Risk Management and Healthcare Policy

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Development and Validation of a Risk Prediction Model for Female Stress Urinary Incontinence in Rural Fujian, China

Qi Wang[1,*], Xiao-Xiang Jiang[1,*], Yan-Zhen Que[2,*], Xiao-Ying Wan[2], Chao-Qin Lin[1]

[1]Department of Gynecology, Fujian Maternity and Child Health Hospital, Fujian Provincial Key Laboratory of Women and Children's Critical Diseases Research, College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, People's Republic of China; [2]Department of Gynecology and Obstetrics, Shaxian General Hospital, Sanming, People's Republic of China

*These authors contributed equally to this work

Correspondence: Chao-Qin Lin, Department of Gynecology, Fujian Maternity and Child Health Hospital, 18 Dao-Shan Street, Gu-Lou District, Fuzhou, 350000, People's Republic of China, Tel +8613950422970, Email lcqfjsfy@126.com; Xiao-Xiang Jiang, Department of Gynecology, Fujian Maternity and Child Health Hospital, Fujian Provincial Key Laboratory of Women and Children's Critical Diseases Research, College of Clinical Medicine for Obstetrics & Gynecology and Pediatrics, Fujian Medical University, Fuzhou, People's Republic of China, Email 19959179535@163.com

Purpose: With China's rapidly aging population and the rising proportion of obese people, an increase in the number of women suffering from urinary incontinence (UI) is to be expected. In order to identify high-risk groups before leakage occurs, we aimed to develop and validate a model to predict the risk of stress UI (SUI) in rural women.

Patients and methods: This study included women aged 20–70 years in rural Fujian who participated in an epidemiologic survey of female UI conducted between June and October 2022. Subsequently the data was randomly divided into training and validation sets in a ratio of 7:3. Univariate and multivariate logistic regression analyses were used to identify independent risk factors as well as to further construct a nomogram for risk prediction. Finally, concordance index (C-index), calibration curve and decision curve analysis were applied to evaluate the performance of the predictive models.

Results: A total of 5290 rural females were enrolled, of whom 771 (14.6%) had SUI. Age, body mass index (BMI), postmenopausal status, number of vaginal deliveries, vaginal delivery of large infant, constipation and family history of pelvic organ prolapse (POP) and SUI were included in the nomogram. C-index of this prediction model for the training and validation sets was 0.835 (95% confidence interval [CI] = 0.818–0.851) and 0.829 (95% CI = 0.796–0.858), respectively, and the calibration curves and decision analysis curves for both the training and validation sets showed that the model was well-calibrated and had a positive net benefit.

Conclusion: This model accurately estimated the SUI risk of rural women in Fujian, which may serve as an effective primary screening tool for the early identification of SUI risk and provide a basis for further implementation of individualized early intervention. Moreover, the model is concise and intuitive, which makes it more operational for rural women with scarce medical resources.

Keywords: stress urinary incontinence, rural women, risk factors, nomogram, predict model

Introduction

Urinary incontinence (UI) is a fairly common condition that afflicts women, relevant epidemiological studies have shown that the prevalence of UI in middle-aged and elderly women is 44%-57% and 75% respectively.[1] It is not a fatal disease but can bring serious physical, psychological impact to women.[2–5] In addition to this, UI can lead to serious financial burdens, with some scholars estimating that about 6% of all nursing home admissions by older women are due to UI, costing $3 billion per year.[6] Stress UI (SUI) is the most common type, and the International Continence Society (ICS) defines SUI as involuntary leakage of urine on effort or exertion or on sneezing or coughing.[7] Large-scale epidemiologic survey conducted in Fujian during 2022 showed that the prevalence of female SUI was 14.0%, and this survey also

Received: 30 December 2023
Accepted: 19 April 2024
Published: 30 April 2024

revealed that demographic factors such as age, obesity, and postmenopausal status, as well as obstetric-related characteristics such as multiple vaginal deliveries, a history of large infant deliveries, and instrumental deliveries, are high risk factors for the prevalence of SUI.[8] With China's rapidly aging demographics and the rising proportion of obese people, female SUI is gradually becoming an important public health issue.

In recent years, there has been increasing evidence that early interventions, such as pelvic floor muscle training (PFMT), and weight loss, targeted at high-risk groups of women, can be effective in reducing the incidence of SUI.[9–11] Therefore, there is an urgent need to accurately estimate the risk of SUI. Liu et al achieved good results by employing clinical data combined with prenatal ultrasonography data to establish a postpartum SUI risk prediction model, with area under receiver operating characteristic (ROC) curve of 0.883 and 0.807 for the training and validation sets, respectively.[12] Xiao et al predicted the risk of SUI development by translabial three dimensional (3D) ultrasound examination, and constructed several prediction models by combining different ultrasound indicators, with an accuracy of up to 77.8%, a specificity of up to 95.2%, and a sensitivity that could reach close to 70%.[13] Although the aforementioned prediction models can achieved good prediction results, most of the current prediction tools were limited to a specific period of time (postpartum and postoperative),[14,15] and more data are needed to support whether the prediction models for SUI can have a larger scope of application.[16] In addition, many of the predictive models relied on data from urodynamic tests and 3D ultrasound, which are difficult to obtain in rural areas where medical resources are scarce.

Therefore, we attempted to utilize the socio-demographic information and obstetric-related characteristics collected in previous epidemiological surveys to screen for high-risk factors and develop a nomogram prediction model to predict the risk of SUI in rural women, which is conducive to the identification of populations at high risk of SUI and provides data support for the development of early intervention strategies.

