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Received for publication: 22.6.09; Accepted in revised form: 5.11.09

Nephrol Dial Transplant (2010) 25: 1567–1575
doi: 10.1093/ndt/gfp669
Advance Access publication 27 December 2009

Prevalence and risk factors of chronic kidney disease in the Thai adult population: Thai SEEK study

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Abstract

Background. Previous reports of chronic kidney disease (CKD) prevalence in Thailand varied from 4.3% to 13.8%. However, there were methodological concerns with these reports in terms of generalization and the accuracy of estimation. This study was, therefore, conducted to determine CKD prevalence and its risk factors in Thai adult populations.

Methods. The population-based Thai Screening and Early Evaluation of Kidney Disease (SEEK) study was conducted with cross-sectional stratified-cluster sampling. Serum creatinine was analysed using the modified Jaffe method and then standardized with isotope dilution mass spectrometry.

Results. The study included 3,459 subjects were included in the study. The mean age was 45.2 years (SE = 0.8), and 54.5% were female. Six hundred and twenty-six subjects were identified as having CKD, which evidenced an overall CKD prevalence of 17.5% [95% confidence interval (95% CI) = 14.6–20.4%]. The CKD prevalence of Stages I, II, III and IV were 3.3% (95% CI = 2.5%, 4.1%), 5.6% (95% CI = 4.2%, 7.0%), 7.5% (95% CI = 6.2%, 8.8%) and 1.1% (95% CI = 0.7%, 1.5%), respectively. The prevalence of CKD was higher in Bangkok, the Northern and Northeastern regions than in the Central and Southern regions. Seven factors (i.e. age, gender, diabetes, hypertension, hyperuricaemia, history of kidney stones and the use of traditional medicines) were associated with

CKD. Only 1.9% of the subjects were aware that they had CKD.

Conclusions. CKD prevalence in the Thai population is much higher than previously known and published. Early stages of CKD seem to be as common as later stages. However, albuminuria measurement was not confirmed and adjusting for persistent positive rates resulted in the prevalence of 14.4%. Furthermore, the awareness of CKD was quite low in the Thai population.

Keywords: chronic kidney disease; population-based; prevalence; risk factor; stratified-cluster sampling

Introduction

Chronic kidney disease (CKD) is an important risk factor for cardiovascular disease and mortality and can progress to end-stage renal disease (ESRD), requiring dialysis or transplantation. Compared to the CKD prevalence reported from the United States, China and Japan, reports from Thailand showed that CKD prevalence fluctuated from a much lower to a high rate of occurrence, i.e. ranged from +AH44.6% to 13.8% [1–3]. The low prevalence by the Royal Thai Air Force study would suggest that CKD is not a major public health problem in Thailand. On the other hand, methodological concerns with the Thai Air force study [1] raise doubts about the generalizability and accuracy of the current prevalence estimates. This is because the study enrolled only Thai Air Force members aged 19 to 65 years and screened for macroproteinuria. However, some of the low prevalence rates of CKD in Thailand that are reported in the literature seem at odds with the relatively high prevalence rates for treated ESRD of 220–286 per million population [4]. An accurate estimate of CKD magnitude is crucial for its ranking as a public health priority in Thailand. Furthermore, accurate data are essential for adequate allocation of educational resources and awareness programs, designing screening strategies and planning of nephrological resources for the care of CKD patients.

The objectives of the current study were to perform a cross-sectional survey to estimate CKD prevalence and to identify predictors of CKD using a standardized method for GFR estimation in representative Thai adult populations. We took advantage of methods utilized in other countries as part of the Global Screening and Early Evaluation of Kidney Disease (SEEK) program.

Materials and methods

Study design and subjects

A community-based cross-sectional survey study was conducted between August 2007 and June 2008. Thai male and female subjects with the following criteria were included: aged 18 or older, no menstruation period and no fever for at least a week before examination date and willingness to participate and provide a signed consent form. Subjects were excluded if blood or urine specimens were not taken. The study was approved by three Thai Institutional Review Boards (IRB), i.e. the IRB of the Faculty of Medicine at Ramathibodi Hospital, Mahidol University, the IRB of the Ministry of Public Health and as a part of the Global SEEK program by Partners Healthcare IRB in Boston, USA.

Sampling method

Four regions of Thailand (i.e. Northern, Northeastern, Central and Southern) and Bangkok (metropolitan) were treated as strata. Stratified-cluster random sampling was applied to selected subjects. At the first stage, two to three provinces in each region were randomly selected. Each selected province was next classified as either an urban or rural area, and then one district from each area was randomly selected (i.e. the second-stage sampling unit). There were, in total, 10 provinces (i.e. Bangkok, Cholburi, Lopburi, Payau, Prae, Sakolnakorn, Nong-Bau Lamphu, Mahasarakam, Puket and Songkhla), and 20 districts were chosen for study sampling. Finally, subjects in each sampled district were randomly selected stratified by age group (i.e. 18–30, 31–40, 41–50, 51–60, 61–70 and >70 years) and gender. Data registry of health coverage of local hospitals were retrieved and used for this sampling.

