npg

ORIGINAL ARTICLE

Prevalence of microalbuminuria and associated risk factors among adult Korean hypertensive patients in a primary care setting

Yon Su Kim[1], Han Soo Kim[2], Ha Young Oh[3], Moon-Kyu Lee[4], Cheol Ho Kim[5], Yong Soo Kim[6], David Wu[6], Amy O Johnson-Levonas[6] and Byung-Hee Oh[7]

Microalbuminuria is an early sign of nephropathy and an independent predictor of end-stage renal disease. The purpose of this study was to assess microalbuminuria prevalence and its contributing factors in Korean hypertensive patients. This cross-sectional study enrolled male and female patients of $\geqslant 35$ years old with an essential hypertension diagnosis as made by 841 physicians in primary care clinics and 17 in general hospitals in the Republic of Korea between November 2008 and July 2009. To assess microalbuminuria prevalence, urine albumin/creatinine ratio (UACR) was measured in patients with a positive dipstick test. Of the 40 473 enrolled patients, 5713 (14.1%) had a positive dipstick test. Of 5393 patients with a positive dipstick test and valid UACR values, 2657 (6.6%) had significantly elevated UACR ($\geqslant 30 \mu g \, mg^{-1}$), 2158 (5.4%) had microalbuminuria ($30 \mu g \, mg^{-1} \leqslant UACR < 300 \mu g \, mg^{-1}$) and 499 (1.2%) had macroalbuminuria (UACR $\geqslant 300 \mu g \, mg^{-1}$). Based on multivariate analysis, independent factors associated with elevated UACR included low adherence to antihypertensive medication (23% higher; $P = 0.042$), poorly controlled blood pressure (BP; 38% higher for systolic BP/diastolic BP $\geqslant 130 \, mm \, Hg / \geqslant 80 \, mm \, Hg$; $P < 0.001$), obesity (47% higher for body mass index (BMI) $\geqslant 25.0 \, kg \, m^{-2}$; $P < 0.001$), age (17% lower and 58% higher for age categories 35–44 years ($P = 0.043$) and >75 years ($P < 0.001$), respectively) and a prior history of diabetes (151% higher; $P < 0.001$) and kidney-related disease (71% higher; $P < 0.001$). The prevalences of elevated UACR and microalbuminuria were 6.6% and 5.4%, respectively. Age, increased BMI, presence of comorbidities, poor medication adherence and inadequately controlled BP were independent predictors of elevated UACR after controlling for potential confounders.

INTRODUCTION

The excretion of small, subclinical amounts of albumin in the urine is a condition known as microalbuminuria.[1] Initially, this condition was found to be a predictor of future progression of renal disease in patients with diabetic nephropathy.[2,3] However, the presence of microalbuminuria has since been associated with higher cardiovascular risk and end-stage renal disease in patients with other conditions (for example, hypertension)[4–6] as well as in the general population.[7,8] Microalbuminuria is defined as a urinary albumin/creatinine ratio (UACR) higher than the threshold value obtained from studies assessing the risk for developing nephropathy in diabetes patients (that is, between 20 and $200 \mu g \, min^{-1}$ or $\geqslant 30$ to < 300 mg per day).[9,10]

Hypertension is one of the most important risk factors for cardiovascular disease.[11] The association of hypertension with elevated levels of urinary albumin excretion is well established.[12–14] The incidence of microalbuminuria is more common among hypertensive patients, even in nondiabetic patients.[15] Several epidemiologic studies also have shown that the presence of proteinuria or microalbuminuria is an independent predictor of cardiovascular morbidity and mortality in patients with essential hypertension.[16–20] Therefore, current guidelines recommend routine screening of microalbuminuria in hypertensive patients to ensure appropriate interventions are initiated early in the disease process before progression to chronic kidney disease and/or renal failure.[10]

[1]Division of Nephrology, Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea; [2]Division of Cardiology, 21st Century Clinic, Seoul, Korea; [3]Division of Nephrology, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea; [4]Division of Endocrinology, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea; [5]Division of Cardiology, Seoul National University College of Medicine, Bundang Seoul National University Hospital, Seoul, Korea; [6]Merck Sharp & Dohme Corp., Whitehouse Station, NJ, USA and [7]Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea
Correspondence: Professor B-H Oh, Department of Internal Medicine, Seoul National University College of Medicine, 101 Daehak-ro, Seoul 110-744, Korea.
E-mail: ohbhmed@snu.ac.kr
Received 23 August 2012; revised 13 February 2013; accepted 14 February 2013; published online 23 May 2013

Screening programs for high-risk patients with diabetes and/or hypertension represent excellent opportunities for prevention and early treatment of albuminuria. Such screening programs are important in Asian countries because of the increasing incidence of diabetes and hypertension seen in this region.[11,21,22] Asian patients with diabetes have the highest incidence of albuminuria, accounting for roughly 55% of all cases worldwide.[23] In the Asia Pacific region, microalbuminuria prevalence is estimated to range between 10.0 and 13.7% among hypertensive patients,[7,8,24] 15.0 and 20.3% in diabetic patients[25–27] and 22.2 and 48.5% in diabetic hypertensive patients.[25,28–35] Microalbuminuria can be decreased by as much as 44% using hypertension interventions in Asian populations, thus highlighting the need for adequate blood pressure (BP) control in such patients.[27,36,37]

Large ethnic/racial variations in the prevalence of microalbuminuria among hypertensive patients have been documented. Two recently published large-scale population-based surveys, the NHANES III (US National Health and Nutrition Examination Survey) and the PREVEND (Prevention of Renal and Vascular End-Stage Disease study), reported microalbuminuria prevalences of 16 and 11.5% among people with hypertension in the United States and Europe (that is, the Netherlands).[38,39] In the I-DEMAND (Italy Developing Education and awareness on Microalbuminuria in patients with hyperteNsive Disease) study, microalbuminuria was observed in 27% of the overall population.[40] An international, observational study, i-SEARCH (Survey for Evaluating Microalbuminuria Routinely by Cardiologists conducted in patients with Hypertension), demonstrated a very high worldwide prevalence (58.4%) of microalbuminuria in high-risk cardiovascular patients with hypertension.[41] More recently, a lower frequency of microalbuminuria (22.7%) was observed in the REDHY (Renal Dysfunction in Hypertension) study conducted in patients with hypertension without cardiovascular complications and known renal disease.[42,43] Reported differences in prevalence rates among studies may be due to the differences in the number of patients studied, severity of hypertension, average age of the study populations, racial/ethnic differences, coexistence of comorbid diseases in the study populations (for example, diabetes and renal insufficiency) and study methodologies.

Although it is well known that the frequency of microalbuminuria differs widely across ethnic/racial populations, few studies have evaluated the prevalence of microalbuminuria specifically in Korean hypertensive patients. Three prior cross-sectional studies conducted in Koreans reported prevalence rates ranging from 2.8 to 12% in healthy, non-diabetic patients,[7,44] 10.1% in hypertensive patients without diabetes,[7] 16.1% in patients with type 2 diabetes[7] and 23.1% in patients with hypertension and type 2 diabetes.[45] Reasons for the wide variability in microalbuminuria rates observed in Koreans are unknown but may be due in part to differences in the UACR criteria and methodologies employed to define and identify microalbuminuria, the small number of patients enrolled in these studies (study N's ranged from 497 to 7569) and differences in the patient populations (for example, preferential enrollment of patients from rural areas vs nationwide enrollment). The purpose of this large, cross-sectional study was to provide a more definitive assessment of the prevalence of microalbuminuria among Koreans diagnosed with primary/essential hypertension. This study surveyed people receiving treatment in a primary care setting to allow for a more representative sample of the overall population of hypertensive patients living in the Republic of Korea. Furthermore, the detection of microalbuminuria was based on an antibody-based dipstick screening test with subsequent confirmation via measurement of UACR to definitively

identify patients with microalbuminuria. The specific objectives of this study were as follows: (1) determine the prevalence of albuminuria as assessed by a positive dipstick test alone; (2) determine prevalence of microalbuminuria as assessed by a positive dipstick test and a valid UACR value (that is, $\geqslant 30$ to $< 300\,\mu g\,mg^{-1}$); (3) evaluate the clinical and demographic characteristics associated with albuminuria and microalbuminuria in Korean hypertensive patients.

MATERIALS AND METHODS
Study population
This cross-sectional study was performed from November 2008 to July 2009 by 858 physicians practicing in general medical clinics (for example, primary care physician, family medicine or outpatient primary care clinic in hospitals) in the Republic of Korea. A total of 777 general medical clinics and 4 general hospitals enrolled 40 604 patients. The study was conducted in accordance with principles of Good Clinical Practice, and the study protocol was reviewed and approved by the appropriate Institutional Review Board (IRB; Cheju Halla General Hospital IRB, Special Self-Governing Province, Korea; Bong Seng Memorial Hospital IRB, Busan, Korea; Daedong Hospital IRB, Busan, Korea; Keimyung University Dongsan Medical Center IRB, Daegu, Korea). Each physician screened an average of 50 patients to determine study eligibility and each enrolled 1–113 patients. All patients provided written informed consent form at the time of enrollment.

The major inclusion criteria were age $\geqslant 35$ years, diagnosis of primary/essential hypertension (that is, defined as BP $> 140/90\,mm\,Hg$ in patients not previously diagnosed with hypertension or in patients with a previous diagnosis of hypertension and reported current use of antihypertensive medications) and ability to understand and complete the patient questionnaire in Korean. Patients were excluded from the study if they had secondary hypertension, were involved in another interventional clinical study or were incapable of completing the questionnaire in Korean. Patients were allowed to take any medication deemed necessary by their prescribing physician throughout the course of this study.

Data collection and evaluation
During each clinic visit, physicians assessed the patients' hypertension status, medication use and BP. The physician also provided information regarding patient comorbidities, laboratory data for assessing coronary heart disease (CHD) risk (for example, lipids and lipoprotein values) and duration of hypertension. In addition, patients were required to fill out a questionnaire for collecting information on demographics, lifestyle, current medical illness (age at hypertension diagnosis, diabetes status, history of stroke, kidney problems, heart attack/myocardial infarction, other heart problems, heart-related surgery), family history of CHD and medication adherence.

At enrollment, all eligible patients had BP measured in duplicate by a standard mercury sphygmomanometer at 2-min intervals using the right arm after the patient had assumed a seated position for at least 5 min. Caffeine was not allowed for at least 1 h and smoking was not allowed for at least 30 min before the BP measurement. Venous blood samples (5 ml) for measurement of plasma lipids were collected after an 8-h fast.