Methods

Data Collection

This analysis is the second part of a previous study and an important component of the Female Pelvic Floor Health Management Centre Project in Fujian Province.[8,17] Data were obtained from a large-scale epidemiologic survey of female UI conducted between June and October 2022 in the Shaxian County of southeastern China. 6000 rural women aged 20–70 years of Shaxian County were selected to participate in this study through multistage stratified random sampling. The International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) distinguishes the presence of UI by inquiring about the following symptoms associated with urinary leakage and further identifies subtypes of UI: (1) never—urine does not leak; (2) leaks before you can get to the toilet; (3) leaks when you cough or sneeze; (4) leaks when you are asleep; (5) leaks when you are physically active/exercising; (6) leaks when you have finished urinating and are dressed; (7) leaks for no obvious reason; (8) leaks all the time. If the respondent selected option (1), she would be considered as not having UI. If she selected options (3) and/or (5), she would be considered as having SUI. If she selected one or more of options (2), (4), and (6), urgency UI (UUI) would be considered. If the respondent had both SUI and UUI as described above, or chose options (7) and/or (8), then she would be identified as having mixed UI (MUI).[18] A self-administered questionnaire were applied to collect data related to obstetric deliveries, and socio-demographic information. All questionnaires were filled out in the form of face-to-face interviews, taking into account the fact that a significant proportion of rural female respondents were illiterate. Relevant processes and results of previous studies are described in detail in previously published reports.[8,17] This survey was conducted in full compliance with the principles of the Declaration of Helsinki and was approved by the Ethical Review Committee of Fujian Maternity and Child Health Hospital (2023KYLLR01045). Before participating in the survey, respondents were required to sign an informed consent form.

Risk Factors for SUI

By reviewing previously published literature,[2,4,8,17] potential risk factors included age, body mass index (BMI), education level, monthly income, postmenopausal status, number of vaginal deliveries, vaginal delivery of large infants, vacuum extraction or forceps delivery, history of pelvic floor surgery, and family history of pelvic organ prolapse (POP) and SUI, as well as comorbidities including hypertension, diabetes, chronic cough, and constipation. Age and BMI were expressed as continuous numerical types, education and monthly income level as ordinal types, and all the remaining risk factors were expressed as binary types.

Educational levels were divided into four categories: "Primary school and below", "Junior high school", "Senior high school", "College graduate or higher". Monthly income was categorized as "<140", "140–419", "419–698", "698–1396", "≥1396", based on the exchange rate at the time of the survey when converted to US dollars. Since the opening of China's two-child policy in 2015, having two children has become a common choice for couples of childbearing age, so The number of vaginal deliveries was categorized as "0–2" and "≥3". Vaginal delivery of large infants was defined as a previous vaginal delivery of a neonate ≥3500g.

Model Development and Validation

Firstly, the individual cases with incomplete data will be excluded from the database, and the data of the remaining cases were divided into training set and validation set according to the ratio of 7:3. The training set data were screened by applying univariate analysis, then the risk factors with *P*-value less than 0.05 were included in the multivariate logistic regression analysis to establish a risk prediction model and nomogram, and finally, the validation set data were applied to evaluate the prediction effect of this model. The performance of the nomogram was evaluated by the discrimination and calibration. Discrimination was measured by the concordance index (C-index), obtained by the area under ROC curve (AUC), and calibration was demonstrated by the calibration curve and evaluated by applying the Hosmer-Lemeshow test. A decision curve analysis (DCA) was also performed to determine the net benefit threshold of prediction.

Statistical Analysis

All computations were performed with R software (version 4.3.0) and its many packages. After Kolmogorov–Smirnov test, Continuous variables that conform to normal distribution are expressed as mean±standard deviation and differences were compared using Student's *t*-test, non-normally distributed continuous variables are expressed as medians and quartiles (Q1-Q3) and differences were compared using Mann–Whitney *U*-test. Categorical variables are expressed as counts (percentages) and differences were compared using the chi-square test or Fisher's exact test when appropriate. Results with a *P*-value of <0.05 were considered significant.

Results

Of the 6000 women selected for the study, 710 were excluded due to refusal to participate or missing data. A total of 771 of the final 5290 included were diagnosed with SUI, for an overall prevalence of 14.6%. Through a 7:3 ratio of randomization, 3704 and 1586 individuals were assigned to the training and validation sets, respectively, and the detailed flowchart is represented in Figure 1.

Univariate and Multivariate Analysis of Factors Associated with SUI

Student's *t*-test and chi-square test were used to compare the differences in factors between the SUI and no SUI groups. A total of 12 important factors were selected in the training set (all $P < 0.05$), including age, BMI, education level, monthly income, postmenopausal status, number of vaginal deliveries, vaginal delivery of large infant, history of pelvic floor surgery, family history of POP and UI, hypertension, diabetes, and constipation. Socio-demographic characteristics, obstetric history of participants in training and validation set are summarized in Table 1.

Further multivariate logistic regression analyzed incorporated variables including age (odds ratio [OR]=1.048, 95% confidence interval [CI]=1.029–1.068, *P*<0.001), BMI (OR=1.216, 95% CI =1.182–1.252, *P*<0.001), postmenopausal status (OR=2.657, 95% CI=1.850–3.843, *P*<0.001), number of vaginal deliveries (OR=2.605, 95% CI=2.058–3.311, *P*<0.001), vaginal delivery of large infant (OR=7.505, 95% CI=5.693–9.917, *P*<0.001), family history of POP and SUI (OR=3.206, 95% CI=2.081–4.915, *P*<0.001), and constipation (OR=5.735, 95% CI=2.403–13.052, *P*<0.001). Detailed information is presented in Table 2.