Sample size estimation

Sample size estimation was performed based on an estimation of the prevalence of CKD, which varied from 3% to 13.7% as per previous reports [1,2,5,6]. Type 1 error, confidence interval width and expected prevalence were set at 5%, +AH4±2.1% and 13.7%, respectively. A design effect for stratified-cluster sampling was set as three times higher than simple random sampling. If 3000 subjects were enrolled, the expected prevalence rate would lie between 11.7% and 16.0%. The percentage of missing data was set at 10%, and thus at least 3300 subjects were needed for sampling. The sample size for each district–province was calculated proportionally to their census population as of 2007 [7].

Data collection and measurements

Data collection was performed in 10 provinces at 20 camp sites. Data collection teams at each site consisted of five to seven nurses and technicians and 15 interviewers led by a nephrologist. Teams were given orientation and informed of their responsibilities 1 day in advance of camp set-up. Subjects were interviewed by well-trained interviewers using standard questionnaires. Arterial blood pressure was measured twice after a rest for 15 min using mercury sphygmomanometers. The mean of the two measurements was used in the analysis. Physical examinations (e.g. weight, height, waist and hip circumferences) were performed by nurses. All subjects were instructed to maintain an 8-h, overnight fast before performing blood chemistry tests (e.g. plasma glucose, lipid profile, haemoglobin, uric acid) and urine collection the following day. Blood analyses were processed (i.e. centrifuged and separated) and transported at controlled temperatures (4–9°C) within 24 h to the Central Laboratory Department at Ramathibodi Hospital, Bangkok. Urine analysis and supernatant were performed at the local camp site.

All blood chemistry was measured using the Dimension RxL MAX analyser (Siemens Healthcare Diagnostics, USA). The Ramathibodi Central Laboratory Department was certified by the US Centers for Disease Control (National Heart, Lung and Blood Institute Lipid Standardization Program).

Urine albumin was measured using the immunoturbidimetry technique with the COBAS INTEGRA 700 analyser (Roche Diagnostics, USA).

Creatinine gas chromatography/isotope dilution mass spectrometry traceability

Serum creatinine was measured using the modified Jaffe method, and three-levels were calibrated using CHEM I calibrators provided by the manufacturer.

In addition, serum creatinine was further standardized using the SRM-967 as a calibrator. Regression analysis was applied to construct a calibration equation between the isotope dilution mass spectrometry (IDMS) and the modified Jaffe methods. This equation, based on the conventional unit (CU) unit, was finally used to calibrate the whole modified Jaffe serum creatinine to the IDMS serum creatinine as shown below:

$$\text{IDMS} = -0.0067 + 0.9525 \times \text{MJ}$$

The glomerular filtration rate (GFR) was then calculated using the modification of diet in renal disease (MDRD) equation for the IDMS traceable serum creatinine values as follows [8]: estimated glomerular

Table 1. General characteristics of subjects enrolled in the Thai SEEK study

Characteristics	Number (n = 3459)	% (SE)
Age, year, mean (SE)		45.19 (0.79)
Sex		
Male	1569	45.46 (0.02)
Female	1890	54.54 (0.02)
Income, Baht		
≤2000	264	6.71 (0.01)
2001–5000	1106	27.96 (0.04)
5001–10 000	935	28.10 (0.01)
10 001–15 000	455	14.29 (0.01)
>15 000	629	21.00 (0.04)
No income	62	1.93 (0.00)
Education		
Primary	1985	55.69 (0.03)
Secondary	975	29.09 (0.02)
Diploma	148	4.65 (0.01)
Bachelor's degree	194	6.17 (0.01)
Master's degree	12	0.39 (0.00)
None	128	4.01 (0.01)
BMI, kg/m^2, mean (SE)		24.03 (0.21)
<25	2250	63.86 (0.02)
25–29	924	27.26 (0.02)
≥30	285	8.88 (0.01)
WHR, mean (SE)		0.84 (0.01)
Smoke, cigarettes per day		
0	2194	65.99 (0.02)
1–10	823	23.9 (1.02)
>10	331	10.09 (0.01)
Alcohol		
Current	1596	45.19 (0.02)
Ever	488	13.77 (0.01)
Never	1360	41.04 (0.03)
Exercise		
Yes	2057	59.85 (0.03)
No	1390	40.15 (0.03)
Work involve significant physical activity		
Yes	2115	57.96 (0.05)
No	1296	42.04 (0.05)
Underlying disease		
History of diabetes		
Yes	331	8.88 (0.01)
No	3098	91.12 (0.01)
Fasting plasma glucose, mg/dl, mean (SE)		99.96 (0.73)
≥126	276	7.66 (0.01)
<126	3183	92.34 (0.01)
Diabetes		
Yes	434	11.92 (0.01)
No	3025	88.08 (0.01)
History of hypertension		
Yes	563	16.47 (0.01)
No	2887	83.53 (0.01)
SBP ≥140 or DBP ≥90 mmHg		
Yes	676	19.74 (0.02)
No	2783	80.26 (0.02)
Hypertension		
Yes	955	27.52 (0.02)
No	2504	72.48 (0.02)
History of high cholesterol		
Yes	300	11.62 (0.03)
No	2574	88.38 (0.03)
Cholesterol level, mg/dl, mean (SE)		204.59 (1.41)
≥240	642	19.90 (0.02)
<240	2816	80.10 (0.02)
Abnormal cholesterol		
Yes	851	26.39 (0.03)
No	2608	73.61 (0.03)
History of heart disease		
Yes	118	3.37 (0.00)
No	3124	96.63 (0.00)
Cerebrovascular accident		
Yes	44	1.35 (0.00)
No	3385	98.65 (0.00)
Anaemia		
Yes	269	6.97 (0.01)
No	3129	93.03 (0.01)
History of kidney stone		
Yes	169	5.04 (0.00)
No	3085	94.96 (0.00)
LDL, mg/dl		
<130	1979	57.55 (0.02)
130–159	807	23.27 (0.01)
≥160	591	19.19 (0.02)
Serum creatinine, mg/dl, mean (SE)		
Male	1569	1.07 (0.02)
Female	1890	0.83 (0.02)
Uric acid, mg/dl, mean (SE)		5.32 (0.03)
Haemoglobin, mg/dl, mean (SE)		13.36 (0.09)
NSAIDs		
Yes	1577	44.71 (0.02)
No	1882	55.29 (0.02)
Using traditional medicine		
Yes	1143	33.49 (0.02)
No	2300	66.51 (0.02)
Family history		
Diabetes		
Yes	860	27.21 (0.02)
No	2316	72.79 (0.02)
Hypertension		
Yes	1014	34.08 (0.01)
No	1976	65.92 (0.01)
High cholesterol		
Yes	265	10.77 (0.02)
No	2358	89.23 (0.02)
Heart disease		
Yes	382	12.80 (0.01)
No	2770	87.20 (0.01)
Cerebrovascular accident		
Yes	125	4.14 (0.00)
No	3058	95.86 (0.00)
Anaemia		
Yes	145	4.19 (0.00)
No	2807	95.81 (0.00)
Stone		
Yes	289	8.15 (0.01)
No	2826	91.85 (0.01)
Renal disease		
Yes	230	7.26 (0.00)
No	2820	92.74 (0.00)