Attainment of the hypertension goal was determined using the cutoff value of $< 130/80\,mm\,Hg$ in patients with and without compelling complications such as diabetes, high CHD risk, prior history of a CHD event as assessed from information obtained in the physician and participant questionnaires.[45]

Urinary albumin measurements
At the screening visit, all patients provided spot urine samples for evaluation of albuminuria using an antibody-based dipstick test. The dipstick test was similar to Micral (Roche Diagnostics, Mannheim, Germany), which has been shown to detect urinary albumin concentrations $\geqslant 20\,mg\,l^{-1}$.[46] At the threshold of $\geqslant 20\,mg\,l^{-1}$, this test has been found to be 95% sensitive (confidence interval (CI): 90–99%) and $> 80\%$ specific (CI: 70–90%). Patients were classified as either negative (that is, normal) or positive (that is,

Table 1 Baseline demographic characteristics of enrolled patients both in the overall population and broken down by dipstick test status

| Characteristics	All patients (N = 40 153)	Patients with negative Micral test (N = 34 760)	Patients with positive Micral test[a] (N = 5393)
Clinical Characteristics			
Age, years, mean ± s.d.	58.5 ± 10.2	58.4 ± 10.1	59.4 ± 10.3**
Age category, years, N (%)			
35–44	3269 (8.1)	2900 (8.3)	369 (6.8)**
45–54	11 498 (28.6)	10 006 (28.8)	1492 (27.7)
55–64	13 533 (33.7)	11 750 (33.8)	1783 (33.1)
65–74	9354 (23.3)	8009 (23.0)	1345 (24.9)
⩾75	2499 (6.2)	2095 (6.0)	404 (7.5)
Gender, N (%)			
Male	19 686 (49.0)	16 914 (48.7)	2772 (51.4)**
Female	20 462 (51.0)	17 843 (51.3)	2619 (48.6)
Missing	5 (0.0)	3 (0.0)	2 (0.0)
Height, cm, mean ± s.d.	163.1 ± 8.8	163.2 ± 8.8	162.7 ± 8.5**
Weight, kg, mean ± s.d.	65.5 ± 10.4	65.3 ± 10.4	66.7 ± 10.7**
BMI, kg m^{-2}, mean ± s.d.	24.6 ± 2.9	24.5 ± 2.8	25.1 ± 3.1**
BMI category, kg m^{-2}, N (%)			
Underweight (<18.5)	450 (1.1)	413 (1.2)	37 (0.7)
Normal (18.5–22.9)	11 236 (28.0)	10 023 (28.8)	1213 (22.5)**
Overweight (23.0–24.9)	12 102 (30.1)	10 518 (30.3)	1584 (29.4)
Obese (⩾25.0)	16 365 (40.8)	13 806 (39.7)	2559 (47.5)
Smoking status, N (%)			
Never	23 800 (59.3)	20 587 (59.2)	3213 (59.6)
Former (quit >1 month)	7194 (17.9)	6260 (18.0)	934 (17.3)
Current	7994 (19.9)	6891 (19.8)	1103 (20.5)
Unknown	1165 (2.9)	1022 (2.9)	143 (27.5)
Alcohol consumption frequency, mean ± s.d.	0.9 ± 1.4	0.9 ± 1.3	1.1 ± 1.5**
Alcohol consumption category, N (%)			
4–6 Times per week	2028 (5.1)	1642 (4.7)	386 (7.2)**
2–3 Times per week	5557 (13.8)	4738 (13.6)	819 (15.2)
Once per week	4387 (10.9)	3856 (11.1)	531 (9.9)
1–3 Times per month	3812 (9.5)	3330 (9.6)	482 (8.9)
Less than once per month	2783 (6.9)	2389 (6.9)	394 (7.3)
I do not drink alcohol	15 046 (37.5)	13 086 (37.7)	1960 (36.3)
I do not know	1179 (2.9)	1027 (3.0)	152 (2.8)
Not applicable	5361 (13.4)	4692 (13.5)	669 (12.4)
Duration of hypertension, years, mean ± s.d.	6.1 ± 5.0	6.0 ± 4.9	6.9 ± 5.6**
Duration of hypertension category, years, N (%)			
<1	84 (0.2)	65 (0.2)	19 (0.4)**
1–5	23 975 (59.7)	21 131 (60.8)	2844 (52.7)
6–10	11 421 (28.4)	9750 (28.1)	1671 (31.0)
11–20	3191 (8.0)	2626 (7.6)	565 (10.5)
⩾21	1452 (3.6)	1162 (3.3)	290 (5.4)
Missing	30 (0.1)	26 (0.1)	4 (0.1)
SBP, mm Hg, mean ± s.d.	130.2 ± 11.0	130.1 ± 10.8	131.0 ± 12.2**
DBP, mm Hg, mean ± s.d.	81.8 ± 7.7	81.7 ± 7.7	82.2 ± 8.0**
Blood pressure control, N (%)			
SBP <130 mm Hg and DBP <80 mm Hg	6613 (16.5)	5778 (16.6)	835 (15.5)*
SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg	33 540 (83.5)	28 982 (83.4)	4558 (84.5)
Currently prescribed antihypertensive medications			
ARB (or associated fixed dose combo)	26 685 (66.5)	23 113 (66.5)	3572 (66.2)
ACEI (or associated fixed dose combo)	3264 (8.1)	2860 (8.2)	404 (7.5)
β-Blockers	5785 (14.4)	4960 (14.3)	825 (15.3)*

Table 1 (Continued)

Characteristics	All patients (N = 40 153)	Patients with negative Micral test (N = 34 760)	Patients with positive Micral test[a] (N = 5393)
CCB	18 248 (45.5)	15 429 (44.4)	2819 (52.3)
Diuretics (including thiazides)	6466 (16.1)	5667 (16.3)	799 (14.8)*
α-2 Agonist	153 (0.4)	131 (0.4)	22 (0.4)
Others	327 (0.8)	266 (0.8)	61 (1.1)*
None	3 (0.0)	3 (0.0)	0 (0.0)**
No. of antihypertensive medications, mean ± s.d.	1.5 ± 0.6	1.5 ± 0.6	1.6 ± 0.7**
No. of antihypertensive medications category, N (%)			
None	3 (0.0)	3 (0.0)	0 (0.0)**
1	22 453 (55.9)	19 556 (56.3)	2897 (53.7)
2	14 914 (37.1)	12 953 (37.3)	1961 (36.4)
⩾3	2783 (6.9)	2248 (6.5)	535 (9.9)
Adherence to antihypertensive medication scale, mean ± s.d.[b]	0.4 ± 0.8	0.3 ± 0.8	0.4 ± 0.9**
Adherence to antihypertensive medication category, N (%)			
0 Items	32 284 (80.4)	28 164 (81.0)	4120 (76.4)**
1 Item	3546 (8.8)	3026 (8.7)	520 (9.6)
2 Items	2946 (7.3)	2398 (6.9)	548 (10.2)
3 Items	451 (1.1)	374 (1.1)	77 (1.4)
4 Items	926 (2.3)	798 (2.3)	128 (2.4)
Use of traditional herbal Rx to reduce BP	663 (1.7)	116 (2.2)	547 (1.6)*
Use of medication to control blood glucose	5738 (14.3)	1329 (24.6)	4409 (12.7)
Comorbidities, N (%)			
Diabetes	7082 (17.6)	5508 (15.9)	1574 (29.2)**
Stroke/transient ischemic attack	2150 (5.4)	1801 (5.2)	349 (6.5)**
Revascularization procedure	376 (0.9)	323 (0.9)	53 (1.0)
Kidney-related disease	1369 (3.4)	1090 (3.1)	279 (5.2)**
Myocardial infarction	1004 (2.5)	866 (2.5)	138 (2.6)
Heart failure	1351 (3.4)	1159 (3.3)	192 (3.6)
Laboratory Parameters			
TC, mg dl^{-1}, mean ± s.d.	193.8 ± 39.7	196.6 ± 41.1	189.7 ± 37.3**
HDL-C, mg dl^{-1}, mean ± s.d.	49.6 ± 13.2	50.4 ± 13.4	48.7 ± 12.9**
LDL-C, mg dl^{-1}, mean ± s.d.	109.4 ± 34.0	111.6 ± 35.7	107.9 ± 32.7**
LDL-C category, mg dl^{-1}, N (%)			
<70	979 (2.4)	343 (1.0)	636 (11.9)**
70 to <100	2695 (6.7)	1050 (3.0)	1645 (30.5)
100 to <130	3166 (7.9)	1404 (4.0)	1762 (32.7)
⩾130	2354 (5.9)	1008 (2.9)	1346 (25.0)
Missing	30 959 (77.1)	30 955 (89.1)	4 (0.1)
TG, mg dl^{-1}, mean ± s.d.	176.2 ± 111.5	166.4 ± 98.9	188.2 ± 124.1**
UACR, μg mg^{-1}, mean ± s.d.	103.9 ± 237.8	32.2 ± 135.3	110.7 ± 244.2**
UACR category, μg mg^{-1}, N (%)			
<30	3205 (8.0)	469 (1.4)	2736 (50.7)**
30 to <300	2190 (5.5)	32 (0.1)	2158 (40.0)
⩾300	510 (1.3)	11 (0.1)	499 (9.3)
Missing	34 248 (85.3)	34 248 (98.5)	0 (0.0)

Abbreviations: ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BMI, body mass index; CCB, calcium channel blocker; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; UACR, urine albumin/creatinine ratio.
All values are shown as mean ± s.d. or n (%) of patients.
*$P<0.05$; **$P<0.001$ represents the significance of differences in distribution of variables/values between patients with positive and negative Micral tests and is estimated after excluding patients with the missing values.
[a]Patients with positive Micral test = patients with positive dipstick test and valid UACR value.
[b]High medication adherence scores indicate poor adherence to medication based on the range of 0–4 (0 = high, 1–2 = medium, 3–4 = low adherence).
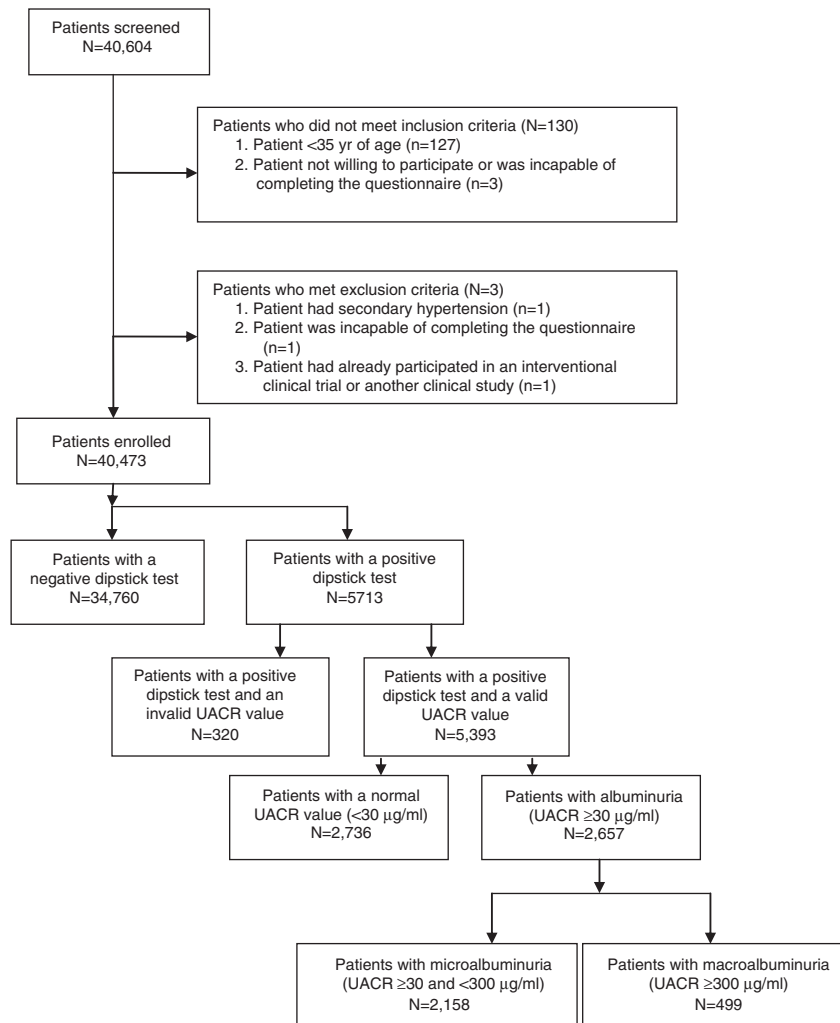
Figure 1 Disposition of patients in study.

at least $20 \, \text{mg} \, \text{l}^{-1}$) on the dipstick testing. Urine samples collected from patients with a positive dipstick test were sent to a central laboratory (Green Cross Reference Laboratory, Kyunggi-do, Korea) for a more quantitative measurement of UACR as assessed by the immunoturbidimetric technique (Microalbumin Analyzer: ADVIA 1650 Analyzer, Bayer Diagnostics, Tarrytown, NY, USA). Patients were classified into normal (that is, UACR $<30 \, \mu\text{g} \, \text{mg}^{-1}$), microalbuminuria (that is, UACR $\geqslant 30$ to $<300 \, \mu\text{g} \, \text{mg}^{-1}$) or macroalbuminuria/proteinuria (that is, $\geqslant 300 \, \mu\text{g} \, \text{mg}^{-1}$) based on a single UACR value.

