Original Article

Development and validation of a score for the screening of Loei urolithiasis patients

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Keywords:
Water spinach, Bamboo shoot, Laab/Koi, score, screening urolithiasis

Abstract

Objective: To evaluate risk factors associated with stone formation and development and validation of a score for screening Loei urolithiasis patients.

Materials and Methods: This cross-sectional study included 1008 individuals, 466 of which were urolithiasis patients and 542 non-urolithiasis, with no history of stone and no evidence of stone from investigations at Loei Hospital between July 2014 and January 2019. This group was used effectively as a control group. Questionnaires were used to collect information regarding demographic parameters, food and water intake and frequency. The information was used to identify any associations with stone formation using logistic regression analysis. Univariable and multivariable analysis were carried out in order to build a predictive model for the likelihood of stone formation. The strength of the classifier from the predictive model was evaluated using the area under the receiver operating characteristics (ROC) curve.

Results: Multivariable analysis showed increasing BMI (adjusted odds ratio (aOR) =1.06; 95% CI: 1.01-1.1, p = 0.01); male gender (aOR = 2.09; 95%CI: 1.46-2.98, p < 0.001); family history of urolithiasis (a OR = 2.81; 95% CI: 1.78-4.42, p < 0.001); farmer (aOR = 3.59; 95% CI: 2.44-5.29, p < 0.001); working time > 8 hours/day (aOR = 2.19; 95%CI: 1.47-3.27, p < 0.001); drinking more than 2 liters per day of water (aOR = 1.58; 95%CI: 1.13-2.22, p = 0.01); always eat water spinach (aOR = 3.37; 95% CI: 1.47-7.74, p = 0.01); always eat bamboo shoots (aOR = 9.53; 95% CI: 4.54-19.99, p < 0.001); eat Laab/Koi (a local Thai spicy salad made of raw meat and fish) more than or equal to 3 times per week (aOR = 1.75; 95% CI: 1.05-2.9, p = 0.03) and drink bottled water (aOR = 0.17.; 95% CI: 0.12-0.24, p < 0.001) were statistically significant for stone formation. The predictive model for the likelihood of stone formation has a cut-off value greater than or equal to 0.46 for a sensitivity of 72.41%, a specificity of 79.52%, and area under the ROC curve of 0.83.

Conclusions: Increasing BMI, being of male gender, a family history of urolithiasis,

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farmers, working time > 8 hours/day, regular consumption of water spinach, regular consumption of bamboo shoots, eat Laab/Koi more than or equal to 3 times per week were associated significantly with stone formation. We developed and validated a predictive model to indicate the likelihood of stone formation, which can be utilized for the screening of Loei urolithiasis patients facilitating early detection and early treatment.

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Introduction

Urolithiasis is a longstanding health problem and is of major concern in Thailand, especially in the northeast part with a prevalence of 16.9%.[1] Loei is a province in the northeast that has many urolithiasis patients. Urinary tract calculi causing pain, infection, renal failure, and death have increased annually. There has been a concordant increase in government healthcare expenditure. The major problems of urolithiasis are seen in patients with complications as a result of urolithiasis, many having large stones that are difficult to treat in comparison to small stones, and also a high recurrence of stone formation.

To date the etiology of stone formation is still not clear. Stone formation occurs as a result of multifactorial factors, urolithiasis patients in different places having differences in stone analysis.[2,3] Analysis of the risk factors for stone formation which could be used as a guide for the prevention of urolithiasis and the development of a score for screening for Loei urolithiasis patients could reduce the number of patients with complications regarding urolithiasis. The guide could also reduce the costs of treatment of stones, for example if the screening tool could be used to identify small size stones before they increased in size stone the costs would be much reduced. Therefore this research was conducted in order to develop a screening test.

Materials and Methods

Ethics statement

The study was approved by the Ethical Committee for Research in Human Subjects of Loei Hospital (Study Number: EC 009/2559).

Study design and patient selection

This research was a cross-sectional study conducted in Loei Hospital between July 2014 and January 2019. 1,008 patients were divided into 2 groups. Group 1 included urolithiasis patients, defined as having a stone in any urinary tract from radiographic or urologic investigation and group 2 included patients who were not urolithiasis. The patients in Group 2 had no history of either urolithiasis radiologic investigation, for example, ultrasound whole abdomen, and CT whole abdomen or urologic investigations such as cystoscopy, and ureterorenoscopy which had not found a stone in the urinary tract.