SBP, systolic blood pressure; DBP, diastolic blood pressure.

filtration rate (eGFR) (in millilitres per minute per 1.73 m^2) = 175 × (serum creatinine)$^{-1.154}$ × (age)$^{-0.203}$ × (0.742 if female).

Definitions

CKD staging was defined considering kidney function with or without kidney damage [9] as follows: CKD Stages I and II were defined as GFR >90 and 60–89 ml/min/1.73 m^2, respectively, with haematuria and/or albumin–creatinine ratio 30 mg/g or greater, whereas Stages III, IV and V were defined as GFR 30–59, 15–29 and <15 ml/min/1.73 m^2, regardless of kidney damage.

Haematuria was defined by the presence of more than five red blood cells per high-power ocular field in spun urine sediment. Microalbumi-

Table 2. Estimation of CKD prevalence according to gender

		CKD staging								Overall	
		I		II		III		IV			
Gender	*n*	No.[a]	Prevalence[b] (%)	No.	Prevalence (%)	No.	Prevalence (%)	No.	Prevalence (%)	No.	Prevalence (%)
Male	1569	51	2.6 (1.4, 3.8)	100	5.8 (4.0, 7.6)	104	6.9 (4.9, 8.9)	15	0.9 (0.5, 1.3)	270	16.3 (12.5, 20.0)
Female	1890	83	3.8 (2.8, 4.9)	107	5.4 (3.5, 7.4)	144	8.0 (6.0, 9.9)	22	1.3 (0.6, 2.0)	356	18.5 (14.8, 22.3)
Overall	3459	134	3.3 (2.5, 4.1)	207	5.6 (4.2, 7.0)	248	7.5 (6.2, 8.8)	37	1.1 (0.7, 01.5)	626	17.5 (14.6, 20.4)
			8.9 (6.8, 11.0)				8.6 (7.0, 10.3)				

[a]Number of CKD patients from our samples.
[b]Standardized prevalence to the national distribution for that gender.

nuria was defined as having an albumin–creatinine ratio of 30 to 300 mg/g without regard to gender.

The classification of subjects with hypertension, diabetes and high cholesterol was based on history, relevant medicines used, blood tests and physical examinations. For instance, subjects were classified as having diabetes if they had one of the following criteria: self-reported as being told by doctors that they had diabetes, if they were taking oral hypoglycaemic agents or fasting plasma glucose levels ≥126 mg/dl. Subjects were classified as having hypertension if they were told by doctors, taking antihypertensive drug(s) or had systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg. Anaemia was diagnosed if subjects had haemoglobin levels <11 g/dl.

Statistical analysis

Data record forms were transported to the central data management centre, Section for Clinical Epidemiology and Biostatistics, Faculty of Medicine, Ramathibodi Hospital. Quality control programs were developed while doing data entry. EpiData version 3.1 was used for all databases.