Statistical analyses

The overall analysis population ($N = 40\,153$; that is, after excluding 320 patients with invalid UACR values) was prespecified to include patients with negative dipstick ($n = 34\,760$) or positive dipstick tests and valid UACR values ($n = 5393$). The prevalences of microalbuminuria (UACR $\geqslant 30$ to $<300 \, \mu\text{g} \, \text{mg}^{-1}$) in the overall study population and within subject subgroups were estimated. Patients had to have a positive dipstick test and a valid UACR value to be included in the analysis of albuminuria. Categorical variables were summarized using frequency and percentages. Continuous variables were summarized using mean ± standard deviation (s.d.) unless otherwise indicated. The prevalence of albuminuria was calculated by stratifying patients based on demographic parameters, clinical characteristics, use of antihypertensive medication and comorbidities (Table 1). Differences in continuous variables

were tested using Student's *t*-test, and differences in categorical variables were tested using χ^2 or Fisher's exact test.

Factors associated with the presence of albuminuria

The relationship between albuminuria and various factors (that is, covariates) were assessed using logistic regression analyses. A univariate logistic regression model estimated the crude, unadjusted odds ratios (ORs) and 95% CIs for the presence of albuminuria. A multiple logistic regression model was then used to estimate the OR and 95% CI for the presence of albuminuria after adjusting for confounding factors, including patient demographics, clinical characteristics, use of medication and comorbid conditions. Low-density lipoprotein cholesterol (LDL-C) values and physical activity were not included in this model, because of the large number of missing data for these parameters. The independent variables in logistic regression models were selected using forward stepwise regression with 0.2 of significant value for staying in the model. *P*-values were two sided, and $P < 0.050$ was considered to indicate statistical significance. All analyses were performed using System Analysis System Software Version 8.2 (SAS Institute, Cary, NC, USA).

RESULTS

A total of 858 physicians agreed to participate in this study, with each physician enrolling approximately 47 patients on average. The

majority of physicians were from the Seoul region (49.3%) of Korea. The overall disposition of patients in this study is shown in Figure 1. In total, 40 604 patients were screened for study entry, of which 40 473 (99.7%) were enrolled after applying inclusion and exclusion criteria. The most common reason for lack of entry was failure to meet the age inclusion criteria ($n = 127$). Of the 40 473 eligible patients enrolled in the study, 34 760 (85.9%) and 5713 (14.1%) had negative and positive dipstick tests, respectively. Of the 5713 patients with a positive dipstick test, 5393 (94.4%) had a valid UACR value and were included in the subsequent analyses of albuminuria, whereas 320 (5.6%) had an invalid UACR value and were excluded from all analyses.

In the overall analysis population ($N = 40 153$), 13.4% (5393/40 153) of the patients had a positive dipstick result, whereas 86.6% (34 760/40 153) had a negative dipstick result (Table 1). Of the 5393 patients with a positive dipstick test and a valid UACR value, 2736 (50.7%) had a normal UACR $< 30 \, \mu g \, mg^{-1}$ and 2657 (49.3%) patients had albuminuria as defined by a positive dipstick test and a clinically elevated UACR value $\geqslant 30 \, \mu g \, mg^{-1}$. The albuminuria cohort comprised of 2158/2657 (81.2%) and 499/2657 (18.8%) patients with microalbuminuria and macroalbuminuria, respectively. Therefore, in the overall analysis population, after excluding 320 patients with an invalid UACR value, the prevalence of albuminuria, as defined by a positive dipstick test and a clinically elevated UACR value, was 6.6% (2657/40 153). The prevalences of microalbuminuria (that is, positive dipstick test and a valid UACR $\geqslant 30$ to $< 300 \, \mu g \, mg^{-1}$) and macroalbuminuria (that is, positive dipstick test and a valid UACR $\geqslant 300 \, \mu g \, mg^{-1}$) were 5.4% (2185/40 153) and 1.2% (499/40 153), respectively.

The demographic and baseline clinical characteristics of the overall analysis population, including patients with negative and positive dipstick tests, are shown in Table 1. The overall analysis population comprised of 20 462 (51.0%) women and 19 686 (49.0%) men with a mean ± s.d. age of 58.5 ± 10.2 years. At baseline, the mean ± s.d. duration of hypertension was 6.1 ± 5.0 years, mean ± s.d. systolic BP (SBP) was 130.2 ± 11.0 mm Hg and mean ± s.d. diastolic BP (DBP) was 81.8 ± 7.7 mm Hg. Most patients were taking one or two antihypertensive medications, primarily angiotensin II receptor blockers (66.5%), calcium channel blockers (45.5%) and/or thiazide diuretics (16.1%) at the time of study enrollment. The majority (83.5%) of patients had BP values $\geqslant 130/80$ mm Hg at baseline. Of the patients with available data regarding smoking status, 19.9% were current smokers and 59.3% had never smoked. The mean BMI was 24.6 ± 2.9 kg m^{-2} and the majority of patients were either overweight or obese (that is, $\geqslant 23.0$ kg m^{-2}; 30.1% and 40.8%, respectively). The proportion of patients with a history of diabetes, stroke/transient ischemic attack, kidney disease, myocardial infarction and heart failure were 17.6%, 5.4%, 3.4%, 2.5 and 3.4%, respectively.

The baseline demographic and clinical characteristics were compared across participant subgroups defined by positive ($n = 5393$) and negative ($n = 34 760$) dipstick tests (Table 1). Patients with a positive dipstick test were slightly older than those with a negative dipstick test (59.4 vs 58.4 years; $P < 0.001$). The average duration of hypertension was longer in patients with a positive dipstick test (6.9 vs 6.0 years; $P < 0.001$). The mean BMI value (25.1 vs 24.5 kg m^{-2}; $P < 0.001$) was slightly higher in patients with a positive dipstick test. Other relevant factors included a higher prevalence of obesity (47.5% vs 39.7%; $P < 0.001$) and fewer patients with SBP < 130 mm Hg and DBP < 80 mm Hg (15.5% vs 16.6%; $P = 0.036$) among patients with a positive dipstick test. In addition, significantly more patients in the positive dipstick group had a history of diabetes (29.2% vs 15.9%;

$P < 0.001$), stroke/transient ischemic attack (6.5% vs 5.2%; $P < 0.001$) and kidney-related disease (5.2% vs 3.1%; $P < 0.001$) than the dipstick-negative group. The majority of study patients were well adherent to medication regimen, with 80.4% of patients having a non-adherence score of zero.

Baseline demographic and clinical characteristics were compared across participant subgroups defined by normoalbuminuria ($n = 37 496$ (that is, patients with a negative dipstick test or a positive dipstick test and a valid UACR $< 30 \, \mu g \, mg^{-1}$)), microalbuminuria ($n = 2158$ (patients with a positive dipstick test and a valid UACR $\geqslant 30$ to $< 300 \, \mu g \, mg^{-1}$)) and macroalbuminuria ($n = 499$ (patients with a positive dipstick test and a valid UACR $\geqslant 300 \, \mu g \, mg^{-1}$)) in the overall analysis population ($N = 40 153$; patients with either a negative dipstick test or a positive dipstick test and a valid UACR value; Table 2). Compared with normal patients, patients with albuminuria (including both microalbuminuria and macroalbuminuria) were older (60.1 vs 58.4 years), had a longer duration of hypertension (7.6 vs 6.0 years), and a larger proportion were male (51.7% vs 48.8%). Other demographic characteristics with significant differences between normal patients and patients with albuminuria included height ($P = 0.001$), weight ($P < 0.001$), education ($P < 0.001$), use of traditional herbs to reduce BP ($P = 0.003$), use of medication to control blood glucose ($P < 0.001$), alcohol consumption frequency ($P = 0.021$), use of soju alcohol ($P < 0.001$), menopausal status ($P < 0.001$) and level of physical activity ($P < 0.001$) and minutes of physical activity per week ($P = 0.006$; Table 2). Clinical characteristics found to demonstrate significant differences between normal patients and those with albuminuria included mean BMI ($P < 0.001$), having controlled BP ($P < 0.001$), mean SBP ($P < 0.001$), mean DBP ($P < 0.001$), current use of calcium channel blockers ($P < 0.001$), use of antihypertensive medications ($P = 0.001$), adherence to antihypertensive medication scale ($P < 0.001$), number of patients with diabetes, stroke or transient ischemic attack, or kidney-related disease (all $P < 0.001$), number of comorbidities except hypertension ($P < 0.001$), number of medications except those for hypertension ($P < 0.001$), and lipids and lipoprotein levels (that is, total cholesterol, high-density lipoprotein cholesterol, LDL-C and triglycerides (all $P < 0.001$); Table 2).

The prevalences of albuminuria, microalbuminuria and macroalbuminuria also were examined within participant subgroups defined by baseline demographics and clinical characteristics (Table 3). The prevalence of albuminuria increased with age such that 10.2% of patients >75 years had albuminuria compared with only 5.2% of patients 35–44 years ($P < 0.001$ for all albuminuria classifications). The prevalences of albuminuria and microalbuminuria were greater in men than women ($P \leqslant 0.012$ for albuminuria and microalbuminuria); however, similar prevalences of macroalbuminuria were seen in both men and women ($P = 0.147$). A similar finding was observed for the BMI stratifications, such that higher prevalences of albuminuria and microalbuminuria were seen in overweight and obese patients vs underweight patients; however, the prevalence of macroalbuminuria was relatively consistent across these BMI categories (Table 3). Other factors associated with increased prevalence of albuminuria (including both microalbuminuria and macroalbuminuria) included SBP $\geqslant 130$ mm Hg and/or DBP $\geqslant 80$ mm Hg, number of antihypertensive medications, poor adherence to antihypertensive medications, prior history of diabetes, stroke/transient ischemic attack or kidney-related disease, and number of comorbidities (Table 3). In contrast, smoking status did not appear to influence the prevalence of albuminuria, nor did a family history of myocardial infarction/sudden death (data not shown).