Data collection

Data collected included: [1] baseline characteristics and demographic data: sex, age, body mass index, comorbidities, history of family urolithiasis, previous stone treatment, occupation, education, income per month, working time and place; [2] Consumption of types of food and water related to urolithiasis

Evaluation variables

The questionnaire was used for data collection by direct interview. The workplace was divided into either an outdoor occupation (getting sunlight exposure), or an indoor occupation (e.g. office, hospital). The amount of drinking water was estimated using the question: How many glasses of water do you drink per day (1 glass of water equals 250 ml). Questions regarding frequency of consumption of specific foods were used to assess dietary risk factors for urolithiasis. Frequency of consumption was divided into 4 categories: [1] Never defined as never to eat; [2] Seldom defined as eat monthly; [3] Sometimes defined as eat weekly; [4] Always defined as eat daily. Patients were asked to recall all their consumption of the specific foods within 1 year.

Statistical analysis

Continuous variables are reported as mean and standard deviation if there is a normal distribution. Other variables are reported as median and interquartile ranges. The normality of distribution was tested using the Shapiro-Wilk test. Categorical variables are reported by frequency and percentage. Comparison of characteristics between urolithiasis and non-urolithiasis patients for the categorical variables were analyzed using Fisher's exact test and the continuous variables using the student T-test. All analyses used a $p < 0.05$ as a measure of statistical significance and the analysis was carried out using IBM SPSS Statistics for Windows version 23.0 (IBM Corp, 2015).

Model development

Variables that could potentially be statistically and clinically significant were identified from the review literature for inclusion in the analysis by univariable logistic regression. Then the variables with a $p < 0.15$ were selected to determine the potential factors affecting urolithiasis in the multivariable analysis. Complete-case analysis and backward elimination were used in this analysis. The variable with the largest p-value was deselected in each iteration until only variables with $p < 0.05$ remained in the multivariable model. The final multivariable model then included only factors that affect urolithiasis. The likelihood model was set up in exponential function (Probability = $1/e^{-y}$, when y = the multivariable model with coefficients) for predicting the likelihood of urolithiasis formation. The area under the receiver operating characteristic (AUROC) was performed by all cutoff points. We evaluated the suitable probability cutoff from the intersecting line between sensitivity and specificity versus probability cutoff. The selected cutoff point indicates the optimal maximum sensitivity and specificity.

Model validation

Datasets from other sources represented values into the multivariable model which developed from the model development stage using the training dataset. Each dataset was used to generate sensitivity, specificity, and AUROC from the model. The multiple AUROC was tested for equality using an algorithm by DeLong and Clarke-Pearson (1988). When compared models differ statistically significantly, the highest AUROC was considered the best model for predicting the likelihood of the formation of urolithiasis.

Results

Data from 1,008 individuals was divided into 466 urolithiasis patients and 542 classed as non-urolithiasis, with no history of stone and no evidence of stone from investigation. The male to female ratio in urolithiasis patients was 3.1:1, and in the non-urolithiasis group was only 1.1:1. 23.6% of urolithiasis patients had a family history of stones while only 10.5% of non-urolithiasis patients had a family history. 52.1% had a history of previous treatment for stones. Most urolithiasis patients were farmers (Table 1).

Rain water was the most frequent source of water consumed by urolithiasis patients (71.7%) while most non-urolithiasis patients drank bottled water (68.6%). Both groups favored papaya salad with pickled fish (Table 2).

Types of high oxalate vegetables[4] eaten by Loei patients are shown in table 3.

Logistic regression analysis found increasing BMI, male gender, family history of urolithiasis, farmers, working time > 8 hours/day, drinking water more than 2 liters/day, outdoor work, eating peanuts, amaranth, pea eggplant, eggplant, betel, small eggplant, Cha-om, water spinach, paprika, neem, bamboo shoots, dill and Laab/Koi, papaya salad with pickled fish, spicy shredded bamboo-shoot 3 times/week or more, and drinking rain water was significant for stone formation. Underlying disease, an income of more than 30,000 baht per month, eating fish, drinking bottled and filter water were statistically significantly associated with the prevention of stone formation as shown in table 4. These factors were selected as variables for multivariable logistic regression.