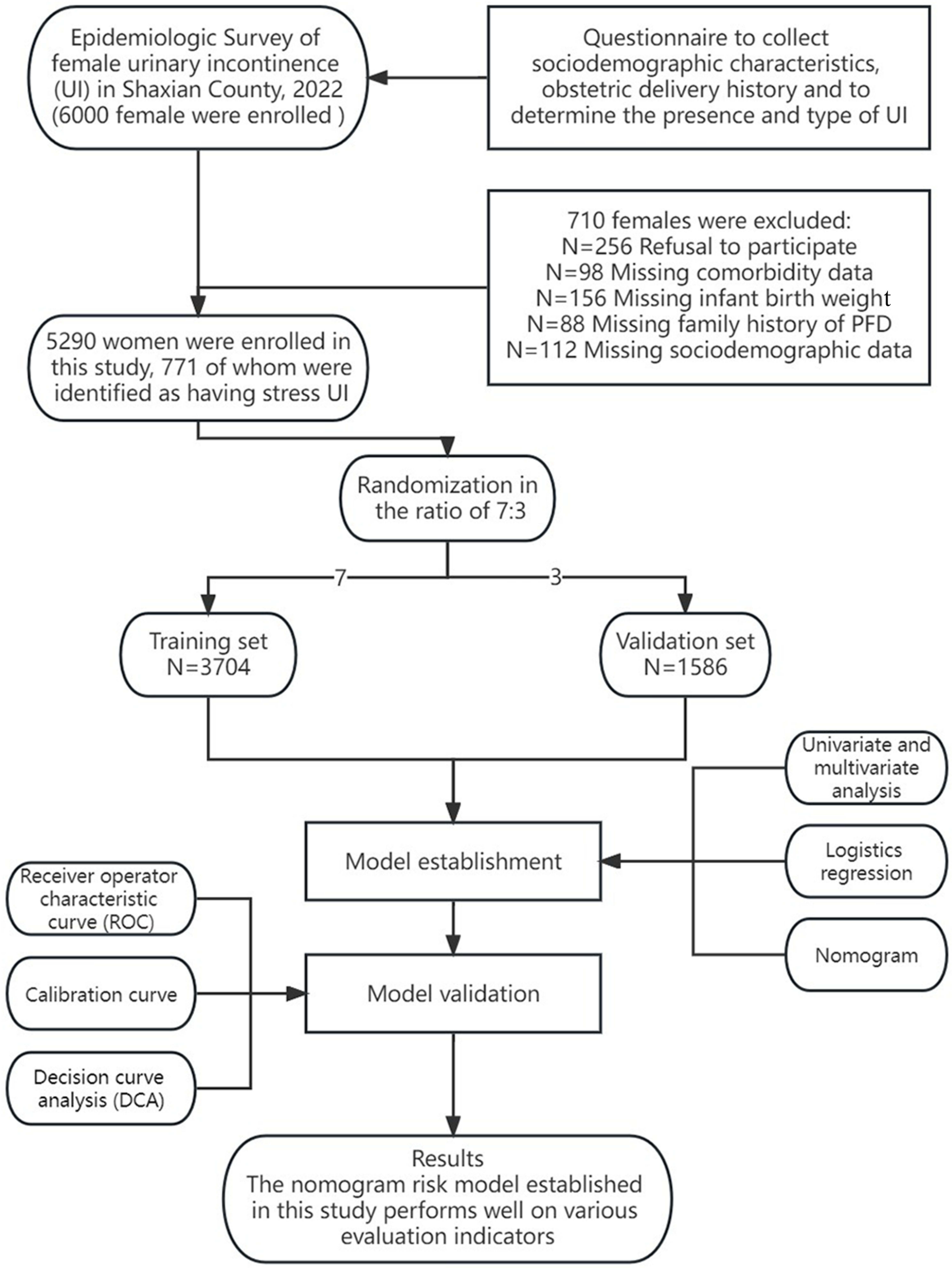

Figure 1 Flowchart for respondent selection and model development and validation.
Abbreviations: UI, urinary incontinence; PFD, pelvic floor dysfunction.

Development and Validation of Risk Prediction Model

Based on the results in Table 2, seven risk factors were ultimately included in the final nomogram prediction model (Figure 2), including age, BMI, postmenopausal status, number of vaginal deliveries, vaginal delivery of large infant, family history of POP and SUI, and constipation.

The corresponding ROC curves for the training and validation sets are plotted based on the above model (Figure 3). The AUC of the training and validation sets are 0.835 (95% CI=0.818–0.851) and 0.829 (95% CI=0.796–0.858), suggesting that the models are well discriminated. The calibration plots corresponding to the training and validation sets are shown in Figure 4, and the Hosmer-Lemeshow test showed no significant deviation (P=0.669 and 0.245, respectively), which suggests a good correlation between the observed and predicted risk of SUI. The DCA curves for

Table 1 Sociodemographic Characteristics, Obstetric History of Participants in Training and Validation Set