Table 2 Characteristics of patients with albuminuria defined by UACR levels

Characteristics (N for all patients)	Normal, N = 37496	Albuminuria, N = 2657	Level of Albuminuria		P-value[a]
			Microalbuminuria N = 2158	Macroalbuminuria N = 499	
Age, years, mean ± s.d.	58.4 ± 10.1	60.1 ± 10.6	59.9 ± 10.6	60.9 ± 10.8	<0.001
35–44 (3269)	3099 (8.3)	170 (6.4)	144 (6.7)	26 (5.2)	<0.001
45–54 (11498)	10791 (28.8)	707 (26.6)	565 (26.2)	142 (28.5)	
55–64 (13533)	12697 (33.9)	836 (31.5)	704 (32.6)	132 (26.5)	
65–74 (9354)	8664 (23.1)	690 (26.0)	548 (25.4)	142 (28.5)	
⩾75 (2499)	2245 (6.0)	254 (9.6)	197 (9.1)	57 (11.4)	
Gender					
Male (19686)	18312 (48.8)	1374 (51.7)	1114 (51.6)	260 (52.1)	0.004
Female (20462)	19179 (51.2)	1283 (48.3)	1044 (48.4)	239 (47.9)	
Missing (5)	5 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Height, cm, mean ± s.d.	163.2 ± 8.8	162.6 ± 8.6	162.6 ± 8.6	162.6 ± 8.6	0.001
Weight, kg, mean ± s.d.	65.4 ± 10.4	67.1 ± 10.9	67.2 ± 10.9	66.5 ± 10.9	<0.001
BMI, kg m^{-2}, mean ± s.d.	24.5 ± 2.8	25.3 ± 3.2	25.3 ± 3.2	25.1 ± 3.3	<0.001
Underweight (<18.5; 450)	433 (1.2)	17 (0.6)	15 (0.7)	2 (0.4)	<0.001
Normal (18.5–22.9; 11236)	10654 (28.4)	582 (21.9)	453 (21.0)	129 (25.9)	
Overweight (23.0–24.9; 12102)	11374 (30.3)	728 (27.4)	582 (27.0)	146 (29.3)	
Obese (⩾25.0; 16365)	15035 (40.1)	1330 (50.1)	1108 (51.3)	222 (44.5)	
Alcohol consumption frequency, mean ± s.d.	0.9 ± 1.4	1.0 ± 1.5	1.0 ± 1.5	0.9 ± 1.4	0.021
4–6 Times per week (2028)	1851 (4.9)	177 (6.7)	152 (7.0)	25 (5.0)	0.001
2–3 Times per week (5557)	5184 (13.8)	373 (14.0)	308 (14.3)	65 (13.0)	
Once per week (4387)	4129 (11.0)	258 (9.7)	215 (10.0)	43 (8.6)	
1–3 Times per month (3812)	3574 (9.5)	238 (9.0)	190 (8.8)	48 (9.6)	
Less than once per month (2783)	2595 (6.9)	188 (7.1)	161 (7.5)	27 (5.4)	
I do not drink alcohol (15046)	14019 (37.4)	1027 (38.7)	824 (38.2)	203 (40.7)	
I do not know (1179)	1106 (3.0)	73 (2.8)	54 (2.5)	19 (3.8)	
Not applicable (5361)	5038 (13.4)	323 (12.2)	254 (11.8)	69 (13.8)	
Type of alcohol					
Soju (13773)	12779 (34.1)	994 (37.4)	827 (38.3)	167 (33.5)	<0.001
Beer or macju (4434)	4210 (11.2)	224 (8.4)	185 (8.6)	39 (7.8)	
Whiskey or Yanju (353)	338 (0.9)	15 (0.6)	13 (0.6)	2 (0.4)	
Missing (21593)	20169 (53.8)	1424 (53.6)	1133 (52.5)	291 (58.3)	
Education					
<High school (12589)	11677 (31.1)	912 (34.3)	726 (33.6)	186 (37.3)	<0.001
High school (18386)	17193 (45.9)	1193 (44.9)	979 (45.4)	214 (42.9)	
Bachelors (8257)	7790 (20.8)	467 (17.6)	384 (17.8)	83 (16.6)	
Graduate (599)	557 (1.5)	42 (1.6)	37 (1.7)	5 (1.0)	
Others (322)	279 (0.7)	43 (1.6)	32 (1.5)	11 (2.2)	
Menopausal status (women)					
Pre-menopausal (2555)	2425 (6.5)	130 (4.9)	106 (4.9)	24 (4.8)	<0.001
Menopausal (1869)	1757 (4.7)	112 (4.2)	92 (4.3)	20 (4.0)	
Post-menopausal (15847)	14824 (39.5)	1023 (38.5)	831 (38.5)	192 (38.5)	
I do not know (114)	99 (0.3)	15 (0.6)	12 (0.6)	3 (0.6)	
Missing (19768)	18391 (49.1)	1377 (51.8)	1117 (51.8)	260 (52.1)	
Frequency of physical activity, days, mean ± s.d.	3.4 ± 1.8	3.6 ± 1.9	3.6 ± 1.9	3.6 ± 1.9	<0.001
1–2 (6684)	6250 (16.7)	434 (16.3)	360 (16.7)	74 (14.8)	<0.001
3–5 (10017)	9391 (25.1)	626 (23.6)	508 (23.5)	118 (23.7)	
5–7 (2645)	2404 (6.4)	241 (9.1)	197 (9.1)	44 (8.8)	
Missing (20807)	19451 (51.9)	1356 (51.0)	1093 (50.7)	263 (52.7)	

Table 2 (Continued)

Characteristics (N for all patients)	Normal, N = 37 496	Albuminuria, N = 2657	Level of Albuminuria Microalbuminuria N = 2158	Level of Albuminuria Macroalbuminuria N = 499	P-value[a]
Daily physical activity, min, mean ± s.d.	64.5 ± 42.6	64.0 ± 47.7	64.9 ± 50.1	59.8 ± 34.3	0.738
1 to <15 (106)	95 (0.3)	11 (0.4)	9 (0.4)	2 (0.4)	<0.001
15 to 30 (4674)	4288 (11.4)	386 (14.5)	318 (14.7)	68 (13.6)	
30 to 60 (10 942)	10 290 (27.4)	652 (24.5)	526 (24.4)	126 (25.3)	
>60 (3624)	3372 (9.0)	252 (9.5)	212 (9.8)	40 (8.0)	
Missing (20 807)	19 451 (51.9)	1356 (51.0)	1093 (50.7)	263 (52.7)	
Total min per week, mean ± s.d.	215.1 ± 202.6	235.3 ± 256.7	236.7 ± 264.3	228.8 ± 219.7	0.006
1 to <150 (8071)	7525 (20.1)	546 (20.6)	441 (20.4)	105 (21.0)	0.851
⩾150 (11 275)	10 520 (28.1)	755 (28.4)	624 (28.9)	131 (26.3)	
Missing (20 807)	19 451 (51.9)	1356 (51.0)	1093 (50.7)	263 (52.7)	
Duration of hypertension, years, mean ± s.d.	6.0 ± 4.9	7.6 ± 6.0	7.4 ± 6.1	8.0 ± 5.6	<0.001
<1 (84)	74 (0.2)	10 (0.4)	7 (0.3)	3 (0.6)	<0.001
1–5 (23 975)	22 704 (60.6)	1271 (47.8)	1063 (49.3)	208 (41.7)	
6–10 (11 421)	10 549 (28.1)	872 (32.8)	693 (32.1)	179 (35.9)	
11–20 (3191)	2861 (7.6)	330 (12.4)	254 (11.8)	76 (15.2)	
⩾21 (1452)	1280 (3.4)	172 (6.5)	139 (6.4)	33 (6.6)	
Missing (30)	28 (0.1)	2 (0.1)	2 (0.1)	0 (0.0)	
SBP, mm Hg, mean ± s.d.	130.1 ± 10.8	132.5 ± 12.8	132.0 ± 12.5	134.5 ± 13.9	<0.001
<130 (16 944)	15 960 (42.6)	984 (37.0)	829 (38.4)	155 (31.1)	<0.001
⩾130 (23 209)	21 536 (57.4)	1673 (63.0)	1329 (61.6)	344 (68.9)	
DBP, mm Hg, mean ± s.d.	81.7 ± 7.7	82.7 ± 8.2	82.6 ± 8.1	83.1 ± 8.5	<0.001
<80 (10 199)	9619 (25.7)	580 (21.8)	477 (22.1)	103 (20.6)	<0.001
⩾80 (29 954)	27 877 (74.4)	2077 (78.2)	1681 (77.9)	396 (79.4)	
Blood pressure control					
SBP <130 mm Hg and DBP <80 mm Hg (6613)	6263 (16.7)	350 (13.2)	292 (13.5)	58 (11.6)	<0.001
SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg (33 540)	31 233 (83.3)	2307 (86.8)	1866 (86.5)	441 (88.4)	
Currently prescribed antihypertensive medications					
ARB (or associated fixed dose combo; 26 685)	24 889 (66.4)	1796 (67.6)	1438 (66.6)	358 (71.7)	0.199
ACEI (or associated fixed dose combo; 3264)	3062 (8.2)	202 (7.6)	159 (7.4)	43 (8.6)	0.304
β-Blockers (5785)	5350 (14.3)	435 (16.4)	361 (16.7)	74 (14.8)	0.003
CCB (18 248)	16 769 (44.7)	1479 (55.7)	1202 (55.7)	277 (55.5)	<0.001
Diuretics (including thiazides; 6466)	6035 (16.1)	431 (16.2)	350 (16.2)	81 (16.2)	0.864
α-2 Agonist (153)	139 (0.4)	14 (0.5)	11 (0.5)	3 (0.6)	0.207
Others (327)	298 (0.8)	29 (1.1)	22 (1.0)	7 (1.4)	0.100
No. of antihypertensive medications, mean ± s.d.	1.5 ± 0.6	1.7 ± 0.7	1.6 ± 0.7	1.7 ± 0.8	
0 (3)	3 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.001
1 (22 453)	21 164 (56.4)	1289 (48.5)	1050 (48.7)	239 (47.9)	
2 (14 914)	13 853 (37.0)	1061 (39.9)	871 (40.4)	190 (38.1)	
⩾3 (2783)	2476 (6.6)	307 (11.6)	237 (11.0)	70 (14.0)	
Adherence to antihypertensive medication scale, mean ± s.d.[b]	0.4 ± 0.8	0.5 ± 1.0	0.5 ± 0.9	0.5 ± 1.0	<0.001
0 Items (32 284)	30 257 (80.7)	2027 (76.3)	1638 (75.9)	389 (78.0)	<0.001
1 Item (3546)	3314 (8.8)	232 (8.7)	194 (9.0)	38 (7.6)	
2 Items (2946)	2668 (7.1)	278 (10.5)	230 (10.7)	48 (9.6)	
3 Items (451)	412 (1.1)	39 (1.5)	34 (1.6)	5 (1.0)	
4 Items (926)	845 (2.3)	81 (3.1)	62 (2.9)	19 (3.8)	
Use of traditional herbal Rx to reduce BP (663)	600 (1.6)	63 (2.4)	56 (2.6)	7 (1.4)	0.003
Use of medication to control blood glucose (5738)	4868 (13.0)	870 (32.7)	655 (30.4)	215 (43.1)	<0.001

Table 2 (Continued)