The multivariable model showed BMI, male gender, family history of urolithiasis, farmer, working time > 8 hours/day, drinking more than 2 liters of water /day, always eating water spinach, and bamboo shoots, and eating Laab/Koi 3 or more times/week were significant risk factors for stone formation. But drinking bottled water is a preventative factor for stone formation as shown in table 4.

Table 1. Demographic data of urolithiasis and non-urolithiasis (control) patients (N = 1,008)

Characteristics	Urolithiasis patients (n = 466)	Non-urolithiasis patients (n = 542)
Sex		
Male	353 (75.8)	292 (53.9)
Female	113 (24.2)	250 (46.1)
Age, median (IQR)	55 (47-63)	57 (44-69)
BMI, median (IQR)	23 (20.6-25.4)	22.1 (19.6-25.1)
Underlying diseases	174 (37.3)	285 (52.6)
Diabetes mellitus[1]	55 (11.8)	98 (18.1)
Hypertension[1]	98 (21)	151 (27.9)
Dyslipidemia[1]	19 (4.1)	53 (9.8)
Gout[1]	34 (7.3)	14 (2.6)
Chronic kidney disease[1]	9 (1.9)	28 (5.2)
History of family urolithiasis	110 (23.6)	57 (10.5)
Previous stone treatment	179 (38.4)	0 (0)
Occupations		
Farmer	376 (80.7)	230 (42.4)
Self-employed/labor	29 (6.2)	67 (12.3)
Others	61 (13.1)	245 (45.2)
Education		
Equal to or lower than Bachelor's degree	463 (99.4)	540 (99.6)
Higher than Bachelor's degree	3 (0.6)	2 (0.4)
Income per month		
≤ 10,000 Baht	358 (76.8)	429 (79.2)
10,001-20,000 Baht	79 (17.0)	64 (11.8)
20,001-30,000 Baht	20 (4.3)	24 (4.4)
> 30,000 Baht	9 (1.9)	25 (4.6)
Working times (missing 1 case-0.1%)		
≤ 8 hours/day	306 (65.8)	449 (82.8)
> 8 hours/day	159 (34.2)	93 (17.2)
Workplace		
Outdoors	406 (87.1)	292 (53.9)
Indoors	29 (6.2)	249 (45.9)
Other	31 (6.7)	1 (0.2)
Amount of water intake (missing 1 case-0.1%)		
≤ 1 liter/day	33 (7.1)	61 (11.3)
1-2 liters/day	179 (38.5)	285 (52.6)
> 2 liters/day	253 (54.4)	196 (36.2)

Data expressed as n (%) unless otherwise stated
IQR = interquartile range, BMI = body mass index
1% calculated from 466 from urolithiasis patients and 542 non-urolithiasis patients

Model development and validation

Excluded from the predictive model for stone formation is a water intake of more than 2 liters/day and drinking bottled water, which were not of clinical significance. We constructed a model to predict the probability of stone formation (Table 5) which can be seen at https://3557-171-102-53-178.ngrok.io/stone/ or scan (Figure 1A) The cut-off of probability for stone formation is 0.46 with a sensitivity of 72.41%, a specificity of 79.52%, and an area under the ROC curve of 0.83 (Figure 2). For example, a 65-year-old male, weight 65 kg, height 1.66 m (BMI = 23.59), with no family history of urolithiasis, a farmer, working time > 8 hours/day, never eats water spinach, sometimes consumes bamboo shoots, and eats Laab/Koi less than 3 times/week had a probability of stone formation

Table 2. Type of food and water-related to urolithiasis in the patient group and control group.

Characteristics	Urolithiasis patients (n = 466) n (%)	Non-urolithiasis patients (n = 542) n (%)
Type of water		
Tap water[1]	40 (8.6)	30 (5.5)
Ground water[1]	19 (4.1)	27 (5.0)
Boiled water[1]	15 (3.2)	29 (5.4)
Rain water[1]	334 (71.7)	209 (38.6)
Bottled water[1]	104 (22.3)	372 (68.6)
Filtered water[1]	11 (3.4)	42 (7.7)
Other[1]	4 (0.9)	2 (0.4)
Food that is eaten 3 or more times/week		
Noodles[1]	68 (14.6)	97 (17.9)
*Laab/Koi[1]	87 (18.7)	41 (7.6)
Papaya salad with pickled fish[1]	252 (54.1)	219 (40.4)
Chilli fried rice with holy basil (missing 1 case-0.1%)[1]	73 (15.7)	83 (15.3)
Spicy shredded bamboo-shoots[1]	201 (43.1)	110 (20.3)
Rice noodles in fish curry sauce with vegetables[1]	38 (8.2)	64 (11.8)
Chilli paste[1]	11 (2.4)	5 (0.9)
Fish[1]	36 (7.7)	64 (11.8)
Other[1]	8 (1.7)	9 (1.7)