Characteristics	Training Set					Validation Set			
	Total (n=5290)	**Overall (n=3704)**	**SUI Group (n=540)**	**No SUI Group (n=3164)**	***P* value**	**Overall (n=1586)**	**SUI Group (n=231)**	**No SUI Group (n=1355)**	***P* value**
Age, yr (mean ± SD)	48.0±11.1	48.0±11.3	54.7±9.0	46.8±11.2	< 0.001	48.2±10.8	54.5±8.5	47.1±10.8	< 0.001
Body mass index, kg/m2 (mean ± SD)	22.4±3.8	22.4±3.8	24.3±3.9	22.1±3.6	< 0.001	22.4±3.8	24.3±3.7	22.1±3.7	< 0.001
Educational level, n (%)					< 0.001				< 0.001
Primary school or below	2198(41.6)	1538 (41.5)	333 (61.7)	1205 (38.1)		660 (41.6)	146 (63.2)	514 (37.9)	
Junior high school	1892(35.8)	1324 (35.7)	128 (23.7)	1196 (37.8)		568 (35.8)	56 (24.2)	512 (37.8)	
Senior high school	817(15.4)	570 (15.4)	65 (12.0)	505 (16.0)		247 (15.6)	25 (10.8)	222 (16.4)	
College graduate or higher	383 (7.2)	272 (7.3)	14 (2.6)	258 (8.2)		111 (7.0)	4 (1.7)	107 (7.9)	
Monthly income*, n(%)					< 0.001				0.01
<140	2382(45.0)	1658 (44.8)	301 (55.7)	1357 (42.9)		724 (45.6)	126 (54.5)	598 (44.1)	
140–419	1556(29.4)	1091 (29.5)	162 (30.0)	929 (29.4)		465 (29.3)	66 (28.6)	399 (29.4)	
419–698	1011(19.1)	703 (19.0)	60 (11.1)	643 (20.3)		308 (19.4)	33 (14.3)	275 (20.3)	
698–1396	307 (5.8)	230 (6.2)	16 (3.0)	214 (6.8)		77 (4.9)	6 (2.6)	71 (5.2)	
≥1396	34 (0.6)	22 (0.6)	1 (0.2)	21 (0.7)		12 (0.8)	0 (0)	12 (0.9)	
Postmenopausal status, n (%)					< 0.001				< 0.001
Yes	2512(47.5)	1757 (47.4)	421 (78.0)	1336 (42.2)		755 (47.6)	179 (77.5)	576 (42.5)	
No	2778(52.5)	1947 (52.6)	119 (22.0)	1828 (57.8)		831 (52.4)	52 (22.5)	779 (57.5)	
Number of vaginal deliveries, n (%)					< 0.001				< 0.001
0–2	2575(48.7)	1828 (49.4)	151 (28.0)	1677 (53.0)		747 (47.1)	55 (23.8)	692 (51.1)	
3	2715(51.3)	1876 (50.6)	389 (72.0)	1487 (47.0)		839 (52.9)	176 (76.2)	663 (48.9)	
Vaginal delivery of large infant, n(%)					< 0.001				< 0.001
Yes	650(12.3)	464 (12.5)	153 (28.3)	311 (9.8)		186 (11.7)	58 (25.1)	128 (9.4)	
No	4640(87.7)	3240 (87.5)	387 (71.7)	2853 (90.2)		1400 (88.3)	173 (74.9)	1227 (90.6)	
Vacuum extraction or forceps delivery, n (%)					0.545				0.333
Yes	195 (3.7)	131 (3.5)	22 (4.1)	109 (3.4)		64 (4.0)	12 (5.2)	52 (3.8)	
No	5095(96.3)	3573 (96.5)	518 (95.9)	3055 (96.6)		1522 (96.0)	219(94.8)	1303 (96.2)	
Previous pelvic floor surgery, n (%)					0.006				0.005
Yes	99 (1.9)	66 (1.8)	18 (3.3)	48 (1.5)		33 (2.1)	11 (4.8)	22 (1.6)	
No	5191(98.1)	3638 (98.2)	522 (96.7)	3116 (98.5)		1553 (97.9)	220 (95.2)	1333 (98.4)	
Family history of POP and SUI, n (%)					< 0.001				< 0.001
Yes	181 (3.4)	132 (3.6)	52 (9.6)	80 (2.5)		49 (3.1)	21 (9.1)	28 (2.1)	
No	5109(96.6)	3572(96.4)	488(90.4)	3084(97.5)		1537(96.9)	210(90.9)	1327(97.9)	

(*Continued*)

https://doi.org/10.2147/RMHP.S457332

Table 1 (Continued).

Characteristics	Training Set					Validation Set			
	Total (n=5290)	**Overall (n=3704)**	**SUI Group (n=540)**	**No SUI Group (n=3164)**	***P* value**	**Overall (n=1586)**	**SUI Group (n=231)**	**No SUI Group (n=1355)**	***P* value**
Comorbidity, n (%)									
Hypertension					< 0.001				< 0.001
Yes	400 (7.6)	290 (7.8)	81 (15.0)	209 (6.6)		110 (6.9)	32 (13.9)	78 (5.8)	
No	4890(92.4)	3414 (92.2)	459 (85.0)	2955 (93.4)		1476 (93.1)	199 (86.1)	1277 (94.2)	
Diabetes mellitus, n (%)					< 0.001				0.034
Yes	137 (2.6)	97 (2.6)	31 (5.7)	66 (2.1)		40 (2.5)	11 (4.8)	29 (2.1)	
No	5153(97.4)	3607 (97.4)	509 (94.3)	3098 (97.9)		1546 (97.5)	220 (95.2)	1326 (97.9)	
Chronic coughing, n (%)					0.259				0.718
Yes	35 (0.7)	19 (0.5)	5 (0.9)	14 (0.4)		16 (1.0)	3 (1.3)	13 (1.0)	
No	5255(99.3)	3685 (99.5)	535 (99.1)	3150 (99.6)		1570 (99.0)	228(98.7)	1342(99.0)	
Constipation, n (%)					0.001				0.009
Yes	56 (1.1)	38 (1.0)	13 (2.4)	25 (0.8)		18 (1.1)	7 (3.0)	11 (0.8)	
No	5234(98.9)	3666 (99.0)	527 (97.6)	3139 (99.2)		1568 (98.9)	224 (97.0)	11 (0.8)	

Notes: *US dollars: According to the exchange rate on November 20, 2022. Continuous variables are given as mean ± standard deviation, categorical variables are presented as number (percentage). P value was calculated with a Pearson Chi-square test, Fisher exact, Student's *t* test.
Abbreviations: SD, standard deviation; SUI, stress urinary incontinence; POP, pelvic organ prolapse.

https://doi.org/10.2147/RMHP.S457332

Table 2 Multivariate Logistic Regression Analyses of Factors Influencing SUI

Characteristics	OR	95% CI	*P* value
Age	1.048	1.029–1.068	< 0.001
Body mass index	1.216	1.182–1.252	< 0.001
Educational level			
Primary school or below	Ref.		
Junior high school	1.259	0.768–1.987	0.339
Senior high school	1.195	0.819–1.700	0.336
College graduate or higher	0.747	0.564–1.099	0.062
Personal monthly income			
<140	Ref.		
140–419	0.536	0.082–1.648	0.370
419–698	0.847	0.173–2.197	0.778
698–1396	1.409	0.525–2.809	0.384
≥1396	1.140	0.707–1.761	0.562
Postmenopausal status			
Yes	2.657	1.850–3.843	< 0.001
No	Ref.		
Number of vaginal deliveries			
0–2	Ref.		
3	2.605	2.058–3.311	< 0.001
Vaginal delivery of large infant			
Yes	7.505	5.693–9.917	< 0.001
No	Ref.		
Previous pelvic floor surgery			
Yes	0.873	0.453–1.626	0.676
No	Ref.		
Family History of POP and SUI			
Yes	3.206	2.081–4.915	< 0.001
No	Ref.		
Hypertension			
Yes	1.058	0.751–1.475	0.743
No	Ref.		
Diabetes mellitus			
Yes	1.346	0.781–2.274	0.273
No	Ref.		
Constipation			
Yes	5.735	2.403–13.052	< 0.001
No	Ref.		

