

RESEARCH ARTICLE

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# Burden and predictors of hypertension in India: results of SEEK (Screening and Early Evaluation of Kidney Disease) study

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## Abstract

**Background:** Hypertension (HTN) is one of the major causes of cardiovascular morbidity and mortality. The objective of the study was to investigate the burden and predictors of HTN in India.

**Methods:** 6120 subjects participated in the Screening and Early Evaluation of Kidney disease (SEEK), a community-based screening program in 53 camps in 13 representative geographic locations in India. Of these, 5929 had recorded blood pressure (BP) measurements. Potential predictors of HTN were collected using a structured questionnaire for SEEK study.

**Results:** HTN was observed in 43.5% of our cohort. After adjusting for center variation ( $p < 0.0001$ ), predictors of a higher prevalence of HTN were older age  $\geq 40$  years ( $p < 0.0001$ ), BMI of  $\geq 23$  Kg/M<sup>2</sup> ( $p < 0.0004$ ), larger waist circumference ( $p < 0.0001$ ), working in sedentary occupation ( $p < 0.0001$ ), having diabetes mellitus ( $p < 0.0001$ ), having proteinuria ( $p < 0.0016$ ), and increased serum creatinine ( $p < 0.0001$ ). High school/some college education ( $p = 0.0016$ ), versus less than 9th grade education, was related with lower prevalence of HTN. Of note, proteinuria and CKD were observed in 19% and 23.5% of HTN subjects. About half (54%) of the hypertensive subjects were aware of their hypertension status.

**Conclusions:** HTN was common in this cohort from India. Older age, BMI  $\geq 23$  Kg/M<sup>2</sup>, waist circumference, sedentary occupation, education less, diabetes mellitus, presence of proteinuria, and raised serum creatinine were significant predictors of hypertension. Our data suggest that HTN is a major public health problem in India with low awareness, and requires aggressive community-based screening and education to improve health.

**Keywords:** Hypertension, CKD, Awareness

## Background

The burden of hypertension varies remarkably throughout the regions of the world and is a serious public health problem in both developed and developing countries [1,2]. Both systolic and diastolic hypertension are important predicting risk factors of cardiovascular disease, chronic kidney disease and stroke. [3] World Health Organization (WHO) data indicate that by 2025 the global burden of

hypertension will increase by 60% to be 1.56 billion individuals worldwide and higher in the developed nations [4]. Lopez et al. have shown that 5.3 million deaths were attributable to cardiovascular disease in the western world as compared to 8 to 9 million in the developing world [5]. According to a recent report, hypertension was the third major cause of disease burden, in both developed and developing regions worldwide, with 64 million disability adjusted life years (DALY) [6].

Hypertension is one of the most important modifiable risk factors for cardiovascular disease (CVD) [7]. Hypertension in early stages does not show any symptoms; hence many are unaware of its presence. The prevalence

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of hypertension is increasing and it correlates with the chronic kidney disease in the US [9,10]. Early detection is feasible using a simple and accurate screening test and aggressive blood pressure management. Yet this has not received adequate attention or allocation of public health resources for planning effective preventive strategies. In India, as a developing country with a population estimated at 1.1 billion, the prevalence of hypertension has been estimated to be 3% to 34.5% in males and 5.8% to 33.5% of females [10-13].

Understanding the burden of hypertension, as a preventable disease, and underlying risk factors by organizing population screening is the first step towards planning any effective preventive programs. The Screening and Early Evaluation of Kidney Disease (SEEK Study) aimed at generating epidemiological information on chronic kidney disease and its associated non-communicable disease in India. This article presents the results from SEEK Study on the prevalence and risk factors of hypertension.

## Methods

### Assembly of the SEEK cohort

Thirteen academic and private medical centers in India participated in the study under the name of "Screening and Early Evaluation of Kidney disease- SEEK". It was conducted between June 2005 to May 2007, coordinated from the Brigham and Women's Hospital in Boston, Massachusetts. The protocol was approved by the Partner's Institutional Review Board (IRB) as well as by individual centers' own institutional IRBs in India. Signed or verbal informed consent (confirmed by a witness) was obtained before administering the questionnaire, taking measurements or blood collection. The database is based at the Brigham and Women's Hospital.

Geographic distribution of the centers is shown in Table 1. In general, sampling of subjects from all parts of India except the Eastern region was achieved. The camps were conducted in a community-based setting, and any Indian above the age of 18 years was eligible to participate in the screening. Participants voluntarily walked in the screening camp as they noticed the flyer. Six of the 13 centers screened an exclusive urban population, 5 screened an exclusively rural population; and two screened a mixture. The urban population in our study comprised 51.2% and 48.8% were rural. Of the 6120 screened subjects, 6047 (98.8%) were adults and without any prior history of renal replacement therapy or dialysis. Of these 5929 subjects (98%) had blood pressure measurements, comprising the analysis population for this article.