			Level of Albuminuria		
Characteristics (N for all patients)	Normal, N = 37 496	Albuminuria, N = 2657	Microalbuminuria N = 2158	Macroalbuminuria N = 499	P-value[a]
Comorbidities[c]					
Diabetes (7082)	6090 (16.2)	992 (37.3)	753 (34.9)	239 (47.9)	<0.001
Stroke/transient ischemic attack (2150)	1940 (5.2)	210 (7.9)	164 (7.6)	46 (9.2)	<0.001
Revascularization procedure (376)	347 (0.9)	29 (1.1)	19 (0.9)	10 (2.0)	0.391
Kidney-related disease (1369)	1167 (3.1)	202 (7.6)	130 (6.0)	72 (14.4)	<0.001
Myocardial infarction (1004)	927 (2.5)	77 (2.9)	59 (2.7)	18 (3.6)	0.174
Heart failure (1351)	1245 (3.3)	106 (4.0)	76 (3.5)	30 (6.0)	0.065
Comorbidities except hypertension, mean ± s.d.	0.7 ± 0.9	1.0 ± 1.1	1.0 ± 1.1	1.3 ± 1.2	<0.001
None (22 323)	21 272 (56.7)	1051 (39.6)	891 (41.3)	160 (32.1)	<0.001
1 (11 209)	10 343 (27.6)	866 (32.6)	714 (33.1)	152 (30.5)	
2–3 (5866)	5219 (13.9)	647 (24.4)	491 (22.8)	156 (31.3)	
⩾4 (681)	600 (1.6)	81 (3.1)	55 (2.6)	26 (5.2)	
Missing (74)	62 (0.2)	12 (0.5)	7 (0.3)	5 (1.0)	
Medications except antihypertensive medications, mean ± s.d.	0.8 ± 1.3	1.3 ± 1.6	1.2 ± 1.5	1.6 ± 1.8	<0.001
0 (23 832)	22 635 (60.4)	1197 (45.1)	1007 (46.7)	190 (38.1)	<0.001
1–2 (12 001)	11 100 (29.6)	901 (33.9)	741 (34.3)	160 (32.1)	
⩾3 (4320)	3761 (10.0)	559 (21.0)	410 (19.0)	149 (29.9)	
TC, mg dl^{-1}, mean ± s.d.	194.6 ± 39.8	190.7 ± 39.1	189.7 ± 38.0	195.1 ± 43.3	<0.001
<200 (7736)	6096 (16.3)	1640 (61.7)	1354 (62.7)	286 (57.3)	0.007
200 to <240 (3988)	3235 (8.6)	753 (28.3)	610 (28.3)	143 (28.7)	
⩾240 (1365)	1104 (2.9)	261 (9.8)	192 (8.9)	69 (13.8)	
HDL-C, mg dl^{-1}, mean ± s.d.	50.0 ± 13.1	48.2 ± 13.4	48.1 ± 11.9	48.6 ± 18.6	<0.001
<40 (Male) or <50 (Female; 4326)	3206 (8.6)	1120 (42.2)	898 (41.6)	222 (44.5)	<0.001
40 or 50 to <60 (4979)	3852 (10.3)	1127 (42.4)	933 (43.2)	194 (38.9)	
⩾60 (2088)	1680 (4.5)	408 (15.4)	326 (15.1)	82 (16.4)	
LDL-C, mg dl^{-1}, mean ± s.d.	110.2 ± 34.2	107.5 ± 33.6	107.7 ± 32.9	107.0 ± 36.2	<0.001
<70 (979)	642 (1.7)	337 (12.7)	263 (12.2)	74 (14.8)	<0.001
70 to <100 (2695)	1880 (5.0)	815 (30.7)	655 (30.4)	160 (32.1)	
100 to <130 (3166)	2329 (6.2)	837 (31.5)	696 (32.3)	141 (28.3)	
⩾130 (2354)	1688 (4.5)	666 (25.1)	543 (25.2)	123 (24.7)	
TG, mg dl^{-1}, mean ± s.d.	169.6 ± 104.2	199.5 ± 131.4	195.7 ± 130.7	215.8 ± 133.3	<0.001
<150 (5755)	4626 (12.3)	1129 (42.5)	946 (43.8)	183 (36.7)	<0.001
150 to <200 (2720)	2184 (5.8)	536 (20.2)	435 (20.2)	101 (20.2)	
200 to <500 (3306)	2394 (6.4)	912 (34.3)	720 (33.4)	192 (38.5)	
⩾500 (186)	109 (0.3)	77 (2.9)	55 (2.6)	22 (4.4)	

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BMI, body mass index; BP, blood pressure; CCB, calcium channel blocker; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
Data are shown as *n* (%) of patients relative to all patients in the albuminuria category unless otherwise stated.
Variables that were not significantly different in the distribution between patients with normal and albuminuria UACR levels (that is, marital status, age at initial diagnosis of hypertension, smoking status, family history of sudden death, use of fixed dose combination medication) are not shown in the table.
[a]P-value represents the differences in distribution of variables/values between patients with normal and albuminuria urine albumin/creatinine ratio levels and is estimated after excluding patients with the missing values.
[b]High medication adherence scores indicate poor adherence to medication based on the range of 0–4 (0 = high, 1–2 = medium, 3–4 = low adherence).
[c]Comorbidities were identified by either physician or patient reports.

Univariate and multivariate logistic regression analyses were performed to determine the influence of various factors on urinary albumin excretion (Table 4). For the purpose of this analysis, data from the microalbuminuria and macroalbuminuria groups were combined together (*n* = 2657) and compared with the normoalbuminuria group (*n* = 34 760 (dipstick negative)). The odds of having an elevated UACR value ⩾30 µg mg^{-1} were estimated before (univariate model) and after (multivariate model) adjusting for various factors suspected to be associated with increased urinary albumin excretion.

Table 3 Prevalence (*N* (%)) of albuminuria presented by baseline characteristics

	Albuminuria	Microalbuminuria	Macroalbuminuria
Total population (N = 40 153)	(N = 2657)	(N = 2158)	(N = 499)
Baseline characteristics (N for all patients in category)			
Age, years			
35–44 (3269)	170 (5.2)**	144 (4.4)**	26 (0.8)**
45–54 (11 498)	707 (6.1)	565 (4.9)	142 (1.2)
55–64 (13 533)	836 (6.2)	704 (5.2)	132 (1.0)
65–74 (9354)	690 (7.4)	548 (5.9)	142 (1.5)
⩾75 (2499)	254 (10.2)	197 (7.9)	57 (2.3)
Gender			
Male (19 686)	1374 (7.0)*	1114 (5.7)*	260 (1.3)
Female (20 462)	1283 (6.3)	1044 (5.1)	239 (1.2)
BMI, kg m^{-2}			
Underweight (<18.5; 450)	17 (3.8)**	15 (3.3)**	2 (0.4)
Normal (18.5–22.9; 11 236)	582 (5.2)	453 (4.0)	129 (1.1)
Overweight (23.0–24.9; 12 102)	728 (6.0)	582 (4.8)	146 (1.2)
Obese (⩾25.0; 16 365)	1330 (8.1)	1108 (6.8)	222 (1.4)
Alcohol consumption frequency			
4–6 times per week (2028)	177 (8.7)*	152 (7.5)**	25 (1.2)
2–3 times per week (5557)	373 (6.7)	308 (5.5)	65 (1.2)
Once per week (4387)	258 (5.9)	215 (4.9)	43 (1.0)
1–3 times per month (3812)	238 (6.2)	190 (5.0)	48 (1.3)
Less than once per month (2783)	188 (6.8)	161 (5.8)	27 (1.0)
I do not drink alcohol (15 046)	1027 (6.8)	824 (5.5)	203 (1.3)
I do not know (1179)	73 (6.2)	54 (4.6)	19 (1.6)
Not applicable (5361)	323 (6.0)	254 (4.7)	69 (1.3)
Education			
<High school (12 589)	912 (7.2)**	726 (5.8)**	186 (1.5)**
High school (18 386)	1193 (6.5)	979 (5.3)	214 (1.2)
Bachelors (8257)	467 (5.7)	384 (4.7)	83 (1.0)
Graduate (599)	42 (7.0)	37 (6.2)	5 (0.8)
Other (322)	43 (13.4)	32 (9.9)	11 (3.4)
Menopausal status (women)			
Pre-menopausal (2555)	130 (5.1)*	106 (4.1)*	24 (0.9)
Menopausal (1869)	112 (6.0)	92 (4.9)	20 (1.1)
Post-menopausal (15 847)	1023 (6.5)	831 (5.2)	192 (1.2)
I do not know (114)	15 (13.2)	12 (10.5)	3 (2.6)
Frequency of physical activity, days			
1–2 (6684)	434 (6.5)**	360 (5.4)**	74 (1.1)
3–5 (10 017)	626 (6.2)	508 (5.1)	118 (1.2)
5–7 (2645)	241 (9.1)	197 (7.4)	44 (1.7)
Daily physical activity, min			
1 to <15 (106)	11 (10.4)**	9 (8.5)**	2 (1.9)
15 to 30 (4674)	386 (8.3)	318 (6.8)	68 (1.5)
30 to 60 (10 942)	652 (6.0)	526 (4.8)	126 (1.2)
>60 (3624)	252 (7.0)	212 (5.8)	40 (1.1)
Duration of hypertension, years			
<1 (84)	10 (11.9)**	7 (8.3)**	3 (3.6)**
1–5 (23 975)	1271 (5.3)	1063 (4.4)	208 (0.9)
6–10 (11 421)	872 (7.6)	693 (6.1)	179 (1.6)
11–20 (3191)	330 (10.3)	254 (8.0)	76 (2.4)
⩾21 (1452)	172 (11.8)	139 (9.6)	33 (2.3)

Table 3 (Continued)

Total population (N = 40 153)	Albuminuria (N = 2657)	Microalbuminuria (N = 2158)	Macroalbuminuria (N = 499)
SBP, mm Hg			
<130 (16 944)	984 (5.8)**	829 (4.9)**	155 (0.9)**
≥130 (23 209)	1673 (7.2)	1329 (5.7)	344 (1.5)
DBP, mm Hg			
<80 (10 199)	580 (5.7)**	477 (4.7)**	103 (1.0)*
≥80 (29 954)	2077 (6.9)	1681 (5.6)	396 (1.3)
Blood pressure control			
SBP <130 mm Hg and DBP <80 mm Hg (6613)	350 (5.3)**	292 (4.4)**	58 (0.9)*
SBP ≥130 mm Hg and/or DBP ≥80 mm Hg (33 540)	2307 (6.9)	1866 (5.6)	441 (1.3)
Currently prescribed antihypertensive medications			
ARB (or associated fixed dose combo; 26 685)	1796 (6.7)	1438 (5.4)	358 (1.3)*
ACEI (or associated fixed dose combo; 3264)	202 (6.2)	159 (4.9)	43 (1.3)
β-Blockers (5785)	435 (7.5)*	361 (6.2)*	74 (1.3)
CCB (18 248)	1479 (8.1)**	1202 (6.6)**	277 (1.5)**
Diuretics (including thiazides; 6466)	431 (6.7)	350 (5.4)	81 (1.3)
α-2 Agonist (153)	14 (9.2)	11 (7.2)	3 (2.0)
Others (327)	29 (8.9)	22 (6.7)	7 (2.1)
No. of antihypertensive medications			
0 (3)	0 (0.0)**	0 (0.0)**	0 (0.0)**
1 (22 453)	1289 (5.7)	1050 (4.7)	239 (1.1)
2 (14 914)	1061 (7.1)	871 (5.8)	190 (1.3)
≥3 (2783)	307 (11.0)	237 (8.5)	70 (2.5)
Adherence to antihypertensive medications[a]			
0 Items (32 284)	2027 (6.3)**	1638 (5.1)*	389 (1.2)*
1 Item (3546)	232 (6.5)	194 (5.5)	38 (1.1)
2 Items (2946)	278 (9.4)	230 (7.8)	48 (1.6)
3 Items (451)	39 (8.6)	34 (7.5)	5 (1.1)
4 Items (926)	81 (8.7)	62 (6.7)	19 (2.1)
Use of medication to control blood glucose (5738)	870 (15.2)**	655 (11.4)**	215 (3.7)**
Comorbidities[b]			
Diabetes (7082)	992 (14.0)**	753 (10.6)**	239 (3.4)**
Stroke/transient ischemic attack (2150)	210 (9.8)**	164 (7.6)**	46 (2.1)*
Revascularization procedure (376)	29 (7.7)	19 (5.1)	10 (2.7)*
Kidney-related disease (1369)	202 (14.8)**	130 (9.5)**	72 (5.3)**
Myocardial infarction (1004)	77 (7.7)	59 (5.9)	18 (1.8)
Heart failure (1351)	106 (7.8)	76 (5.6)	30 (2.2)*
Number of comorbidities except hypertension			
0 (22 323)	1051 (4.7)**	891 (4.0)**	160 (0.7)**
1 (11 209)	866 (7.7)	714 (6.4)	152 (1.4)
2–3 (5866)	647 (11.0)	491 (8.4)	156 (2.7)
≥4 (681)	81 (11.9)	55 (8.1)	26 (3.8)
TC, mg dl^{-1}			
<200 (7736)	1640 (21.2)*	1354 (17.5)*	286 (3.7)
200 to <240 (3988)	753 (18.9)	610 (15.3)	143 (3.6)
≥240 (1365)	261 (19.1)	192 (14.1)	69 (5.1)