Abbreviations: OR, odds ratio; CI, confidence interval; Ref., reference;SUI, stress urinary incontinence; POP, pelvic organ prolapse.

the nomogram are presented in Figure 5. The threshold probabilities of positive net benefits associated with the use of the nomogram to detect SUI in the training and validation cohorts were 0.03 to 0.95 and 0.03 to 0.90, which demonstrated that the nomogram had good net benefits for clinical use.

Discussion

According to the results of the latest nationwide survey, the incidence of UI in Chinese women is about 21.2 per 1000 persons per year, and 85.8% of them have symptoms of SUI.[19] Numerous studies have identified SUI as being associated with risk factors such as old age, high BMI, multiple transvaginal deliveries, chronic coughing, constipation, and there is sufficient evidence to suggest that early interventions such as PFMT and weight loss can be effective in preventing the occurrence and progression of SUI.[20–22] Therefore, there is an urgent need for urogynecologists to have

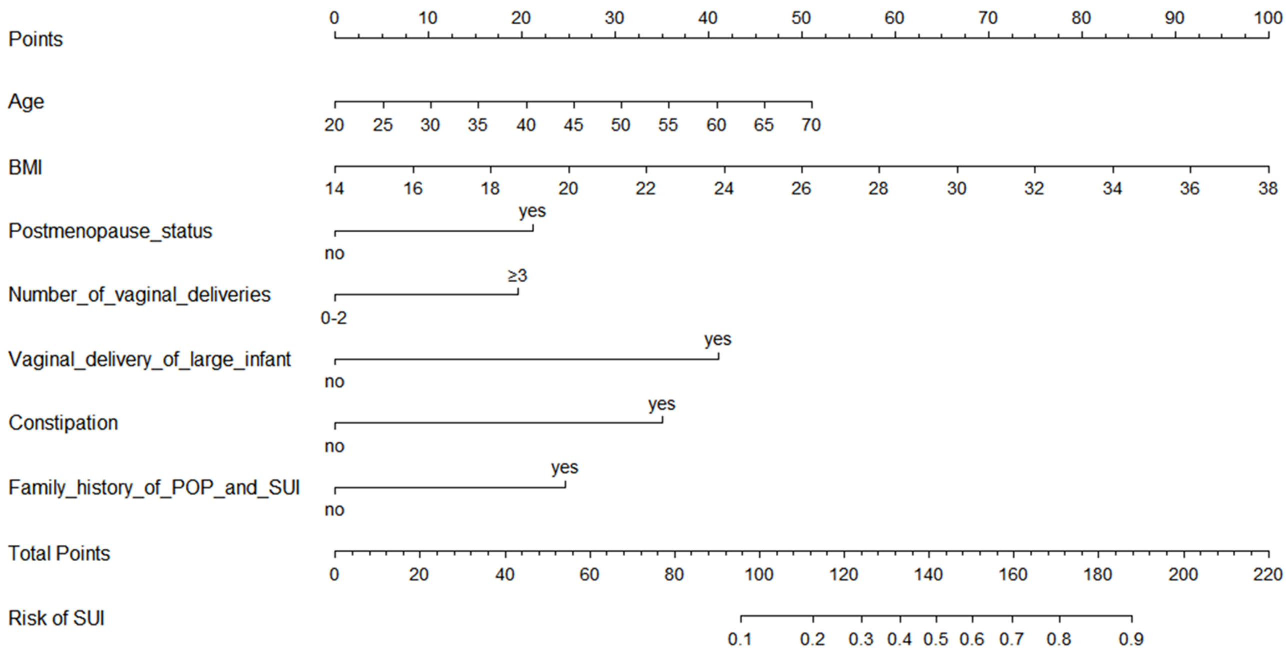

Figure 2 A nomogram for predicting stress urinary incontinence (SUI) in rural women. A score is assigned to the value of each variable on the variable axis. Each individual score was summed to obtain a total score to determine the corresponding risk of SUI prevalence.
Abbreviations: POP, pelvic organ prolapse; SUI, stress urinary incontinence.

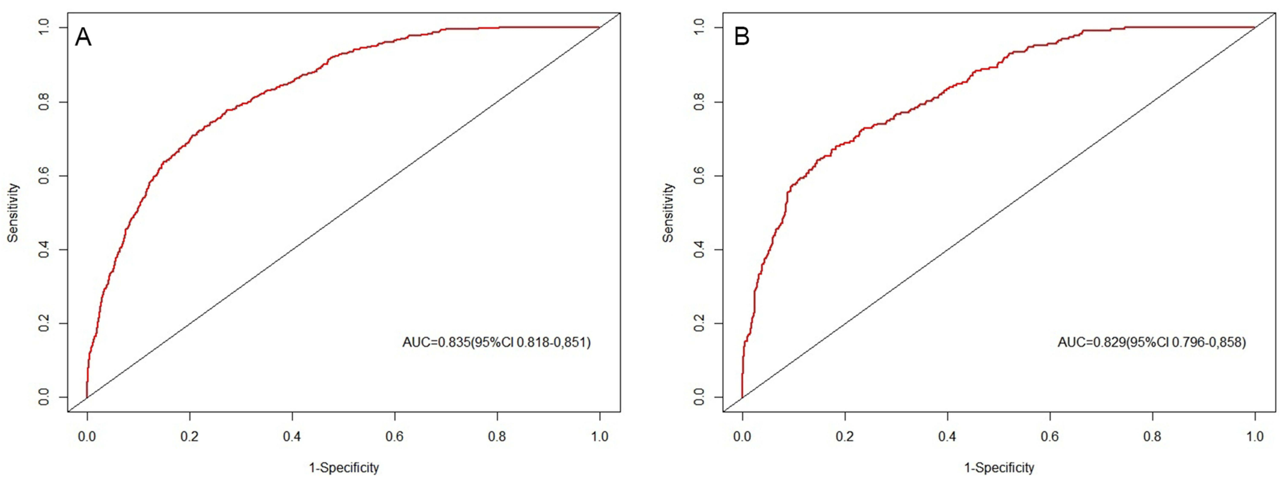

Figure 3 The receiver operating characteristic curve of the predictive model in the training set (**A**) and the validation set (**B**). (ROC) curve, equal to concordance index (C-index value).
Abbreviations: AUC, area under the receiver operating characteristic; CI, confidence interval.

tools that can individually assess the risk of developing SUI as well as visualize and communicate this result to the consulting woman so that she can choose the appropriate intervention based on multiple factors in her situation, rather than just providing the average prevalence rates from the literature.