### Data collection and participant selection

A structured questionnaire translated into local languages was used (Additional file 1). A team of nephrologists,

**Table 1 Centers for the SEEK study**

Center	Screened population
<b>North zone</b>	
Himachal Pradesh*	520
Varanasi, Uttar Pradesh*	515
Kanpur, Uttar Pradesh§	511
Apollo Hospital, Delhi§	472
RML Hospital, Delhi§	280
Ludhiana, Punjab§	402
<b>West-Central zone</b>	
Nadiad, Gujarat*	506
Bombay, Maharashtra§	531
Bhopal, Madhya Pradesh††	438
<b>South zone</b>	
Cochin, Kerala§	497
H.D.Kote, Karnatak*	1022
Bangalore, Karnatak†	275
Vizag, AndhraPradesh*	152
Total	6120

\*Centers that screened 100% rural subjects.

§Centers that screened 100% urban subjects.

†Center screened 73% urban, 27% rural subjects.

††Center that screened 50% each of urban and rural population.

nurses, technicians and interviewers participated in the camps. At every site, staff was trained in interview techniques and measurement of height, weight and blood pressure by organizing a half day workshop prior to the camp. Body mass index (BMI) was calculated using the formula "weight (Kg)/height (M<sup>2</sup>). Overweight was defined as BMI ≥ 23 and < 27.5 Kg/M<sup>2</sup>, obese as BMI ≥ 27.5 Kg/M<sup>2</sup> [12]. We also calculated the prevalence of being overweight and obese using the conventional cut off of BMI ≥ 25 Kg/M<sup>2</sup> and ≥ 30 Kg/M<sup>2</sup> respectively. The waist to hip circumference ratio (WHR) was calculated by using the waist circumference at the narrowest circumference between the lower costal margin and the iliac crest. Hip circumference was measured at the maximum circumference at the level of the femoral trochanters. Abdominal obesity was defined as ≥ 90 cms for males and ≥ 80 cms for females (Asian cut off) [14].

### Blood Pressure (BP) measurements

In order to get a standardized BP measurement, a protocol per American Heart Association guidelines [15] and a power-point presentation was provided to the centers, and staff training on measuring the blood pressure was carried out prior to camps. Systolic blood pressure (SBP) was based on the 1st Korotkoff phase and diastolic (DBP) on the 5th Korotkoff phase. Mercury sphygmomanometer was used after checking for zero error. After rest for 5 minutes, BP was recorded in the sitting position

in the right arm supported at heart level, to the nearest 2 mm using mercury sphygmomanometer. An average of two readings was taken into consideration.

### Laboratory work-up

Non-fasting blood samples were collected in the camps. Blood was sent to a central laboratory. Quality control for temperature transporting specimens was checked and confirmed; i.e., 4–9 degree Celsius. Serum creatinine was measured using Jaffe Colorimetric method on a Roche Hitachi 912 analyzer. The instrument was calibrated (external calibration) using the Cleveland Clinic Foundation (CCF) creatinine panel. Regression analysis was carried out to calculate a formula to convert creatinine values obtained at the SRL-Ranbaxy laboratory (SRL) to the CCF values as follows: CCF creatinine =  $-0.13 + \text{SRL creatinine} \times 0.99$ . Urine protein was detected by dipstick method (Bayer Multistix 10 SG). A modified MDRD-3 equation  $\text{GFR (mL/min/1.73 m}^2) = 175 \times (S_{\text{cr}})^{-1.154} \times (\text{Age})^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African American})$  was used [16]. Plasma glucose was measured by the glucose oxidase peroxidase method using Roche Hitachi 912 analyzer.

### Definition of variables

Urine protein positivity (proteinuria) was defined as urine protein 1+ or more. Elevated blood pressure (EBP) was defined as SBP/DBP  $\geq 140/90$  mmHg [8]. Hypertension was defined as SBP/DBP  $\geq 140/90$  mmHg [8] or if the patient was on medication for hypertension or had a positive self reported history of hypertension (based on a response to “have you ever been told that you have high blood pressure” or ‘a past history of high blood pressure’). Prehypertension was defined as a systolic pressure from 120 to 139 millimeters of mercury (mmHg) or a diastolic pressure from 80 to 89 mmHg [8]. Diabetes was defined as fasting blood sugar FBS  $> 126$  or non-fasting blood sugar  $\geq 200$  or on any medications for diabetes mellitus (ADA definition) [17], or if there was a positive response to the questions “have you ever been told that you have diabetes” or “past history of diabetes”. Self reported history of medications was verified and if the subject did not know the name of the medication and/or if the stated name was incorrect, the response was considered as “no” even if the subject’s response to the question “are you on BP or diabetes medications” was “yes”. CKD stages were defined using NKF-KDOQI guidelines (eGFR  $< 60$  ml/min/1.73 m<sup>2</sup> or proteinuria  $\geq 1+$  on dipstick) [18]. Self reported ischemic heart disease was taken as present if there was a self reported history of a myocardial infarction, percutaneous angioplasty or coronary artery bypass surgery. Family history included only first-degree relatives.