Data were respectively described using the mean (±SE) and proportion (±SE) for continuous and categorical data. The prevalence of CKD was estimated according to the sampling methods. Three-stage sampling weight was applied to estimate prevalence using data from the Thai population (2007 census), Ministry of the Interior [7]. The weight was calculated by 1/[(probability of sampling provinces) × (probability of sampling districts) × (probability of sampling subjects)] in which probabilities of sampling were calculated as follows: The probability of sampling provinces was estimated by the number of sample provinces divided by the total number of provinces in that stratum (region). The probability of sampling districts was calculated by the numbers of sample districts divided by the total numbers of districts in the sample province. Finally, the probability of sampling subjects was estimated by using the number of subjects divided by the size of the population of the sample district. Overall CKD prevalence and gender-, age- and region-specific prevalence were estimated along with a 95% confidence interval (95% CI).

Factors associated with CKD were assessed using simple logistic regression for survey data analysis. Factors with *P*-values <0.15 were simultaneously included into the multivariate logistic model. Adjusted odds ratios (OR) and 95% CI were estimated. Goodness of fit of the model was assessed using chi-square test. All analyses were performed using STATA 10.1.

Results

Three thousand, four hundred and fifty-nine subjects were included in the study. The characteristics of the subjects are described in Table 1. The mean age of subjects was 45.2 years (SE = 0.8), 54.5% were females and 36.1% had a BMI of 25 kg/m^2 or higher. Mean waist–hip ratio (WHR) was 0.8 (SE = 0.01). For blood chemistry tests, the mean fasting plasma glucose, cholesterol level, uric acid and haemoglobin were 99.96 (SE = 0.73), 204.59 (SE = 1.41), 5.32 (SE = 0.03) and 13.36 (SE = 0.09), respectively. The prevalence of diabetes mellitus was 11.9%, whereas the prevalence of hypertension and high cholesterol were as high as 27.5% and 26.4%, respectively. Mean serum creatinine in males and females were 1.1 mg/dl (SE = 0.02) and 0.8 mg/dl (0.02), respectively. A history of taking non-steroidal anti-inflammatory drugs (NSAIDs) and traditional medicines was reported by 44.7% and 33.5%, respectively.

Prevalence of CKD

The prevalence of CKD was estimated according to gender (Table 2). Among 3459 subjects, 626 subjects were classified as having CKD and resulted in an overall CKD prevalence of 17.5% (95% CI = 14.6–20.4%). CKD Stages I and II (8.5% and 9.3% in males and females, respectively) were as high as the aggregates of Stage III, IV and V (7.8% and 9.3% in males and females).

Age- and gender-specific prevalence

CKD prevalence was also estimated according to age and gender groups. We observed higher rates of CKD with increased age in both males and females (Figure 1). Extrapolating the CKD prevalence observed in our study to the Thai general population using the Thai Census Data in 2008[10], there were 15 065 000 adult males and 24 249 000 adult females in Thailand. Our estimates demonstrated that the number of male subjects with CKD aged <40, 40–59, 60–69 and ≥70 years were 392 000 (95% CI = 192 000–591 000), 884 000 (95% CI = 723 000–1 046 000), 416 000 (95% CI = 313 000–518 000) and 471 000 (95% CI = 257 000–686 000), respectively, and for females with the corresponding age ranges, 952 000 (95% CI = 556 000–1 348 000), 1 531 000 (95% CI = 1 233 000–1 830 000), 812 000 (95% CI = 494 000–1 131 000) and 971 000 (95% CI = 598 000–1 344 000), respectively.

CKD prevalence by region

The prevalence of CKD was estimated by region (Figure 2). CKD was highest in Bangkok (23.9%, 95% CI = 22.1–25.8%), followed by the Northeastern (22.2%, 95% CI = 17.7–26.8%) and the Northern regions (20.4%,

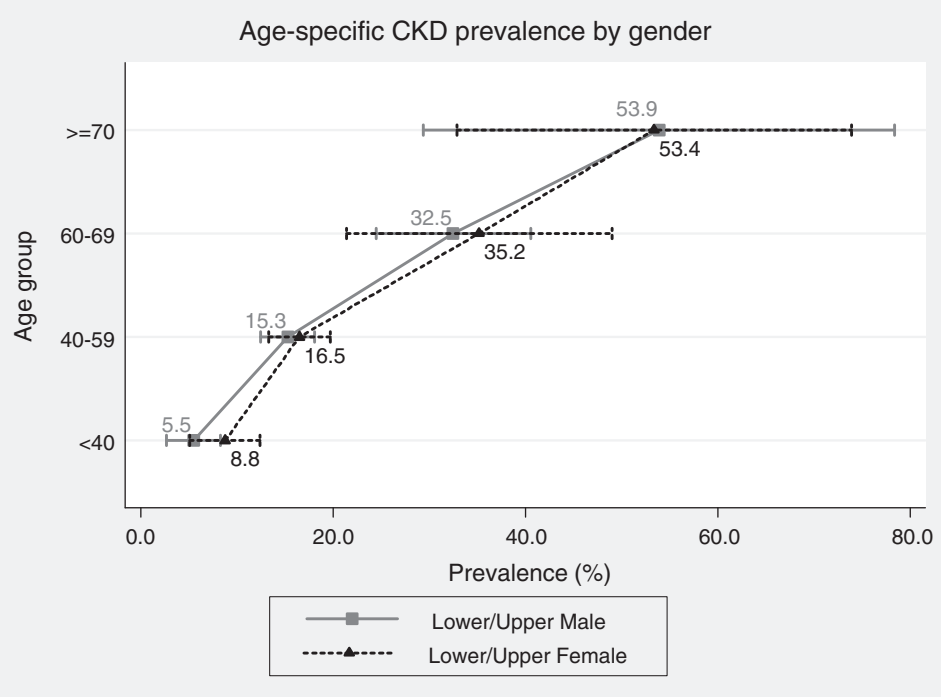

Fig. 1. Age-specific CKD prevalence by sex.