1% calculated from 466 from urolithiasis patients and 542 non-urolithiasis patients
*Laab/Koi is a local Thai spicy salad made of raw meat and fish

Table 3. Type of high oxalate vegetable[4] and frequency to eat.

Characteristics	Urolithiasis patients (n = 466) n (%)	Non-urolithiasis patients (n = 542) n (%)
Peanut (missing 1 case-0.1%)		
Never	307 (56.6)	226 (48.6)
Seldom	188 (34.7)	150 (32.3)
Sometimes	42 (7.7)	80 (17.2)
Always	5 (0.9)	9 (1.9)
Amaranth (missing 1 case-0.1%)		
Never	362 (66.8)	265 (57)
Seldom	121 (22.3)	107 (23)
Sometimes	50 (9.2)	73 (15.7)
Always	9 (1.7)	20 (4.3)
Water fern (missing 1 case-0.1%)		
Never	480 (88.6)	373 (80.2)
Seldom	47 (8.7)	71 (15.3)
Sometimes	12 (2.2)	18 (3.9)
Always	3 (0.6)	3 (0.6)
Vietnamese coriander (missing 1 case-0.1%)		
Never	402 (74.2)	317 (68.2)
Seldom	101 (18.6)	104 (22.4)
Sometimes	37 (6.8)	36 (7.7)
Always	2 (0.4)	8 (1.7)

Table 3. Type of high oxalate vegetable and frequency to eat (continue).

Characteristics	Urolithiasis patients (n = 466) n (%)	Non-urolithiasis patients (n = 542) n (%)
Pea eggplant (missing 2 cases-0.2%)		
Never	199 (36.7)	115 (24.8)
Seldom	217 (40)	145 (31.3)
Sometimes	111 (20.5)	157 (33.8)
Always	15 (2.8)	47 (10.1)
Eggplant (missing 1 case-0.1%)		
Never	270 (49.8)	186 (40)
Seldom	194 (35.8)	168 (36.1)
Sometimes	73 (13.5)	98 (21.1)
Always	5 (0.9)	13 (2.8)
Betel (missing 2 cases-0.2%)		
Never	305 (56.3)	250 (53.9)
Seldom	173 (31.9)	130 (28)
Sometimes	58 (10.7)	75 (16.2)
Always	6 (1.1)	9 (1.9)
Small eggplant (missing 2 cases-0.2%)		
Never	246 (45.5)	165 (35.5)
Seldom	171 (31.6)	152 (32.7)
Sometimes	107 (19.8)	114 (24.5)
Always	17 (3.1)	34 (7.3)
Cha-om (missing 1 case-0.1%)		
Never	205 (37.8)	142 (30.5)
Seldom	193 (35.6)	138 (29.7)
Sometimes	130 (24)	149 (32)
Always	14 (2.6)	36 (7.7)
Water spinach (missing 1 case-0.1%)		
Never	191 (35.2)	138 (29.7)
Seldom	184 (33.9)	132 (28.4)
Sometimes	149 (27.5)	156 (33.5)
Always	18 (3.3)	39 (8.4)
Paprika (missing 1 case-0.1%)		
Never	222 (41)	132 (28.4)
Seldom	62 (11.4)	70 (15.1)
Sometimes	68 (12.5)	49 (10.5)
Always	190 (35.1)	214 (46)
Tomato (missing 3 cases-0.3%)		
Never	224 (41.4)	198 (42.7)
Seldom	173 (32)	136 (29.3)
Sometimes	115 (21.3)	93 (20)
Always	29 (5.4)	37 (8)

Table 3. Type of high oxalate vegetable and frequency to eat (continue).