Table 3 (Continued)

Total population (N = 40 153)	Albuminuria (N = 2657)	Microalbuminuria (N = 2158)	Macroalbuminuria (N = 499)
HDL-C, mg dl^{-1}			
<40 (male) or <50 (female; 4326)	1120 (25.9)**	898 (20.8)**	222 (5.1)*
40 or 50 to <60 (4979)	1127 (22.6)	933 (18.7)	194 (3.9)
⩾60 (2088)	408 (19.5)	326 (15.6)	82 (3.9)
LDL-C, mg dl^{-1}			
<70 (979)	337 (34.4)**	263 (26.9)	74 (7.6)*
70 to <100 (2695)	815 (30.2)	655 (24.3)	160 (5.9)
100 to <130 (3166)	837 (26.4)	696 (22.0)	141 (4.5)
⩾130 (2354)	666 (28.3)	543 (23.1)	123 (5.2)
TG, mg dl^{-1}			
<150 (5755)	1129 (19.6)**	946 (16.4)**	183 (3.2)**
150 to <200 (2720)	536 (19.7)	435 (16.0)	101 (3.7)
200 to <500 (3306)	912 (27.6)	720 (21.8)	192 (5.8)
⩾500 (186)	77 (41.4)	55 (29.6)	22 (11.8)

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BMI, body mass index; CCB, calcium channel blocker; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
All values are shown as *n* (%) of patients relative to all patients in the baseline characteristic category.
*,**Represent the level of significance for differences in prevalence among the categories within each baseline characteristic variable (*P<0.05; **P<0.001).
Variables that were not significantly different in the distribution within baseline category (that is, marital status, smoking status) are not shown in the table.
[a]High medication adherence scores indicate poor adherence to medication based on the range of 0–4 (0 = high, 1–2 = medium, 3–4 = low adherence).
[b]Comorbidities were identified by either physician or patient reports.

In the univariate analysis, elevated UACR was associated with age, gender, smoking status, BMI classifications, duration of hypertension, SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg, baseline LDL-C value classifications, currently prescribed antihypertensive medication, number of antihypertensive medications, adherence to antihypertensive medication scale and comorbidities of diabetes, stroke/ischemic attack and kidney-related disease, and number of medications excluding antihypertensive medications (Table 4). After adjusting for the confounding effects of factors associated with elevated UACR in the univariate analysis (Table 4), the remaining independent determinants of an elevated UACR value in the multivariate analysis were low adherence to antihypertensive medication (OR 1.23 (95% CI: 1.01, 1.50; *P* = 0.042)), uncontrolled BP (OR 1.38 (95% CI: 1.23, 1.56; *P* < 0.001) for SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg), obesity (OR 1.47 (95% CI: 1.32, 1.63; *P* < 0.001) for BMI ⩾25.0 kg m^{-2}), number of antihypertensive medications (ORs 1.13 (95% CI: 1.03, 1.23; *P* = 0.007) and 1.51 (1.31, 1.73; *P* < 0.001) for 2 and ⩾3 antihypertensive drugs, respectively), age (ORs 0.83 (95% CI: 0.70, 0.99; *P* = 0.043) and 1.58 (1.35, 1.85; *P* < 0.001) for 35- to 44-year and >75-year categories, respectively), as well as a prior history of diabetes (OR 2.51 (95% CI: 2.26, 2.78; *P* < 0.001)) or kidney-related disease (OR 1.71 (1.45, 2.03; *P* < 0.001)).

DISCUSSION

This large, cross-sectional study explored the prevalence of albuminuria and identify the independent factors associated with microalbuminuria among Korean patients with essential/primary hypertension receiving treatment in the primary care setting. This study is the largest known epidemiological study (*N* = 40 473) conducted in hypertensive patients undergoing management by primary care physicians in any one country. Albuminuria was detected through the combined use of urine dipstick tests and UACR laboratory values. At the screening visit, physicians collected clinical and demographic information on adult (that is, ⩾35 years) patients

who were diagnosed with primary/essential hypertension or were taking antihypertensive medication to better characterize the following: (1) prevalence of albuminuria in the urine as assessed by a positive dipstick test alone, (2) prevalence of microalbuminuria in the urine as assessed by a positive dipstick test and a valid UACR test ⩾30 to <300 μg mg^{-1}; (3) the clinical and demographic characteristics associated with albuminuria and microalbuminuria in Koreans.

Results of this study show that a significant proportion of Korean hypertensive patients have albuminuria. The frequency of albuminuria in the overall study population as determined by a positive dipstick test was 13.4% (5393/40 153), irrespective of UACR testing. Of the study patients with a positive dipstick test, approximately half were subsequently found to have normal urinary albumin excretion levels (UACR <30 μg mg^{-1}; 50.7%; 2736/5393) and the other half had albuminuria (UACR ⩾30 μg mg^{-1}; 49.3%; 2657/5393) demonstrating the high false positive rate associated with dipstick testing. Hence, the actual prevalence of albuminuria as determined by a positive dipstick test in conjunction with an increased UACR ⩾30 μg mg^{-1} was substantially lower at 6.6% (2657/40 153). More specifically, the prevalences of microalbuminuria and macroalbuminuria were 5.4% (2185/40 153) and 1.2% (499/40 153), respectively. Of the patients with albuminuria determined by UACR testing, 81.2% (2158/2657) and 18.8% (499/2657) were classified as having microalbuminuria and macroalbuminuria, respectively.

Patients with albuminuria tended to be older, had a longer duration of hypertension and had a higher prevalence of obesity and SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg compared with patients with normoalbuminuria (that is, having a negative dipstick test or a positive dipstick test and a valid UACR value <30 μg mg^{-1} (*N* = 37 496)). A previous history of stroke/transient ischemic attack, kidney-related disease and especially diabetes were observed more frequently in patients with vs those without albuminuria. Several factors were found to be independently associated with microalbuminuria in the multivariate model, including age, medication

Table 4 ORs[a] and 95% CIs for the presence of elevated urinary albumin excretion: univariate and multivariate analyses

N = 40 153	All patients	Albuminuria	Univariate model		Multivariable model (Stepwise regression)	
			OR (95% CI)	P-value	OR (95% CI)	P-value
Age, years						
35–44	3269	170	0.84 (0.71–1.00)	0.043	0.83 (0.70–0.99)	0.043
45–54	11 498	707	1		1	
55–64	13 533	836	1.01 (0.91–1.11)	0.925	0.94 (0.84–1.04)	0.243
65–74	9354	690	1.22 (1.09–1.36)	<0.001	1.08 (0.97–1.21)	0.175
⩾75	2499	254	1.73 (1.49–2.01)	<0.001	1.58 (1.35–1.85)	<0.001
Gender						
Male	19 686	1374	1			
Female	20 462	1283	0.89 (0.82–0.97)	0.004		
Smoking status						
Never	23 800	1544	1			
Former (quit>1month)	7194	469	1.01 (0.90–1.12)	0.923		
Current	7994	570	1.11 (1.00–1.22)	0.046		
Gender and smoking interaction						
Female and never	18 442	1168	1		1	
Female and former (quit>1 month)	791	31	0.60 (0.42–0.87)	0.007	0.61 (0.42–0.87)	0.007
Female and current	663	46	1.10 (0.81–1.50)	0.531	1.04 (0.76–1.42)	0.796
Male and never	5354	376	1.12 (0.99–1.26)	0.072	1.12 (0.99–1.27)	0.065
Male and former (quit>1 month)	6403	438	1.09 (0.97–1.22)	0.155	1.01 (0.90–1.13)	0.899
Male and current	7330	524	1.14 (1.02–1.27)	0.017	1.10 (0.99–1.23)	0.083
BMI, kg m^{-2}						
Underweight (<18.5)	450	17	0.72 (0.44–1.18)	0.188	0.75 (0.44–1.27)	0.283
Normal (18.5–22.9)	11 236	582	1		1	
Overweight (23.0–24.9)	12 102	728	1.17 (1.05–1.31)	0.006	1.11 (0.99–1.25)	0.071
Obesity (⩾25.0)	16 365	1330	1.62 (1.46–1.79)	<0.001	1.47 (1.32–1.63)	<0.001
Marital status						
Not married	602	29	1			
Married	39 551	2628	1.41 (0.97–2.04)	0.075		
Physical activity						
Total min per week						
<150	8071	546	1			
⩾150	11 275	755	0.99 (0.88–1.11)	0.851		
Duration of hypertension, years						
<1	84	10	2.41 (1.24–4.68)	0.009		
1–5	23 975	1271	1			
6–10	11 421	872	1.48 (1.35–1.61)	<0.001		
11–20	3191	330	2.06 (1.81–2.34)	<0.001		
⩾21	1452	172	2.40 (2.03–2.84)	<0.001		
Blood pressure control						
Controlled (SBP <130 and DBP <80 mm Hg)	6613	350	1		1	
Uncontrolled (SBP ⩾130 and/or DBP ⩾80 mm Hg)	33 540	2307	1.32 (1.18–1.48)	<0.001	1.38 (1.23–1.56)	<0.001
Currently prescribed antihypertensive medications						
ARB (or associated fixed dose combo)	26 685	1796	1.06 (0.97–1.15)	0.199		
ACEI (or associated fixed dose combo)	3264	202	0.93 (0.80–1.07)	0.304		
β-Blockers	5785	435	1.18 (1.06–1.31)	0.003		
CCB	18 248	1479	1.55 (1.43–1.68)	<0.001		
Diuretics (including thiazides)	6466	431	1.01 (0.91–1.12)	0.864		
α-2 Agonist	153	14	1.43 (0.82–2.47)	0.207		
Others	327	29	1.38 (0.94–2.02)	0.100		

Table 4 (Continued)

N = 40 153	All patients	Albuminuria	Univariate model		Multivariable model (Stepwise regression)	
			OR (95% CI)	P-value	OR (95% CI)	P-value
No. of antihypertensive medications						
0	3	0	NA			
1	22 453	1289	1		1	
2	14 914	1061	1.26 (1.16–1.37)	<0.001	1.13 (1.03–1.23)	0.007
⩾3	2783	307	2.04 (1.79–2.32)	<.001	1.51 (1.31–1.73)	<0.001
Adherence to antihypertensive medication scale[b]						
High (0 items)	32 284	2027	1		1	
Medium (1–2 items)	6492	510	1.27 (1.15–1.41)	<0.001	1.05 (0.94– 1.16)	0.413
Low (3–4 items)	1377	120	1.43 (1.18–1.73)	<0.001	1.23 (1.01–1.50)	0.042
Use of traditional herbal Rx to reduce BP	663	63	1.49 (1.15–1.94)	0.003		
Use of medication to control blood glucose	5738	870	3.26 (2.99–3.56)	<0.001		
Comorbidities[c]						
Diabetes	7082	992	3.07 (2.83–3.34)	<0.001	2.51 (2.26–2.78)	<0.001
Stroke/transient ischemic attack	2150	210	1.57 (1.36–1.82)	<0.001		
Revascularization procedure	376	29	1.18 (0.81–1.73)	0.391		
Kidney-related disease	1369	202	2.56 (2.19–2.99)	<0.001	1.71 (1.45–2.03)	<0.001
Myocardial infarction	1004	77	1.18 (0.93–1.49)	0.175		
Heart failure	1351	106	1.21 (0.99–1.48)	0.065		
Number of comorbidities except hypertension						
None	22 323	1051	1			
1	11 209	866	1.70 (1.54–1.86)	<0.001		
2–3	5866	647	2.51 (2.27–2.78)	<0.001		
⩾4	681	81	2.73 (2.15–3.47)	<0.001		
No. of medications except antihypertensive medications						
0	23 832	1197	1		1	
1–2	12 001	901	1.54 (1.40–1.68)	<0.001	1.02 (0.92–1.13)	0.739
⩾3	4320	559	2.81 (2.53–3.13)	<0.001	1.34 (1.17–1.53)	<0.001
LDL-cholesterol, mg dl^{-1}						
<70	979	337	1			
70–<100	2695	815	0.83 (0.71–0.97)	0.158		
100–<130	3166	837	0.69 (0.59–0.80)	<0.001		
⩾130	2354	666	0.75 (0.64–0.88)	<0.001		