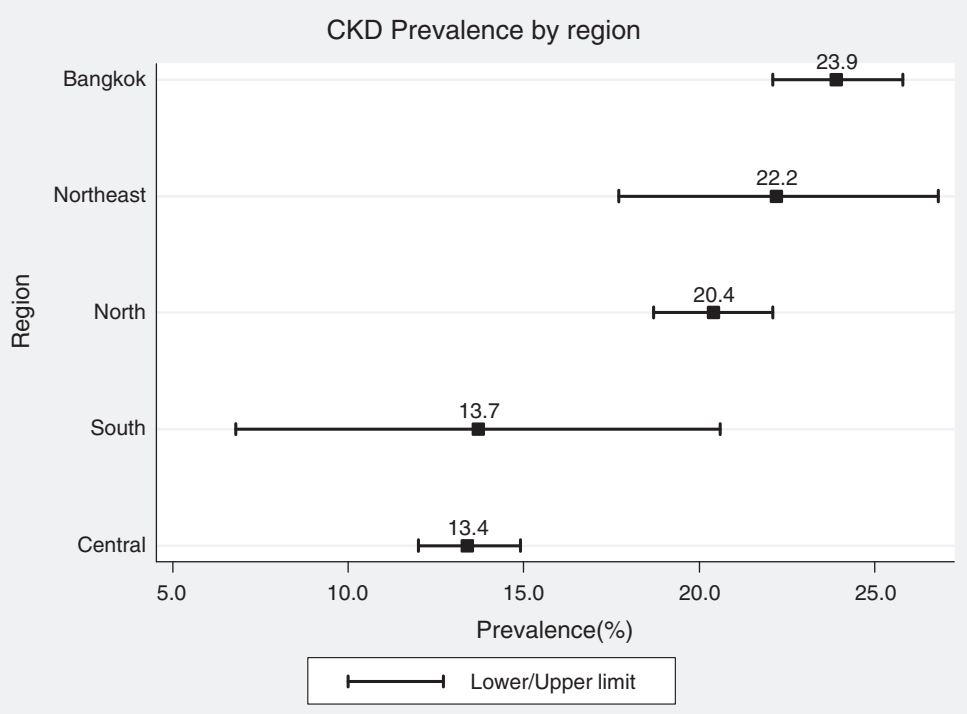

Fig. 2. Prevalence of CKD by region.

95% CI = 18.7–22.1%). The prevalence in the Central and Southern regions were approximately 13% each.

Factors associated with CKD

A univariate analysis was conducted to assess the association between CKD and risk factors. Subjects with CKD Stage I–V were aggregated and compared with normal subjects. The odds of having CKD were estimated for 16 factors: age, gender, body mass index (BMI), WHR, smoking, alcohol, exercise, involvement in a significant working activity, low-density lipoprotein (LDL), cholesterol, uric acid, diabetes, hypertension, history of kidney stone, use of traditional medicine and NSAIDs (Table 3).