Under the guidance of this strategy, the present study utilized the epidemiological database of SUI in local women to establish and validate a nomogram for predicting SUI in rural women.This nomogram prediction model, based on socio-demographic and obstetric-related characteristics, had good differentiation, calibration, and net-benefit performances. It can provide an effective tool for primary care providers to screen and identify women at high risk of developing SUI, and also offers the possibility of further individualized early intervention.

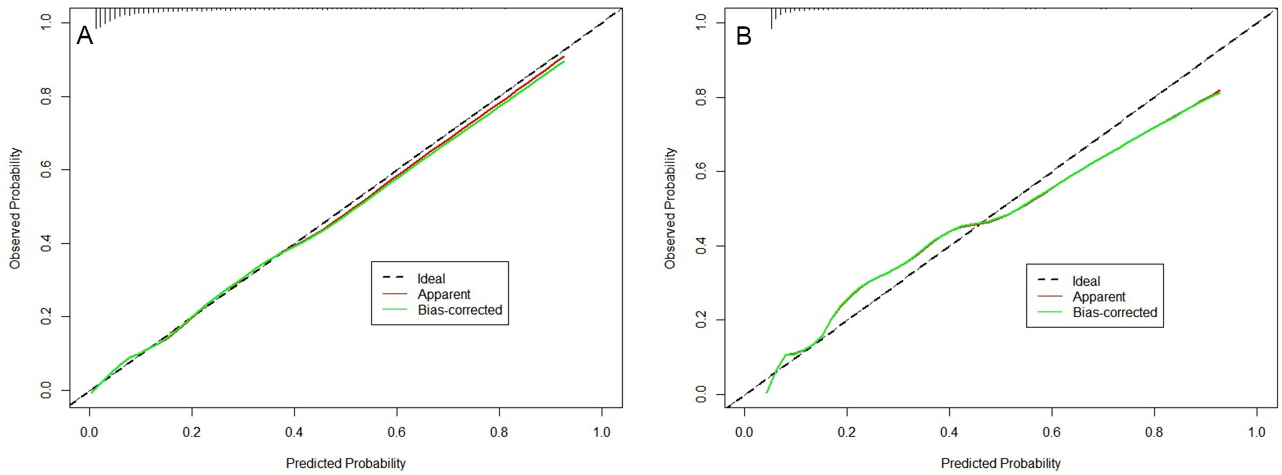

Figure 4 The calibration curve of the predictive model in the training set (**A**) and the validation set (**B**). The Hosmer-Lemeshow test showed no significant deviation between the observed and predicted values (*P*-values of 0.669 and 0.245 for the training and validation sets, respectively).

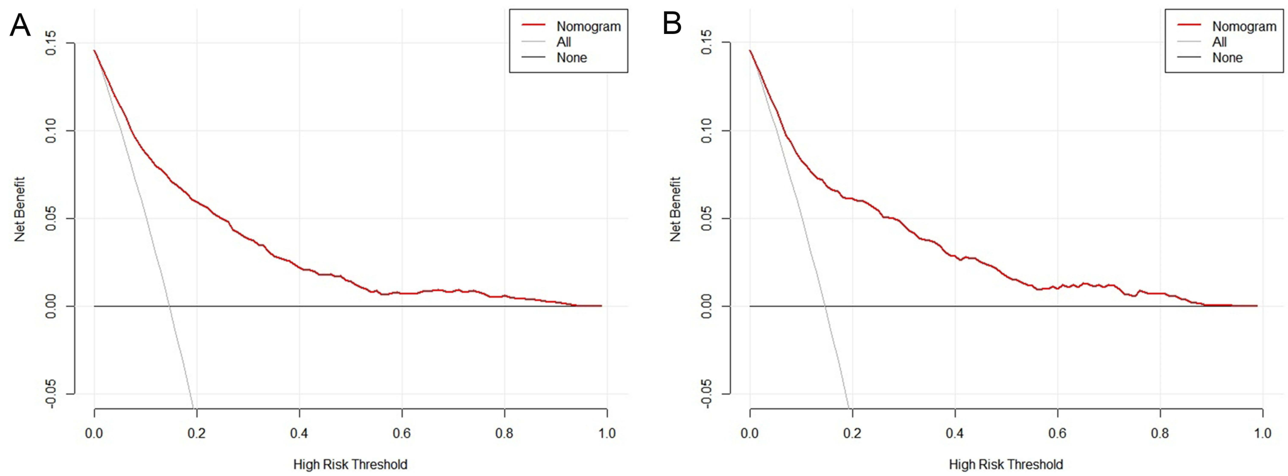

Figure 5 The decision curve analysis (DCA) of the predictive model in the training set (**A**) and the validation set (**B**). The threshold probabilities of positive net benefits associated with the use of the nomogram to detect SUI in the training and validation cohorts were 0.03 to 0.95 and 0.03 to 0.90, respectively.