Characteristics	Urolithiasis patients (n = 466) n (%)	Non-urolithiasis patients (n = 542) n (%)
Neem (missing 2 cases-0.2%)		
Never	346 (63.8)	254 (54.7)
Seldom	140 (25.8)	136 (29.3)
Sometimes	50 (9.2)	62 (13.4)
Always	6 (1.1)	12 (2.6)
Bamboo shoots (missing 1 case-0.1%)		
Never	214 (39.5)	84 (18.1)
Seldom	186 (34.3)	97 (20.9)
Sometimes	131 (24.2)	198 (42.6)
Always	11 (2)	86 (18.5)
Green pepper (missing 1 case-0.1%)		
Never	282 (52)	231 (49.7)
Seldom	175 (32.3)	138 (29.7)
Sometimes	74 (13.7)	77 (16.6)
Always	11 (2)	19 (4.1)
Basil (missing 1 case-0.1%)		
Never	199 (36.7)	170 (36.6)
Seldom	195 (36)	144 (31)
Sometimes	131 (24.2)	129 (27.7)
Always	17 (3.1)	22 (4.7)
Bean sprouts (missing 1 case-0.1%)		
Never	266 (49.1)	237 (51)
Seldom	167 (30.8)	136 (29.2)
Sometimes	100 (18.5)	84 (18.1)
Always	9 (1.7)	8 (1.7)
Dill (missing 2 cases-0.2%)		
Never	138 (25.5)	121 (26)
Seldom	193 (35.7)	115 (24.7)
Sometimes	164 (30.3)	160 (34.4)
Always	46 (8.5)	69 (14.8)

Table 4. Factors associated with stone formation using a univariable and multivariable logistic model

Variables	Univariable analysis		Multivariable analysis	
	OR (95% CI)	P-value	adjusted OR (95% CI)	P-value
Characteristics				
Age (years)	1.00 (0.99-1.01)	0.88		
BMI (kg/m^2)	1.05 (1.02-1.08)	< 0.001	1.06 (1.01-1.10)	0.01
Sex: male vs. female	2.67 (2.04-3.51)	< 0.001	2.09 (1.46-2.98)	< 0.001
Underlying disease: Yes vs. No	0.54 (0.42-0.69)	< 0.001		
Family history of urolithiasis: Yes vs. No	2.63 (1.86-3.72)	< 0.001	2.81 (1.78-4.42)	< 0.001
Education		0.54		
Equal to or below Bachelor's degree	Ref			
Higher than Bachelor's degree	1.75 (0.29-10.51)			

Table 4. Factors associated with stone formation using a univariable and multivariable logistic model (continue)

Variables	Univariable analysis		Multivariable analysis	
	OR (95% CI)	P-value	adjusted OR (95% CI)	P-value
Occupation		< 0.001		< 0.001
Other	Ref		Ref	
Farmer	6.57 (4.74-9.09)		3.59 (2.44-5.29)	
Self-employed/laborer	1.74 (1.04-2.92)		1.01 (0.55-1.90)	
Income per month Baht)		0.02		
> 30,000	Ref			
20,001-30,000	2.31 (0.88-6.08)			
10,001-20,000	3.43 (1.49-7.86)			
≤ 10,000	2.32 (1.07-5.03)			
Working time: > 8 vs. < 8 hours/day	2.51 (1.87-3.37)	< 0.001	2.19 (1.47-3.27)	< 0.001
Workplace: outdoors vs. indoors	5.79 (4.21-7.97)	< 0.001		
Amount of water intake: > 2 vs. < 2 liters/day	2.11 (1.64-2.71)	< 0.001	1.58 (1.13-2.22)	0.01
High oxalate vegetables and frequency eaten				
Peanuts		< 0.001		
Never or seldom	Ref			
Sometimes	2.51 (1.69-3.73)			
Always	2.37 (0.79-7.13)			
Amaranth		< 0.001		
Never or seldom	Ref			
Sometimes	1.9 (1.29-2.78)			
Always	2.89 (1.3-6.41)			
Pea eggplant		< 0.001		
Never or seldom	Ref			
Sometimes	2.26 (1.7-3.02)			
Always	5.01 (2.75-9.15)			
Eggplant		< 0.001		
Never or seldom	Ref			
Sometimes	1.76 (1.26-2.46)			
Always	3.41 (1.2-9.65)			
Betel		0.02		
Never or seldom	Ref			
Sometimes	1.63 (1.13-2.35)			
Always	1.89 (0.67-5.35)			
Small eggplant		< 0.001		
Never or seldom	Ref			
Sometimes	1.4 (1.04-1.89)			
Always	2.63 (1.44-4.79)			
Cha-om		< 0.001		
Never or seldom	Ref			
Sometimes	1.63 (1.23-2.16)			
Always	3.66 (1.94-6.9)			