Table 3. Assessing factors associated with CKD

	CKD				Unadjusted OR		Adjusted OR	
	Stages I–V		Normal					
Factors	Number	%	Number	%	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Age, year								
≥70	139	22.26	128	4.08	14.83 (8.46, 25.99)	<0.001	7.34 (4.18, 12.90)	<0.001
60–69	148	22.85	255	9.40	6.60 (4.22, 10.33)	<0.001	3.63 (2.26, 5.86)	0.001
40–59	237	39.19	1227	43.85	2.43 (1.77, 3.33)	0.001	1.71 (1.16, 2.52)	0.017
<40	102	15.70	1223	42.67	1	1		
History of kidney stone								
Yes	74	11.30	95	3.72	3.30 (2.09, 5.21)	0.001	2.72 (1.80, 4.12)	0.002
No	516	88.70	2569	96.28	1	1		
Diabetes								
Yes	183	28.48	251	8.40	4.34 (2.87, 6.55)	<0.001	2.72 (1.57, 4.73)	0.005
No	443	71.52	2582	91.60	1	1		
Hypertension								
Yes	329	53.60	626	21.99	4.10 (2.94, 5.72)	<0.001	1.96 (1.44, 2.67)	0.002
No	297	46.40	2207	78.01	1	1		
Uric acid, mg/dl								
>5.61	331	55.03	938	35.09	2.68 (1.79, 4.01)	0.001	2.87 (1.77, 4.64)	0.002
4.40–5.61	166	26.58	960	33.49	1.36 (0.89, 2.07)	0.123	1.50 (0.92, 2.46)	0.087
<4.40	129	18.39	935	31.42	1	1		
Using traditional medicine								
Yes	263	42.65	880	31.55	1.61 (1.38, 1.89)	0.001	1.20 (1.02, 1.42)	0.035
No	361	57.35	1939	68.45	1	1		
Sex								
Female	356	57.77	1534	53.86	1.17 (0.85, 1.61)	0.253	1.70 (1.18, 2.43)	0.013
Male	270	42.23	1299	46.14	1	1		
BMI, kg/m^2								
≥30	65	11.71	220	8.29	1.59 (1.15, 2.20)	0.014		
25–29.9	191	30.45	733	26.58	1.29 (1.01, 1.65)	0.045		
<25	370	57.84	1880	65.13	1			
Waist/hip								
Male Female								
≥0.96 ≥0.90	117	18.57	237	7.37	2.87 (1.70, 4.83)	0.004		
<0.96 <0.90	509	81.43	2595	92.63	1			
Smoking, cigarette per day								
1–10	157	23.53	666	25.73	1.10 (0.78, 1.53)	0.191		
>10	53	10.46	278	8.34	0.80 (0.54, 1.18)	0.516		
0	391	66.01	1803	65.93	1			
Alcohol consumption								
Yes	326	49.51	1758	60.97	1.59 (1.02, 2.49)	0.044		
No	299	50.49	1061	39.03	1			
Exercise								
Yes	380	61.87	1677	59.42	1.11 (0.94, 1.30)	0.164		
No	242	38.13	1148	40.58	1			
Work involve significant activity								
Yes	323	49.18	1792	59.85	1.54 (1.13, 2.11)	0.016		
No	297	50.82	999	40.15	1			
Abnormal cholesterol								
Yes	203	34.31	648	24.71	1.59 (1.21, 2.09)	0.007		
No	423	65.69	2185	75.29	1			
LDL, mg/dl								
≥160	116	20.89	475	18.83	1.11 (0.78, 1.56)	0.490		
130–159	134	21.39	673	23.66	0.90 (0.73, 1.11)	0.263		
<130	359	57.72	1620	57.51	1			
NSAIDs								
Yes	308	48.33	1269	43.94	1.19 (0.83, 1.72)	0.266		
No	318	51.67	1564	56.06	1			

In addition, family history (i.e. father, mother and sibling) of chronic diseases (i.e. high cholesterol, diabetes, hypertension, heart disease and kidney stone) were also assessed (data were not shown).

All of these factors with the exception of gender, LDL, smoking, exercise and NSAIDs were associated with CKD in the univariate analysis. Therefore, those 11 factors were considered in the multiple logistic model. Since BMI and WHR were highly correlated ($r = 0.78$, $P \leq 0.001$), including them together in the same model would result in multicollinearity. Because WHR was better at explaining the prevalence of CKD compared with the BMI (F test = 26.8, df (1,5), $P = 0.0035$ for WHR; F test = 7.7, df (2,4), $P = 0.0429$ for BMI), it was cho-

sen in the multivariate model. After adjustment, only seven variables: age, gender, hypertension, diabetes, high uric acid, use of traditional medicine and history of kidney stone were shown to be significant predictors of CKD.

There was a trend of association between age and CKD, i.e. the odds of having CKD were about 1.7 (95% CI = 1.2–2.5), 3.6 (95% CI = 2.3–5.9) and 7.3 (95% CI = 4.2–12.9) times for ages 40–59, 60–69 and ≥70 years, respectively, compared with age <40 years. Subjects with diabetes had about 2.7 (95% CI = 1.6–4.7) times higher prevalence of CKD than non-diabetic subjects. Subjects with hypertension had a risk of having CKD of about 2.0 (95% CI = 1.4–2.7) times higher than non-hypertensive subjects. Subjects with a history of kidney stone had about 2.7 (95% CI = 1.8–4.1) times higher risk of CKD relative to subjects who had never had a history of kidney stones. Although gender and use of traditional medicine were not significant risks in the univariate analysis, they became significant risks after adjusting confounders; a female had about a 70% higher risk (OR = 1.70, 95% CI = 1.2–2.4) of having CKD than a male. Subjects who reported use of traditional medicine have about 20% higher risk (OR = 1.2, 95% CI = 1.0–1.4) of having CKD than subjects who did not.

Discussion

The main finding of this study is that 17.5% of a representative cross-section of the Thai population was observed to have CKD. CKD prevalence in Thailand was estimated based on a community-based cross-sectional study design with stratified-cluster random sampling. The prevalence of CKD Stages I, II, III and IV were observed as 3.3%, 5.6%, 7.5% and 1.1%, respectively. Prevalence was not much different between males and females, but there was a trend toward prevalence with increasing age. The prevalence of CKD was higher in Bangkok, the Northern and Northeastern regions compared to the outlying Central and Southern regions. While the prevalence of CKD was remarkably high in Thailand, awareness of CKD in the Thai general population was quite low: only 1.9% were aware that they had CKD. Predictors of CKD not only included, as expected, older age, diabetes, hypertension, hyperuricaemia and gender but also a history of using traditional medicines and a history of kidney stones.

