outcomes [19]. Commonly utilized thresholds include 3,500 g [20] and 4,000 g [33], with some studies using 4,500 g [34]. A meta-analysis suggested that risk estimates in studies might have been higher if reference groups included lower birthweights [19]. Specifically, birthweights exceeding 3500 g (OR = 1.26) and 4000 g (OR = 1.49) were significantly linked to an increased UI risk. In our sensitivity analysis, we tested various birthweight cut-offs (e.g., 3.5 kg, 4.0 kg, 4.5 kg, SGA and LGA, and low birthweight and macrosomia), and the results remained robust, aligning with the findings from previous studies.

The effects of modifiable and non-modifiable risk factors

Our study identified an interaction between birthweight and modifiable risk factors, specifically physical activity level. Previous research has associated physical activity level with the prevalence of UI, identifying low physical activity as a significant risk factor [35]. Our study found that the relationship between birthweight tertiles and UUI risk was stronger among individuals with low physical activity level, consistent with prior findings linking low activity to higher UUI odds [36]. In contrast, the association between birthweight tertiles and MUI risk was stronger in individuals with high physical activity, consistent with studies linking physical activity to MUI risk [37]. As for non-modifiable risk factors, a stronger association between continuous birthweight and MUI risk was found in younger women (aged 20–29) compared to older women (aged 50–59), in line with the known association between aging and UI prevalence [38]. It is suggested that the risk of UI related to high birthweight may decrease with age, but further research is needed to confirm this association.

The effects of clinical factors

The results of the subgroup analyses indicate that, among individuals with gynecological diseases, higher birthweight is generally associated with an increased risk of any type of UI, which is consistent with prior research. Gynecological diseases, including gynecologic cancer, endometriosis, uterine fibroids, and pelvic prolapse, are prevalent health issues among women, frequently linked to urinary symptoms that adversely affect both quality of life and psychological well-being [39–41]. Given the considerable psychological implications of aggressive treatment approaches, it is essential to consider fertility-sparing strategies or combined surgical treatments during the decision-making process to promote physical and mental health while minimizing potential urinary complications [42–44].

Other clinical factors, such as delivery type, were found to influence the relationship between birthweight and UI in our study. Subgroup analyses revealed that for women who delivered vaginally, higher birthweight was associated with an increased risk of UI. In contrast, this relationship was not significant among those who underwent cesarean sections, supporting the hypothesis of a protective effect offered by cesarean delivery. Despite this understanding, many women in the United States are often compelled to undergo cesarean sections, episiotomies, and the use of forceps, even when they express a desire for vaginal delivery [17]. This practice reflects a concerning trend in which healthcare and social-health professionals frequently disregard and disrespect individual preferences in the context of sexual and reproductive health care. This disregard is commonly referred to as obstetric violence [45–49], a form of violence that is often overlooked in discussions about violence against women. Such practices can negatively impact women's rights, quality of life, and overall well-being during childbirth.

Clinical and research implications

The exact mechanism by which high birthweight increases the risk of UI remains unclear. One possible contributing reason is pelvic floor trauma and pudendal nerve injury during deliveries of larger babies [50]. Electromyography evidence of pudendal nerve injury in the pelvic floor after vaginal birth has been linked to heavier newborns [51]. In addition, primiparous women delivering heavier infants may face prolonged second stages of labor, leading to higher rates of self-reported bladder dysfunction, while those with a second stage lasting over 120 min are more likely to report SUI and UUI [52].

To ensure the physical and psychological well-being of women and their unborn children, it is imperative to cultivate positive interactions between pregnant women and medical staff. Prioritizing a woman-centered approach that respects bodily autonomy is essential. This can be achieved by providing comprehensive information on clinical alternatives and modifiable factors and potential consequences of care options, allowing women to make informed choices. Given the association between UI and birthweight, clinical interventions or preventative measures should aim to balance birthweight and UI risk. Women at risk of excessive baby birthweight should be identified and detected to avoid high infant birthweight, such as growth charts, ultrasound, and symphysis-fundus height measurements. For women with UI, strengthening pelvic muscles, engaging in pelvic floor muscle training [53], maintaining a healthy lifestyle, and achieving optimal weight gain may help prevent and manage UI [54].

Strengths and limitations

As previously mentioned, this is the first national study to assess both the linear and non-linear association of birthweight with UI in primiparas across China. A key strength of this study is the use of standardized methods for sampling, symptom recording, and data collection, providing evidence of associations between continuous and categorical birthweight and various types of UI. However, further research is needed to validate the underlying mechanisms driving these associations.

Several limitations of this study should be noted. First, self-reported questionnaires were used to determine UI status and fetal birthweight, which may introduce recall bias in responses during data collection. Second, the absence of objective tests, such as pad tests or urodynamic studies, limits our ability to confirm the presence of UI symptoms accurately. Third, as a cross-sectional study, it cannot establish a clear causal relationship between birthweight and UI. Future longitudinal studies are necessary to explore the temporal dynamics of this relationship, providing a more comprehensive understanding of its direction and nature. Finally, the study population primarily comprises Chinese primiparas, which may limit the generalizability of the findings to other populations. Socio-demographic and cultural factors also influence the risk of UI and may vary by region. For instance, obstetric violence may impact the incidence of UI in different ways, such as through interventions related to delivery types and the practice of routine or selective episiotomy.

Conclusions

In summary, this study found that higher birthweight was significantly associated with the increased risk of urinary incontinence among Chinese primiparas, and the risk curves were non-linear for UI, UUI, and MUI, with a turning point near 3.9 kg. Our findings suggest that women who have delivered or are expected to deliver high-birthweight babies should receive further screening or therapy for UI, and interventions like pelvic floor rehabilitation or full details of medical information provision should be implemented promptly in these populations.

Abbreviations

ICS	International Continence Society
UI	Urinary Incontinence
SUI	Stress Urinary Incontinence
UUI	Urgency Urinary Incontinence
MUI	Mixed Urinary Incontinence
ICIQ-UI-SF	International Consultation on Incontinence Questionnaire-Urinary Incontinence-Short Form
Intergrowth-21st	International Fetal and Newborn Growth Consortium for the Twenty-First Century
LGA	Large-for-gestational-age
SGA	Small-for-gestational-age
IPAQ-S-C	Chinese Version of the International Physical Activity Questionnaire Short Form
SD	Standard Deviation
ORs	Odds Ratios
CIs	Confidence Intervals
RCS	Restricted Cubic Spline
BMI	Body Mass Index

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

YD, PW, and YC contributed to the conception and design of the study. QL, LW, HJ, LG, JX, TL, AL, LL, LZ, YL, LW, XLL, XPL, YF, JN, WZ, QL, and RZ were responsible for the acquisition of data. YD, PW, and YC analyzed and interpreted data. YD and PW drafted the manuscript and performed the statistical analysis. LZ obtained funding. HP, JZ, and LZ critically revised the manuscript for important intellectual content, provided supervision for the study, and provided administrative, technical, or material support. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Written informed consent was acquired from each participant and the study protocol received approval from the Ethical Review Committee of Peking Union Medical College Hospital (No. S-K970).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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