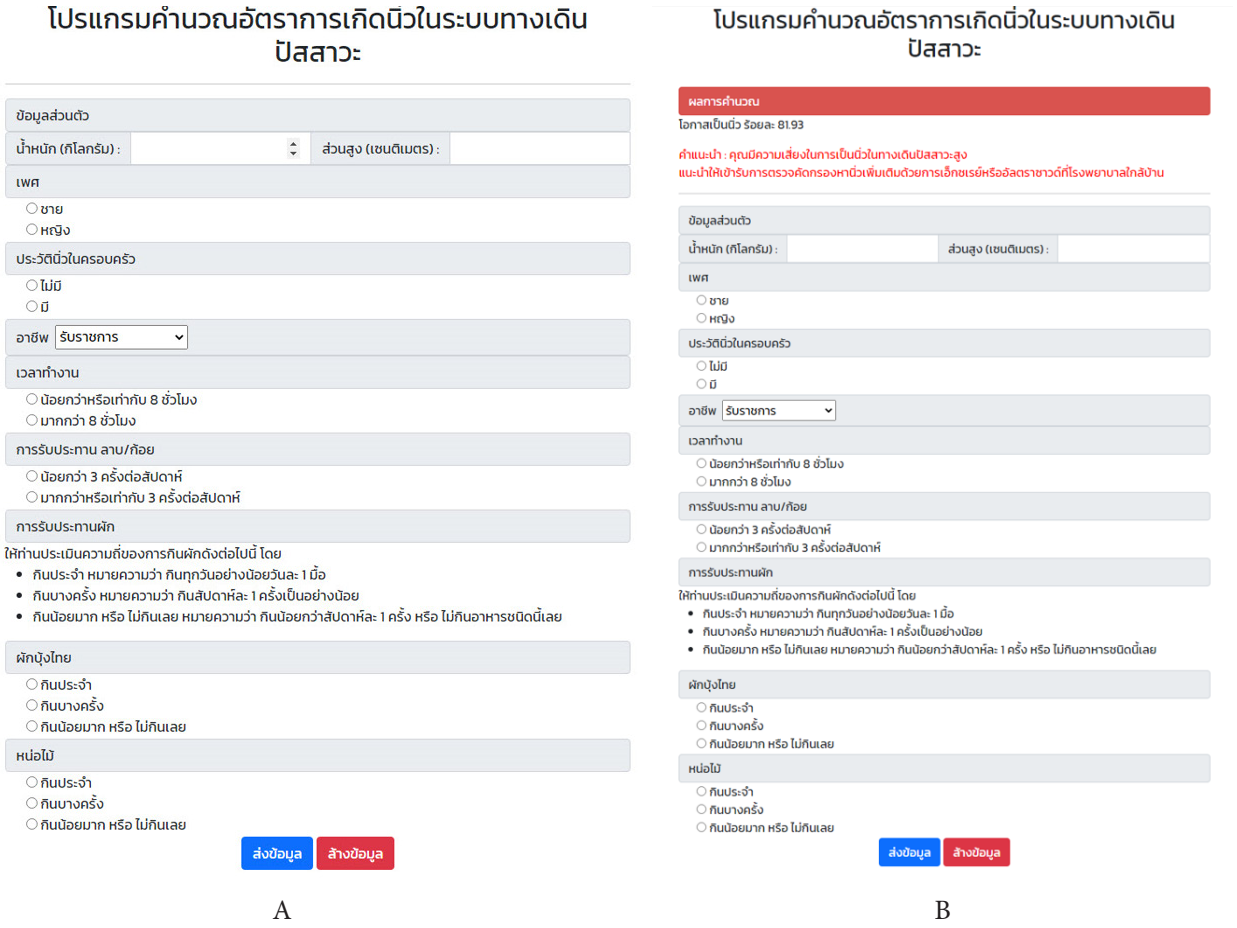
Table 4. Factors associated with stone formation using a univariable and multivariable logistic model (continue)