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BMI, body mass index; CCB, calcium channel blocker; CI, confidence interval; DBP, diastolic blood pressure; LDL, low-density lipoprotein; NA, not applicable; OR, odds ratio; SBP, systolic blood pressure.
[a]Odds ratios of albuminuria were calculated using logistic regression.
[b]High medication adherence scores indicate poor adherence to medication based on the range of 0–4 (0 = high, 1–2 = medium, 3–4 = low adherence).
[c]Comorbidities were identified by either physician or patient reports.

adherence, obesity, SBP ⩾130 mm Hg and/or DBP ⩾80 mm Hg, number of antihypertensive medications, and a previous history of diabetes or kidney disease. More specifically, patients <45 years were 17% less likely to have microalbuminuria, whereas patients ⩾75 years were 58% more likely to have microalbuminuria than those 45–54 years of age. Patients with low adherence to their antihypertensive medications were 23% more likely to have elevated UACR value than patients in the high-adherence category. Other factors, such as, BP (38% increased risk), obesity (47% increased risk) and taking two or three, or more antihypertensive medications (13% and 51% increased risk, respectively) also were significantly associated with elevated UACR values. By comparison, the presence of comorbidities, such as kidney-related disease (71% increased risk) and diabetes (151% increased risk) were the overall strongest determinants of elevated UACR values relative to all other factors. It should be noted that the possible role of LDL-C as a determinant of microalbuminuria was difficult to assess in this study because of widespread missing data among the study patients. The univariate analyses did show a possible role of elevated LDL-C levels in decreasing the risk of microalbuminuria; however, this factor did not remain as an independent predictor in the multivariate analyses possibly due to the small numbers of patients with valid LDL-C values.

Previous studies in the Asia Pacific region have estimated the prevalence of microalbuminuria to be the range of 10.0–13.7% among hypertensive patients,[7,8,24] 15.0–20.3% among diabetic patients[26,27,47] and 22.2–48.5% among diabetic hypertensive patients.[28–35] To date,

most Korean-based epidemiologic studies have examined the prevalence of microalbuminuria specifically in patients with type 2 diabetes (either with or without regard to their hypertension status) and have reported rates in the range of 12.4–25.3%. One recent study found an incidence rate of 13.2% in the general population of Chon-Buk province (that is, rural southwestern Korea), irrespective of diabetes status. In that study, an incidence rate of 21.8% was seen specifically in patients with diabetes. In the current study, the prevalences of microalbuminuria were found to be 10.6% in diabetics and 5.4% in the overall hypertensive study population. The reason for the apparently lower prevalence of microalbuminuria seen in this study compared with other Korean-based studies is unknown, but may be due to differences in the techniques used to measure urinary albumin levels, different threshold values used to categorize patients with/without microalbuminuria and different study populations. However, the prevalence rate of microalbuminuria reported herein is likely to be more indicative of the actual rate in Korean hypertensive patients, because this study enrolled a very large number of patients from primary care practices throughout the country. In Korea, most hypertensive patients are diagnosed and treated by primary care physicians rather than specialists.

Single dipstick testing for the detection of microalbuminuria is an established screening tool in a population setting. However, several false positives (50.7%) resulted from use of the Micral dipstick test as an initial screening tool in this study. Slightly under half (49.3%) of the patients with a positive dipstick test were subsequently shown to have an elevated UACR value. The urine dipstick test is a low-cost, semiquantitative measurement that tends to overestimate urine albumin measurements with a sensitivity of 95% (CI: 90–99%) and specificity >80% (CI: 70–90%). The false positive rate of the dipstick test used in this study falls within the quoted range for specificity. The false negative rate of the dipstick test (that is, use of UACR values to confirm absence of albuminuria in dipstick negative patients) was not determined; however, there must have been some patients with albuminuria that went undetected by dipstick testing in this study. Overall, the dipstick test did prove useful for screening and identifying a large number of patients with a higher chance of having albuminuria; however, a more quantitative measurement of albuminuria was needed to rule out microalbuminuria in a large proportion of dipstick-positive patients.

Several limitations should be considered when interpreting the results of this study. First, a single-spot urine sample was collected to measure urinary albumin excretion in study patients. By comparison, International guidelines recommend that microalbuminuria be established by three separate tests, of which two measurements should be positive.[48] Prior studies have shown that urinary albumin levels demonstrate considerable intra-individual variability; therefore, multiple measurements are preferred for the diagnosis of microalbuminuria in the clinical practice setting.[49] Nevertheless, studies have shown the measurement of UACR from first-morning voided urine samples correlate well with albumin excretion rate as measured by 24-h urine collection.[50] Furthermore, UACR has been shown to be a good predictor of cardiovascular morbidity and all-cause mortality.[48] Second, the traditional UACR cut point of $\geqslant 30$ to $<300 \,\mu g\,mg^{-1}$ was used in this study to identify hypertensive patients with microalbuminuria. This threshold value was initially derived from studies assessing the risk for developing nephropathy in patients with diabetes.[9,10] Several prospective studies have recently shown that apparently healthy individuals demonstrate an increased risk of cardiovascular disease and death at UACR values below this threshold.[9,51–54] As a result, the use of the more stringent UACR cut

point to define albuminuria in this study may have excluded some hypertensive patients who remain at an increased risk and thus require more intensive management.

Another limitation is the use of office-obtained BP measurements rather than 24-h ambulatory BP measurements in this study. In general, BP values and albuminuria are more closely associated when BP is recorded through the more precise method of ambulatory monitoring.[55,56] Because BP varies both diurnally and over longer periods of time, the use of one or two office measurements cannot fully describe the BP pattern for any given patient. Although ambulatory BP is the gold standard for monitoring BP status in the real-world setting, such measurements are not feasible in large epidemiologic studies. There is also the potential for selection bias and confounding as this study population consisted of a self-selected group of patients who agreed to enter the study and undergo study procedures. As a result, the results of this study may not be generalizable to all Korean hypertensive patients, such as those treated by specialists. This was a cross-sectional study; thus causal inferences cannot be established and should be considered hypothesis-generating only. Lastly, the absence of serum creatinine measurements is considered a limitation of this study. The study was conducted in nationwide survey of primary care clinics in Korea, and measurement of serum creatinine concentration is not routine clinical practice in these clinics.

Despite the aforementioned limitations, the present study is the first large epidemiologic survey designed to determine the prevalence of microalbuminuria among individuals with primary/essential hypertension in Korea. The prevalence of microalbuminuria was 5.4%, demonstrating that hypertensive kidney damage is present in a significant number of Korean hypertensive patients in the clinical practice setting. More routine UACR testing of Korean hypertensive patients may enable clinicians to detect albuminuria before target organ damage occurs. Clinicians should highly suspect the presence of microalbuminuria in Korean hypertensive patients who are older, obese, have SBP $\geqslant 130\,mm\,Hg$ and/or DBP $\geqslant 80\,mm\,Hg$ (that is, either through inadequate treatment or poor medication adherence) or difficult to control (that is, taking >3 antihypertensive medications) BP, and particularly in patients with established kidney disease or diabetes. Hypertensive patients should be encouraged to implement healthy lifestyle changes to reduce body weight, control BP and improve blood sugar levels. Where appropriate, clinicians should aggressively manage cardiovascular risk factors (for example, hypertension, diabetes, dyslipidemia and kidney disease) with pharmacologic therapy to slow progression of nephropathy and avoid end-stage renal disease in hypertensive patients with albuminuria.