Our reporting of the prevalence of CKD was similar to previous studies conducted in the Beijing population aged 40 years or older, which found that the prevalence of Stages I and II was about 8% [11]. There was, however, one study in the Thai population which found very low Stages I and II prevalence, i.e. only 1.5% [1]. This could be due to the fact that the study only selected members of the Royal Thai Air Force who were predominately well-educated and relatively diabetes-free (only 8% prevalence). In addition, the degree of Stages I–II prevalence might have been underestimated since it was diagnosed based on urine protein, regardless of microalbuminuria and haematuria. Our finding of the prevalence of Stage III or higher (8.6%) was somewhat higher than the study in Taiwan (6.9%) [5] and previous reports in the Thai population (3.1% [1] and 6.8% [2]), but quite close to the pooled prevalence in Asian studies using meta-analysis (9.3% [12]). However, the figure was lower than the finding by the InterASIA Study (8.6% *versus* 13.2% [3]). Differences might be due to younger subjects in our study (≥ 18 *versus* ≥ 35 years) and creatinine measurements (IDMS *versus* Jaffe).

The CKD prevalence rates varied by region, i.e. highest in Bangkok (23.9%), followed by the Northeastern (22.2%) and North regions (20.4%) (Figure 2). This might be explained by the fact that, in Thailand, Bangkok has the highest prevalence of diabetes (19.0%), compared to the other regions (11–13%). In addition, although the overall prevalence of kidney stones was much lower than previously reported (16% in rural areas of northeast Thailand [13]), there appeared to be geographical variation in self-reporting of kidney stone disease. The Northeastern and North regions had higher prevalence of kidney stone (i.e. 6.4% and 8.4%, respectively) compared to the other regions (2.2–2.6%).

While the prevalence of CKD was remarkably high in Thailand, awareness of CKD in the Thai general population was quite low. Only 1.9% were aware that they had CKD. This could be due to awareness of CKD as a public health problem being new for the Thai population. In addition, previous reports of prevalence, which mostly considered Stage III or higher, appear to be underestimates and may have created a lack of concern by governmental and health organizations about the magnitude of the problem. Underdiagnosis might also be another reason for a lower awareness of CKD. General practitioners in Thailand routinely use serum creatinine to assess kidney function because it is widely available in general hospitals across the country, but do not use an eGFR prediction equation such as either the MDRD or Cockcroft–Gault equation. Using serum creatinine to estimate kidney function would underestimate the diagnosis of CKD, particularly in women and the elderly [13]. Adding eGFR along with serum creatinine in routinely reporting laboratory results should be considered. General practitioners should also become more familiar with the National Kidney Foundation Practice Guidelines in order to correctly diagnose the CKD [9]. Implementation of the guidelines should, therefore, be performed by all general practitioners and laboratories. Education should be encouraged and prevention programs should be launched in order to delay the onset of higher stages of CKD in subjects at risk within the population. Although our study could not confirm the diagnosis of CKD, the magnitude of this problem should be a signal to doctors, health care providers and policy makers to consider more aggressive means of seeking out patients with early stages of CKD.

The public health situation in Thailand differs from the situation in many westernized nations. In most western nations, the onset of end-stage kidney failure allows for dialytic support or transplantation. In most parts of the developing world, renal replacement therapy is unavailable because of resource constraints and ESRD is uniformly fatal. The economic effects are also likely to be profound. In most developing countries, strategies targeting early detection of kidney disease draw on government resources. In develop-

ing countries, however, World Health Organization (WHO) data indicate that governmental spending on health care is limited to 0.4% to 4% of the gross national product, compared with 10% to 16% in developed nations. Our paper emphasizes the magnitude of the problem of kidney disease.

Risk factors

We observed that older age, diabetes, hypertension, hyperuricaemia and gender were associated with CKD, which was consistent with previous studies from developed countries [14–17]. Additional risk factors included history of using traditional medicines and kidney stones. Thirty percent of our studied subjects reported a history of using traditional medicines. Different traditional medicine forms were used, such as boiled medicine, powdered medicine, Chinese traditional medicine and small black tablets (called Luke Klon in Thai). These medicines have been quite popular in the general population because they are less regulated and easily accessible in terms of cost and place (e.g. general drug store, temple or even a grocery). Two reasons for using traditional medicines are to maintain well-being and relieve pain. This finding was similar to one Chinese study that reported an association from the use of Chinese herbs and CKD [18]. Two mechanisms of nephrotoxicity from the use of these traditional medicines were proposed. Firstly, they may be combined with various herbal plants (e.g. *Aristolochia* species, *Securidaca longepedunculata*, *Euphorbia matabelensis*, *Crotalaria laburnifolia* and *Callilepsis laureola* [19–21]) that cause renal damage. Secondly, unregulated compounds may be contaminated with drugs or heavy metals [22–24]. Evidence suggests that some Asian herbal medicines contain toxic heavy metals or undeclared prescription drugs due to either intentional alteration for medicinal purposes or accidental contamination. The role of kidney stones associated with CKD is still unclear, although this was consistent with previous studies [25,26]. Patients with kidney stones should have frequent, careful monitoring to check for CKD.