It is worth noting that the definition of large infants delivered vaginally in this study was a birth weight ≥3500g, whereas the Chinese Obstetrics Clinical Guidelines for macrosomia refers to a birth weight ≥4000g.[23] The adoption of a standardized definition of macrosomia may compromise the applicability of the prediction model, as the proportion of women surveyed who delivered macrosomia vaginally was low, at 2.0% (108/5290), which may be due to the fact that pregnant women with macrosomia are more likely to opt for cesarean section, and that the poorer nutritional status of women in rural areas may also contribute to the low prevalence of macrosomia. According to a meta-analysis that included 15,066 pregnant women, birth weight ≥3500g was associated with a significantly increased risk of UI after vaginal childbirth (OR=1.26, 95% CI=1.15–1.37), Which is why the present study changed the definition to birth weight ≥3500g.[24]

Predictive analysis techniques have received increasing attention in recent years around the diagnosis and prognosis of diseases, and previously have been applied by many scholars to predict the risk of developing SUI. Based on the follow-up data of 457 patients after POP surgery, Jelovsek et al developed a predictive model for predicting the risk of de novo SUI after POP surgery. Multiple variables including age, BMI, number of vaginal deliveries, preoperative incontinence, urinary urgency, and diabetes were ultimately included in the nomogram. Whereas, after internal validation, the model had a C-index of 0.73, and the limited sample size may be one of the reasons affecting the efficacy of the prediction.[25] Another predictive model on postpartum UI included a total of 3051 socio-demographic and obstetric-related characteristics of women who delivered vaginally. Age, number of deliveries, newborn weight, duration of the second stage of labor, and forceps assisted delivery were finally included in the nomogram model, and the C-index of the training and validation sets reached 0.85 and 0.83, respectively.[15]

However, although numerous models can only predict the risk of SUI in specific populations,[12,26–28] and predictive models that can be used as risk screening tools to reach a wider range of women are still rare. In 2019, the study by Xiao et al proposed that the bladder neck position (BNP) and the urethral rotation angle (URA) and the levator hiatus area (LHA) derived from 3D ultrasonography can potentially predict the occurrence of SUI in women of all ages with good accuracy.[13] This seems to provide a theoretical solution to screening for SUI risk in women, but problems with its practical application in rural areas make it difficult to implement: firstly, the cost of the examination, although not as high as that of pelvic floor magnetic resonance imaging (MRI), the application of 3D ultrasound to screen for the risk of SUI is still a significant financial burden for rural women with low incomes, as reflected by the fact that 74.4% of the participants in the study had a monthly income of less than $419; Furthermore, as a relatively new examination technique, equipment and expertise to perform 3D ultrasound is scarce in rural areas, and requiring rural women to travel to urban centers for the examination will further reduce their motivation to participate in the screening process. This is in addition to the fact that previous studies have shown that the majority (82.9%) of rural women do not believe that there are measures that can be taken to prevent UI.[8]

Therefore, based on the above factors, the predictive model developed in this study has significant advantages when applied to screening for the risk of SUI in rural women. Firstly, the variables included in the model are socio-demographic characteristics or information related to delivery, which do not require expensive equipment or incur additional costs to obtain. In addition, the nomogram developed in this study is concise and intuitive enough for rural women to even self-assess, which is especially important for rural women who generally have low educational levels and little medical knowledge. Finally, another advantage is the larger sample size, which makes the model built more representative and improves the predictive effect of the model. To the best of our knowledge, this is the first study conducted to predict the risk of SUI in rural women, which is of great significance for the primary prevention of SUI in rural women and lays the foundation for further individualized and precise interventions for women at risk.

However, there are several limitations in the current study, firstly, in the epidemiologic survey, SUI was determined from self-diagnosis rather than urodynamic examination and cough stress test, which may lead to inaccurate diagnosis of SUI and thus ultimately affect the predictive effect of the model. Secondly, some potential risk factors related to lifestyle behaviors and obstetrics (eg, smoking, alcohol abuse, length of the second stage of labor) were not taken into account in this study. Finally, How to develop early intervention protocols based on model predictions remains to be explored and validated in future multi-geographic, multi-center prospective cohort studies, as a necessary step to validate the real-world applicability of the model, which is what our team are working to achieve.

Conclusion

In conclusion, the novel nomogram established in the present study has good prospects for practical application as it is easy to adopt and has good discriminatory and calibration as well as net benefit to predict the risk of SUI in rural women. The nomogram helps in early screening to identify those at high risk and accordingly individualize precise interventions. However, its benefits remain to be explored in multicenter prospective trials.

Data Sharing Statement

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

Ethics Approval

Ethical approval was granted by the Ethical Review Committee of Fujian Maternity and Child Health Hospital (2023KYLLR01045)

Acknowledgments

We are grateful for the great support from the Shaxian County government and the grassroots administration at all levels in terms of staff deployment and logistical support. We thank the medical staff of the Shaxian County Basic Health Center for their tremendous efforts, and all the women who participated in the study.

Funding

Joint Funds for the innovation of science and Technology, Fujian province (Grant number: 2060304).

Disclosure

The authors report no conflicts of interest in this work.