1 Cerasola G, Cottone S, Mule G. The progressive pathway of microalbuminuria: from early marker of renal damage to strong cardiovascular risk predictor. *J Hypertens* 2010; **28**: 2357–2369.
2 Parving HH, Oxenboll B, Svendsen PA, Christiansen JS, Andersen AR. Early detection of patients at risk of developing diabetic nephropathy. A longitudinal study of urinary albumin excretion. *Acta Endocrinol (Copenh)* 1982; **100**: 550–555.
3 Viberti GC, Hill RD, Jarrett RJ, Argyropoulos A, Mahmud U, Keen H. Microalbuminuria as a predictor of clinical nephropathy in insulin-dependent diabetes mellitus. *Lancet* 1982; **1**: 1430–1432.
4 Haneda M, Kikkawa R, Togawa M, Koya D, Kajiwara N, Uzu T, Shigeta Y. High blood pressure is a risk factor for the development of microalbuminuria in Japanese subjects with non-insulin-dependent diabetes mellitus. *J Diabetes Complications* 1992; **6**: 181–185.
5 Wachtell K, Ibsen H, Olsen MH, Borch-Johnsen K, Lindholm LH, Mogensen CE, Dahlof B, Devereux RB, Beevers G, de Faire U, Fyhrquist F, Julius S, Kjeldsen SE, Kristianson K, Lederballe-Pedersen O, Nieminen MS, Okin PM, Omvik P, Oparil S, Wedel H, Snapinn SM, Aurup P. Albuminuria and cardiovascular risk in hypertensive patients with left ventricular hypertrophy: the LIFE study. *Ann Intern Med* 2003; **139**: 901–906.
6 Forman JP, Brenner BM. 'Hypertension' and 'microalbuminuria': the bell tolls for thee. *Kidney Int* 2006; **69**: 22–28.
7 Choi HS, Sung KC, Lee KB. The prevalence and risk factors of microalbuminuria in normoglycemic, normotensive adults. *Clin Nephrol* 2006; **65**: 256–261.
8 Konta T, Hao Z, Abiko H, Ishikawa M, Takahashi T, Ikeda A, Ichikawa K, Takasaki S, Kubota I. Prevalence and risk factor analysis of microalbuminuria in Japanese general population: the Takahata study. *Kidney Int* 2006; **70**: 751–756.
9 National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis* 2002; **39**: S1–266.
10 Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, Grassi G, Heagerty AM, Kjeldsen SE, Laurent S, Narkiewicz K, Ruilope L, Rynkiewicz A, Schmieder RE, Boudier HA, Zanchetti A, Vahanian A, Camm J, De Caterina R, Dean V, Dickstein K, Filippatos G, Funck-Brentano C, Hellemans I, Kristensen SD, McGregor K, Sechtem U, Silber S, Tendera M, Widimsky P, Zamorano JL, Erdine S, Kiowski W, Agabiti-Rosei E, Ambrosioni E, Lindholm LH, Viigimaa M, Adamopoulos S, Agabiti-Rosei E, Ambrosioni E, Bertomeu V, Clement D, Erdine S, Farsang C, Gaita D, Lip G, Mallion JM, Manolis AJ, Nilsson PM, O'Brien E, Ponikowski P, Redon J, Ruschitzka F, Tamargo J, van Zwieten P, Waeber B, Williams B. 2007 Guidelines for the Management of Arterial Hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2007; **25**: 1105–1187.
11 Lawes CM, Rodgers A, Bennett DA, Parag V, Suh I, Ueshima H, MacMahon S. Blood pressure and cardiovascular disease in the Asia Pacific region. *J Hypertens* 2003; **21**: 707–716.
12 Romundstad S, Holmen J, Hallan H, Kvenild K, Ellekjaer H. Microalbuminuria and all-cause mortality in treated hypertensive individuals: does sex matter? The Nord-Trondelag Health Study (HUNT), Norway. *Circulation* 2003; **108**: 2783–2789.
13 Giaconi S, Levanti C, Fommei E, Innocenti F, Seghieri G, Palla L, Palombo C, Ghione S. Microalbuminuria and casual and ambulatory blood pressure monitoring in normotensives and in patients with borderline and mild essential hypertension. *Am J Hypertens* 1989; **2**: 259–261.
14 Gerber LM, Shmukler C, Alderman MH. Differences in urinary albumin excretion rate between normotensive and hypertensive, white and nonwhite subjects. *Arch Intern Med* 1992; **152**: 373–377.
15 Parving HH, Mogensen CE, Jensen HA, Evrin PE. Increased urinary albumin-excretion rate in benign essential hypertension. *Lancet* 1974; **1**: 1190–1192.
16 Samuelsson O, Wilhelmsen L, Elmfeldt D, Pennert K, Wedel H, Wikstrand J, Berglund G. Predictors of cardiovascular morbidity in treated hypertension: results from the primary preventive trial in Goteborg, Sweden. *J Hypertens* 1985; **3**: 167–176.
17 Lewin A, Blaufox MD, Castle H, Entwisle G, Langford H. Apparent prevalence of curable hypertension in the hypertension detection and follow-up program. *Arch Intern Med* 1985; **145**: 424–427.
18 Bulpitt CJ, Beevers DG, Butler A, Coles EC, Hunt D, Munro-Faure AD, Newson RB, O'Riordan PW, Petrie JC, Rajagopalan B. The survival of treated hypertensive patients and their causes of death: a report from the DHSS hypertensive care computing project (DHCCP). *J Hypertens* 1986; **4**: 93–99.
19 Kannel WB, Stampfer MJ, Castelli WP, Verter J. The prognostic significance of proteinuria: the Framingham study. *Am Heart J* 1984; **108**: 1347–1352.
20 Yudkin JS, Forrest RD, Jackson CA. Microalbuminuria as predictor of vascular disease in non-diabetic subjects. Islington Diabetes Survey. *Lancet* 1988; **2**: 530–533.
21 King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. *Diabetes Care* 1998; **21**: 1414–1431.
22 Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; **365**: 217–223.
23 Parving HH, Lewis JB, Ravid M, Remuzzi G, Hunsicker LG. Prevalence and risk factors for microalbuminuria in a referred cohort of type II diabetic patients: a global perspective. *Kidney Int* 2006; **69**: 2057–2063.
24 Shi HL, Fang JC, Zhu XX. Prevalence of diabetes mellitus and associated risk factors in an adult urban population in Shanghai. *Diabetes Metab* 1998; **24**: 539–542.
25 Gozzoli V, Palmer AJ, Brandt A, Spinas GA. Economic and clinical impact of alternative disease management strategies for secondary prevention in type 2 diabetes in the Swiss setting. *Swiss Med Wkly* 2001; **131**: 303–310.
26 Woo J, Cockram CS, Swaminathan R, Lau E, Chan A, Cheung R. Microalbuminuria and other cardiovascular risk factors in nondiabetic subjects. *Int J Cardiol* 1992; **37**: 345–350.
27 Yamada T, Komatsu M, Komiya I, Miyahara Y, Shima Y, Matsuzaki M, Ishikawa Y, Mita R, Fujiwara M, Furusato N, Nishi K, Aizawa T. Development, progression, and regression of microalbuminuria in Japanese patients with type 2 diabetes under tight glycemic and blood pressure control: the Kashiwa study. *Diabetes Care* 2005; **28**: 2733–2738.
28 Buranakitjaroen P, Deerochanawong C, Bunnag P. Microalbuminuria prevalence study (MAPS) in hypertensive patients with type 2 diabetes in Thailand. *J Med Assoc Thai* 2005; **88**: 1624–1629.
29 DU J, Pan CY. [A survey of microalbuminuria prevalence in hypertensive type 2 diabetic patients in mainland China]. *Zhonghua Nei Ke Za Zhi* 2007; **46**: 184–188.
30 Guan MP, Li CZ, Xue YM, Shen J, Gao F, Luo XR. [Prevalence of microalbuminuria in type 2 diabetic patients with hypertension]. *Di Yi Jun Yi Da Xue Xue Bao* 2005; **25**: 234–235.
31 Kong NC, Chia YC, Khalid BA, Juwita S, Samiah Yasmin AK, Yap LY, Norlaila M, Menon J, Tan C, Fung YK. Microalbuminuria prevalence study in hypertensive type 2 diabetic patients in Malaysia. *Med J Malaysia* 2006; **61**: 457–465.
32 Sja'bani M, Asdie AH, Widayati K, Subroto Y, Kariadi SH, Arifin AY, Adhiarta IG, Permana H, Hendromartono T A, Adi S, Wibisono S, Murtiwi S. Microalbuminuria prevalence study in hypertensive patients with type 2 diabetes in Indonesia. *Acta Med Indones* 2005; **37**: 199–204.
33 Weir MR. Albuminuria predicting outcome in diabetes: incidence of microalbuminuria in Asia-Pacific Rim. *Kidney Int Suppl* 2004; **92**: S38–S39.
34 Wu AY, Tan CB, Eng PH, Tan KT, Lim SC, Tan EK. Microalbuminuria prevalence study in hypertensive patients with type 2 diabetes mellitus in Singapore. *Singapore Med J* 2006; **47**: 315–320.
35 Yeung VT, Lee KF, Chan SH, Ho LF, Leung SK, Wong HY. MicroAlbuminuria Prevalence Study (MAPS) in hypertensive type 2 diabetic patients in Hong Kong. *Hong Kong Med J* 2006; **12**: 185–190.
36 Chan GC. Type 2 diabetes mellitus with hypertension at primary healthcare level in Malaysia: are they managed according to guidelines? *Singapore Med J* 2005; **46**: 127–131.
37 Park JY, Kim HK, Chung YE, Kim SW, Hong SK, Lee KU. Incidence and determinants of microalbuminuria in Koreans with type 2 diabetes. *Diabetes Care* 1998; **21**: 530–534.
38 Coresh J, Selvin E, Stevens LA, Manzi J, Kusek JW, Eggers P, Van Lente F, Levey AS. Prevalence of chronic kidney disease in the United States. *JAMA* 2007; **298**: 2038–2047.
39 Hillege HL, Janssen WM, Bak AA, Diercks GF, Grobbee DE, Crijns HJ, van Gilst WH, De Zeeuw D, De Jong PE. Microalbuminuria is common, also in a nondiabetic, nonhypertensive population, and an independent indicator of cardiovascular risk factors and cardiovascular morbidity. *J Intern Med* 2001; **249**: 519–526.
40 Leoncini G, Viazzi F, Rosei EA, Ambrosioni E, Costa FV, Leonetti G, Pessina AC, Trimarco B, Volpe M, Deferrari G, Pontremoli R. Chronic kidney disease in hypertension under specialist care: the I-DEMAND study. *J Hypertens* 2010; **28**: 156–162.
41 Bohm M, Thoenes M, Danchin N, Bramlage P, La Puerta P, Volpe M. Association of cardiovascular risk factors with microalbuminuria in hypertensive individuals: the i-SEARCH global study. *J Hypertens* 2007; **25**: 2317–2324.
42 Cerasola G, Mule G, Cottone S, Nardi E, Cusimano P. Hypertension, microalbuminuria and renal dysfunction: the Renal Dysfunction in Hypertension (REDHY) study. *J Nephrol* 2008; **21**: 368–373.
43 Cerasola G, Mule G, Nardi E, Cusimano P, Palermo A, Arsena R, Guarneri M, Geraci C, Cottone S. Clinical correlates of renal dysfunction in hypertensive patients without cardiovascular complications: the REDHY study. *J Hum Hypertens* 2010; **24**: 44–50.
44 Kim CH, Kim HK, Park JY, Park HS, Hong SK, Park SW, Lee KU. Association of microalbuminuria and atherosclerotic risk factors in non-diabetic subjects in Korea. *Diabetes Res Clin Pract* 1998; **40**: 191–199.
45 National Heart, Lung, and Blood Institute. JNC 7 Express: the seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. National Institute of Health, Bethesda, MD, 2003.
46 Micral Test: an Accu-Check product 2008, Indianapolis, in, Roche Diagnostics Ltd.
47 Annemans L, Demarteau N, Hu S, Lee TJ, Morad Z, Supaporn T, Yang WC, Palmer AJ. An Asian regional analysis of cost-effectiveness of early irbesartan treatment versus conventional antihypertensive, late amlodipine, and late irbesartan treatments in patients with type 2 diabetes, hypertension, and nephropathy. *Value Health* 2008; **11**: 354–364.
48 Eknoyan G, Hostetter T, Bakris GL, Hebert L, Levey AS, Parving HH, Steffes MW, Toto R. Proteinuria and other markers of chronic kidney disease: a position statement of the national kidney foundation (NKF) and the national institute of diabetes and digestive and kidney diseases (NIDDK). *Am J Kidney Dis* 2003; **42**: 617–622.
49 Jensen JS. Intra-individual variation of overnight urinary albumin excretion in clinically healthy middle-aged individuals. *Clin Chim Acta* 1995; **243**: 95–99.

50 Zelmanovitz T, Gross JL, Oliveira JR, Paggi A, Tatsch M, Azevedo MJ. The receiver operating characteristics curve in the evaluation of a random urine specimen as a screening test for diabetic nephropathy. *Diabetes Care* 1997; **20**: 516–519.

51 Arnlov J, Evans JC, Meigs JB, Wang TJ, Fox CS, Levy D, Benjamin EJ, D'Agostino RB, Vasan RS. Low-grade albuminuria and incidence of cardiovascular disease events in nonhypertensive and nondiabetic individuals: the Framingham Heart Study. *Circulation* 2005; **112**: 969–975.

52 Gerstein HC, Mann JF, Yi Q, Zinman B, Dinneen SF, Hoogwerf B, Halle JP, Young J, Rashkow A, Joyce C, Nawaz S, Yusuf S. Albuminuria and risk of cardiovascular events, death, and heart failure in diabetic and nondiabetic individuals. *JAMA* 2001; **286**: 421–426.

53 Hillege HL, Fidler V, Diercks GF, van Gilst WH, De Zeeuw D, van Veldhuisen DJ, Gans RO, Janssen WM, Grobbee DE, De Jong PE. Urinary albumin excretion predicts cardiovascular and noncardiovascular mortality in general population. *Circulation* 2002; **106**: 1777–1782.

54 Klausen K, Borch-Johnsen K, Feldt-Rasmussen B, Jensen G, Clausen P, Scharling H, Appleyard M, Jensen JS. Very low levels of microalbuminuria are associated with increased risk of coronary heart disease and death independently of renal function, hypertension, and diabetes. *Circulation* 2004; **110**: 32–35.

55 Cerasola G, Cottone S, Mule G, Nardi E, Mangano MT, Andronico G, Contorno A, Li VM, Galione P, Renda F, Piazza G, Volpe V, Lisi A, Ferrara L, Panepinto N, Riccobene R. Microalbuminuria, renal dysfunction and cardiovascular complication in essential hypertension. *J Hypertens* 1996; **14**: 915–920.

56 Hsu CC, Brancati FL, Astor BC, Kao WH, Steffes MW, Folsom AR, Coresh J. Blood pressure, atherosclerosis, and albuminuria in 10 113 participants in the atherosclerosis risk in communities study. *J Hypertens* 2009; **27**: 397–409.