Methodological issues

Our study has both strengths and weaknesses. We selected subjects using a three-stage stratified-cluster random sampling and thus we believe that our study should be representative of the entire adult Thai population. Our analyses were performed according to survey sampling in which the probabilities of subject selection for the three stages were taken into account. We standardized the modified Jaffe creatinine to IDMS standards, aiming for a standardized and validated method for calculation of kidney function.

Our study also had limitations. The diagnosis of CKD was based on single measures of proteinuria and serum creatinine. An important but unexpected finding of our study was that CKD Stages I and II accounted for nearly a half of the total cases of CKD. These early stages are known as silent and asymptomatic stages [29]. Previous studies [8,20] showed that persistent positive rates for microalbuminuria were only 50.9–53% and 66.6–75% for CKD Stages I and II, respectively. Correcting our results with the persistent rates would, respectively, yield CKD Stages I, II and overall prevalence rates of about 1.7%, 4.1% and 14.4%. Another limitation is that we used the MDRD GFR prediction equation. This equation has not been validated for the Thai population and this could have accounted for the lack of precision in estimating GFR. Applying the CKD-EPI equation [30], which is regarded as more accurate in estimating GFR for higher value than the MDRD, one would identify only approximately 2% more CKD Stage I than the MDRD could. The prevalence for CKD-EPI Stages I, II, III and IV–V were 5.0%, 4.3%, 5.5% and 1.0%, respectively, with the overall prevalence of 15.9% (95% CI = 12.1–19.7%). Finally, although we applied stratified-cluster sampling to select subjects across the country, it is possible that our sampling methodology was not representative of the Thai population. We considered this possibility because the mean age of our sample (mean = 45.3, SD = 15.4) was approximately 4 years older than that of the general population with the same age range (mean = 41.2, SD = 15.7). We performed a sensitivity analysis to test whether this altered our results. We calculated age-specific standardized CKD prevalence in the Thai population using the same age groups as the reference population. This yielded the overall CKD prevalence of 15.0% (95% CI = 11.7–18.4%), which was not much different compared to our reported CKD prevalence (i.e. 17.5%, 95% CI = 14.6–20.4%). We had also re-calculated the prevalence by assuming that subjects were approximately 4 years younger: the adjusted CKD prevalence was 16.9% (95% CI = 13.6–20.4%), which was also similar to our reported CKD prevalence rate for Thailand.

In summary, CKD prevalence in the Thai population is much higher than previously published (17.5% *versus* 4.6–13.8%). The early stages of CKD are as common as later stages. However, albuminuria measurement was not confirmed, and adjusting for persistent positive rates resulted in the prevalence of 14.4%. There is some geographical variation in the prevalence of CKD in Thailand. Among predictors of CKD, exposure to traditional medicines seems to be important. Finally, there is low awareness of CKD in the general population. Our recommendation is that, in light of the high rate of CKD, a screening strategy for the early recognition of CKD should be launched to prevent further progression of the disease. This should be initiated by targeting high-risk populations. A clinical prediction score model should be further developed to aid in identifying high-risk populations. Furthermore, considering the high prevalence of predisposing factors like hypertension (27.5%), diabetes (11.9%) and smoking (20.5%) in the screened population, education strategies for awareness of CKD among those high-risk populations should be developed. Also, continuing education for primary health care providers who routinely take care of patients with these diseases should be offered to instruct the providers to test for serum creatinine, estimate GFR and perform simple urine testing for proteinuria for the early detection of ESRD.

Acknowledgements. The Thai-SEEK group members: Anchalee Chitthamma, Ph.D., Division of Clinical Chemistry, Department of Pathology, Faculty of Medicine, Ramathibodi Hospital; Chaiyot, MD., Chon Buri Hospital; Osot Nerapusee, Pharmacist, Medical Affairs Director, Thai Janssen-Cilag Ltd; Talerngsak Kajanabuch, MD, Faculty of Medicine, Chulalongkorn University; Porntip Chatchaipan, M.Sc., Section for Clin-

ical Epidemiology and Biostatistics, Faculty of Medicine, Ramathibodi Hospital; Sasivimol Rattanasiri, Ph.D., Section for Clinical Epidemiology and Biostatistics, Faculty of Medicine, Ramathibodi Hospital; Thananda Trakarnvanich, MD, Renal Unit, Department of Medicine, Bangkok Metropolitan Administration Medical College and Vajira Hospital; Vuddhidej Ophascharoensuk, MD, Faculty of Medicine, Chiang-Mai University Hospital; Warangkana Pichaiwong, MD, Division of Nephrology, Department of Medicine, Faculty of Medicine, Rajvithee Hospital, Bangkok, Thailand; and The Nephrology Society of Thailand and Thai Janssen-Cilag Ltd. This study was partly granted by Thai Janssen-Cilag Ltd and National Health Security Office of Thailand. A.I. has received a travel fund from Pfizer. A. T. has received honorarium from this project. A.S. has received research grants from Johnson and Johnson, Watson, Roche and Amgen.

Conflict of interest statement. None declared.

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Received for publication: 27.5.09; Accepted in revised form: 16.11.09