References

1. Sussman RD, Syan R, Brucker BM. Guideline of guidelines: urinary incontinence in women. *BJU Int*. 2020;125: 638–655. doi:10.1111/bju.14927
2. Akkus Y, Pinar G. Evaluation of the prevalence, type, severity, and risk factors of urinary incontinence and its impact on quality of life among women in Turkey. *Int Urogynecol J*. 2015;27:887–893. doi:10.1007/s00192-015-2904-5
3. Pizzol D, Demurtas J, Celotto S, et al. Urinary incontinence and quality of life: a systematic review and meta-analysis. *Aging Clin Exp Res*. 2020;33 (1):25–35. doi:10.1007/s40520-020-01712-y
4. Murukesu RR, Singh DK, Shahar S. Urinary Incontinence among Urban and rural community dwelling older women: prevalence, risk factors and quality of life. *BMC Public Health*. 2019;19(S4):1–11. doi:10.1186/s12889-019-6870-6
5. Turgut H, Hasırcı E, Atkın MS, et al. Does the sexual function of the spouses change after the TOT procedure? *Arch Gynecol Obstet*. 2021;303:1489–1494. doi:10.1007/s00404-020-05920-9
6. Morrison A, Levy R. Fraction of nursing home admissions attributable to urinary incontinence. *Value. Health*. 2006;9(4):272–274. doi:10.1111/j.1524-4733.2006.00109.x
7. Abrams P, Cardozo L, Fall M, et al. The standardisation of terminology of lower urinary tract function: report from the standardisation sub-committee of the international continence society. *Am. J. Obstet. Gynecol*. 2002;187(1):116–126. doi:10.1067/mob.2002.125704
8. Wang Q, Que Y, Yang Y, Wan X, Lin C. A population-based cross-sectional survey on the prevalence, severity, risk factors, and self-perception of female urinary incontinence in rural Fujian, China. *Int Urogynecol J*. 2023;2023:1–7. doi:10.1007/s00192-023-05518-0
9. Huang P, Luo K, Wang C, et al. Urinary incontinence is associated with increased all-cause mortality in older nursing home residents: a meta-analysis. *J of Nursing Scholarship*. 2021;53(5):561–567. doi:10.1111/jnu.12671
10. Ko PC, Liang CC, Chang SD, Lee JT, Chao AS, Cheng PJ. A randomized controlled trial of antenatal pelvic floor exercises to prevent and treat urinary incontinence. *Int Urogynecol J*. 2010;22(1):17–22. doi:10.1007/s00192-010-1248-4
11. Wesnes SL, Lose G. Preventing urinary incontinence during pregnancy and postpartum: a review. *Int Urogynecol J*. 2013;24(6):889–899. doi:10.1007/s00192-012-2017-3
12. Liu W, Qian L. Establishment and validation of a risk prediction model for postpartum stress urinary incontinence based on pelvic floor ultrasound and clinical data. *Int Urogynecol J*. 2022;33(12):3491–3497. doi:10.1007/s00192-022-05395-z
13. Xiao T, Chen Y, Gan Y, Xu J, Huang WZ, Zhang XL. Can stress urinary incontinence be predicted by ultrasound? *AJR Am. J. Roentgenol*. 2019;213 (5):1163–1169. doi:10.2214/ajr.18.20893
14. Jelovsek JE, Hill AJ, Chagin KM, Kattan MW, Barber MD. Predicting risk of urinary incontinence and adverse events after midurethral sling surgery in women. *Obstet. Gynecol*. 2016;127(2):330–340. doi:10.1097/aog.0000000000001269
15. Xu C, Guo Y, Chi X, Chen Y, Chu L, Chen X. Establishment and validation of a simple nomogram for predicting early postpartum stress urinary incontinence among women with vaginal delivery: a retrospective study. *BMC. Womens. Health*. 2023;23(1):1–10. doi:10.1186/s12905-023-02160-2
16. Palmer MH, Cockerell R, Griebling TL, Rantell A, Houten P, Newman DK. Review of the 6th international consultation on incontinence: primary prevention of urinary incontinence. *Neurourol. Urodynam*. 2019;39(1):66–72. doi:10.1002/nau.24222
17. Wang Q, Que YZ, Wan XY, Lin CQ. Prevalence, risk factors, and impact on life of female urinary incontinence: an epidemiological survey of 9584 women in a Region of Southeastern China. *Risk Manag Healthc Policy*. 2023;16:1477–1487. doi:10.2147/RMHP.S421488
18. Huang L, Zhang S, Wu S, Ma L, Deng X. The Chinese version of ICIQ: a useful tool in clinical practice and research on urinary incontinence. *Neurourol Urodyn*. 2008;27(6):522–524. doi:10.1002/nau.20546
19. Pang H, Lv J, Xu T, et al. Incidence and risk factors of female urinary incontinence: a 4-year longitudinal study among 24 985 adult women in China. *BJOG*. 2021;129(4):580–589. doi:10.1111/1471-0528.16936
20. Newman DK, Cardozo L, Sievert KD. Preventing urinary incontinence in women. *Curr Opin Obstet Gynecol*. 2013;25(5):388–394. doi:10.1097/gco.0b013e328364a35d
21. Aoki Y, Brown HW, Brubaker L, Cornu JN, Daly JO, Cartwright R. Urinary incontinence in women. *Nat Rev Dis Primers*. 2017;3(1):1–20. doi:10.1038/nrdp.2017.42
22. Phelan S, Kanaya AM, Subak LL, et al. Weight loss prevents urinary incontinence in women with type 2 diabetes: results from the look AHEAD trial. *J. Urol*. 2012;187(3):939–944. doi:10.1016/j.juro.2011.10.139
23. Wang D, Hong Y, Zhu L, et al. Risk factors and outcomes of macrosomia in China: a multicen tric survey based on birth data. *J Matern Fetal Neonatal Med*. 2016;30(5):623–627. doi:10.1080/14767058.2016.1252746
24. Wesnes SL, Seim E. Birthweight and urinary incontinence after childbirth: a systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol Adv Online Publ*. 2020. doi:10.1016/j.eurox.2020.100115
25. Jelovsek JE, Chagin K, Brubaker L, et al. A model for predicting the risk of de novo stress urinary incontinence in women undergoing pelvic organ prolapse surgery. *Obstet. Gynecol*. 2014;123(2):279–287. doi:10.1097/aog.0000000000000094

26. Cheng H, Gong F, Shen Y, OuYang P, Ni R, Gao H. A nomogram model predicting the risk of postpartum stress urinary incontinence in primiparas: a multicenter study. *Taiwan. J. Obstet. Gynecol*. 2022;61(4):580–584. doi:10.1016/j.tjog.2022.04.004
27. Oh S, Lee S, Hwang WY, Suh DH, Jeon MJ. Development and validation of a prediction model for bothersome stress urinary incontinence after prolapse surgery: a retrospective cohort study. *BJOG*. 2021;129(7):1158–1164. doi:10.1111/1471-0528.17036
28. Wang X, Jin Y, Xu X, Wang H, Feng S. Development and validation of a predictive model for urinary incontinence postpartum: a prospective longitudinal study. *Int Urogynecol J*. 2022;33(6):1609–1615. doi:10.1007/s00192-022-05105-9