Variables	Univariable analysis		Multivariable analysis	
	OR (95% CI)	P-value	adjusted OR (95% CI)	P-value
Water spinach		< 0.001		0.01
Never or seldom	Ref		Ref	
Sometimes	1.45 (1.11-1.91)		1.32 (0.92-1.89)	
Always	3.01 (1.68-5.37)		3.37 (1.47-7.74)	
Paprika		< 0.001		
Never or seldom	Ref			
Sometimes	1.01 (0.67-1.53)			
Always	1.58 (1.21-2.07)			
Neem		0.02		
Never or seldom	Ref			
Sometimes	1.55 (1.04-2.3)			
Always	2.49 (0.93-6.7)			
Bamboo shoot		< 0.001		< 0.001
Never or seldom	Ref		Ref	
Sometimes	3.34 (2.52-4.43)		2.56 (1.81-3.62)	
Always	17.28 (9-33.15)		9.53 (4.54-19.99)	
Dill		< 0.001		
Never or seldom	Ref			
Sometimes	1.37 (1.04-1.80)			
Always	2.10 (1.40-3.17)			
Type of food eaten 3 or more times/week				
Laab/Koi: Yes vs. No	2.81 (1.89-4.16)	< 0.001	1.75 (1.05-2.90)	0.03
Papaya salad with pickled fish: Yes vs. No	1.74 (1.35-2.23)	< 0.001		
Spicy shredded bamboo-shoot: Yes vs. No	2.98 (2.26-3.93)	< 0.001		
Fish: Yes vs. No	0.63 (0.41-0.96)	0.03		
Type of drinking water				
Rain water: Yes vs. No	4.03 (3.09-5.26)	< 0.001		
Bottled water: Yes vs. No	0.13 (0.10-0.17)	< 0.001	0.17 (0.12-0.24)	< 0.001
Filtered water: Yes vs. No	0.42 (0.21-0.84)	0.01		

OR = odds ratio, BMI = body mass index

Table 5. Probability of stone formation.

Probability stone formation = $1 / (1+e^{-\{-3.800+[0.842*Male]+[0.042*BMI]+[0.962*Family\ history\ of\ urolithiasis]+[1.597*Farmer]+[0.108*(Self\text{-}employed/Laborer)]+[0.826*(Working\ time > 8\ hours/day)]+[0.214*sometimes\ eats\ water\ spinach]+[1.032*\ always\ eats\ water\ spinach]+[1.056*\ sometimes\ eats\ bamboo\ shoots]+[2.581*\ always\ eats\ bamboo\ shoots]+[0.693*eats\ Laab/Koi\ 3\ or\ more\ times/week]\}}$



A B

Figure 1 A. A web-based application for the calculation of the probability stone formation was posted at https://3557-171-102-53-178.ngrok.io/stone/. B. For example: a 65-year-old male, weight 65 kg, height 1.66 m (BMI = 23.59), no family history of urolithiasis, farmer, working time > 8 hours/day, never eats water spinach, sometimes consumes bamboo shoots, and eats Laab/Koi less than 3 times/week. There was a probability of stone formation of 0.8193 (81.93%) that more than 0.46 (46%) advised further investigation for urolithiasis

of 0.8193(81.93%) (Figure 1B) that more than 0.46 (46%) advised further investigation for urolithiasis

Discussion

Urolithiasis is major health problem at Loei Hospital which has recorded an average of 3,083 urolithiasis patients per year.[5]

Urolithiasis has a range of risk factors, including intrinsic factors (age, gender, ethnicity, family history of stone) and extrinsic factors (climate, lifestyle, dietary habits, occupation, and education).[6] We conducted this research at Loei Hospital in order to discover the risk factors for stone formation with the aim of decreasing the incidence and severity of urolithiasis in Loei province.

Aegukkatajit found the most frequent age range of urolithiasis patients in the North east of Thailand was between 41-50 years old[7] which differed from the range of 51-60 found in this study. This is probably due to Loei urolithiasis patients first presenting with symptoms at 42-43 years of age but only beginning to seek treatment 3-4years after that resulting in Loei patients being older than average.[5]

The male to female ratio of Loei urolithiasis patients was 3.1 : 1 which is similar to the male to female ratio of 2.3-4 : 1 found in a study in the Ubonratchathani province.[8] This higher frequency of urolithiasis in males can be explained by the effect of testosterone which increases the synthesis of oxalate in the liver. The inhibitory effect by estrogen on urinary citrate in females also results in lower oxalate levels than in males.[9]

In this study we found that increasing BMI can increase the incidence of stone formation. A study by Taylor, Semin, and Kim[10-12] offers evidence to show that obesity can produce hyperinsulinemia which results in a significant increase

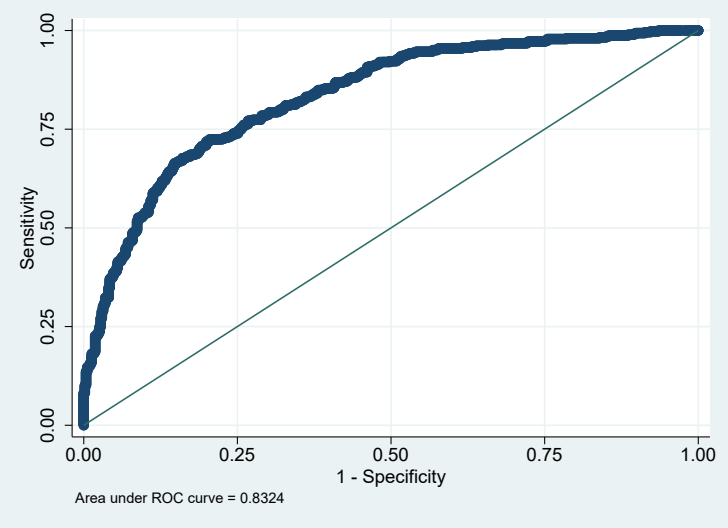


Figure 2. The ROC curve for the predictive model

in urinary calcium excretion.[13] A family history of urinary tract calculi has been shown in several studies to increase the risk of stone formation by 16-37%.[14,15] In this study in Loei urolithiasis patients a family history was also found to be a statistically significant risk for stone formation.

Having an outside occupation, farming in this study, was a significant risk factor for stone formation. This can be explained by working at the high temperatures typical of the Loei climate and also having a working time of more than 8 hours per day. These factors cause sweating and hence increasing the concentration of oxalate in the urine, increasing the risk of stone formation.

Dietary factors are important factors in stone formation.[16] Drinking more than 2 liters of water per day can prevent stone formation[17] but interestingly our study found that most urolithiasis patients drank more than 2 liters of water per day. This may be due to changes in the behavior of patients after a diagnosis of urolithiasis. Drinking bottled water was a statistically significant factor for stone prevention but drinking bottled water was just a favor in Loei within 5 years that Bottled water was may not real factor for stone prevention.

Stone analysis in Loei shows that oxalate is the most common component.[5] Therefore we explored the rate of consumption of high oxalate vegetables which were favored by the Loei population and found water spinach and bamboo shoots were statistically significant for stone formation and it was found that an increase in frequency intake resulted in an increased risk of urolithiasis. Laab/Koi eaten 3 or more times per week was statistically significant for stone formation. Laab/Koi is made from several vegetables high in oxalate such as paprika, betel, Vietnamese coriander, basil, small eggplant, and Neem[4] which can increase the risk of stone formation. Also the daily lifestyle of the Loei population frequently includes a high carbohydrate, low fat, low citric acid diet resulting in hypocitrauria[18,19] and these dietary factors may increase the incidence of urolithiasis in the Loei population.

In this study, we conducted logistic regression model in order to predict the chance of stone formation in Loei enabling screening for urolithiasis to facilitate early detection and early treatment. Our model has several strengths. First, the predictive model is easy to use, not only for urologists, but also for nurses and even the general population. Secondly, the predictive scoring system can be applied from the patient's history rather than by investigations such as scans, facilitating its use in less well-equipped facilities.

However, some limitations need to be addressed. First, in the case of the non- urolithiasis patients the ultrasound scans may have missed tiny stones meaning these patients should have been in the other group. Secondly, a food frequency questionnaire was used for data collection which could potentially result in recall bias.

Conclusion

Increasing BMI, male gender, family history of urolithiasis, farmer, working time > 8 hours/day, eating water spinach and bamboo shoots, and eating Laab/Koi 3 or more times per week were found to be significant factors for stone forma-

tion. This study is the first to publish a method of calculating a score which can be used to screen urolithiasis patients in Thailand facilitating early detection and early treatment of urolithiasis.

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Conflict of Interest

The authors declare no conflict of interest.

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