### Statistical analysis

SAS Statistical Analysis Software Version 9.1.3 (SAS Institute Inc., Cary, NC, USA) was used. Univariate analyses comparing distributions of socio-demographic and clinical/historical measures between HTN groups was performed first, with comparisons made using Fisher’s Exact Test and t-tests. Then a multivariate logistic regression model, with HTN yes or no as the outcome, was fit with variables correlating highly with it univariately ( $p < 0.05$ ). All were entered into the model, and a stepwise selection process combined with finding a parsimonious minimum of the Akaike and Schwarz model information criteria [19] resulted in the final composition of the model. All covariates are adjusted simultaneously for the others including one other covariate, family history of HTN, which was forced to remain in the model. Due to the number of variables and the inclusion of the center variable interactions were not tested. We also presented the adjusted odds ratios and the corresponding 95% confidence intervals for these resulting relationships.

### Results

The main finding of this study is that hypertension prevalence in our SEEK cohort is 43.5%, and 41.5% of subjects had blood pressure in the range of “pre-hypertension”. The mean SBP and DBP of the subjects was 126.8(20) and 80.4(11) mmHg respectively (Table 2).

The demographic and clinical history characteristics of the screened population are shown in Tables 2 and 3. The mean (SD) age of the screened population was 45.3 (15.2) years and 55% were males. Increasing prevalence

**Table 2 Demographic features**

Characteristics		HTN-Yes (43.5%)	HTN-No	p value
Age	n	2578	3351	<b>&lt;.0001</b>
	Mean (SD)	52.1(14.02)	40.0(13.93)	
BMI	n	2561	3340	<b>&lt;.0001</b>
	Mean (SD)	25.7(5.37)	22.7(4.87)	
Waist circum.	n	2426	3236	<b>&lt;.0001</b>
	Mean (SD)	88.3(13.33)	79.3(13.12)	
Hip circum	n	2425	3234	<b>&lt;.0001</b>
	Mean (SD)	96.1(12.21)	89.8(11.07)	
Systolic BP	n	2577	3351	<b>&lt;.0001</b>
	Mean (SD)	140.7(19.97)	116(10.99)	
Diastolic BP	n	2575	3344	<b>&lt;.0001</b>
	Mean (SD)	87.7(10.97)	74.8(7.58)	
S.Creatinine	n	2453	3220	<b>&lt;.0001</b>
	Mean (SD)	1.1(1.10)	0.9(0.34)	

Boldfaced p values means “statistically significant”.

**Table 3 Prevalence of risk factors in HTN population**

Characteristic	Result	HTN-Yes		HTN-No		p-value
		N = 2578		N = 3351		
		n	%	n	%	
Age	< 40 years	515	20	1701	50.8	
	≥ 40 years	2063	80	1650	49.2	<0.0001
Gender	Female	1095	42.5	1572	46.9	
	Male	1482	57.5	1779	53.1	0.0007
Education	≤ 8th grade	1011	39.2	1540	46.0	
	9th to some college	837	32.5	1069	31.9	
	College grad/ Post grad	715	27.7	724	21.6	0.0007
Occupation	Manual labor*	391	15.2	899	26.8	
	Own business/ salaried	867	33.6	1128	33.7	
	Student	18	0.7	122	3.6	
	Sedentary**	1275	49.5	1171	34.9	0.0007
Income	≤ 125 \$/month	1477	57.3	2295	68.5	
	> 125 \$/month	980	38.0	939	28.0	<0.0001
Urban		1502	58.3	1535	45.8	
Rural		1076	41.7	1815	54.2	<0.0001
Obesity status:						
Body mass index	< 23 Kg/M <sup>2</sup>	789	30.6	1904	56.8	
	≥ 23 Kg/M <sup>2</sup>	1772	68.7	1436	42.9	<0.0001
Body mass index††	< 27 Kg/M <sup>2</sup>	1709	66.3	2804	83.7	
	≥ 27 Kg/M <sup>2</sup>	852	33.0	536	16.0	<0.0001
Body mass index†††	< 30 Kg/M <sup>2</sup>	2100	81.5	3090	92.2	
	≥ 30 Kg/M <sup>2</sup>	461	17.9	250	7.5	<0.0001
Abdominal Obesity⊙	No	965	37.4	2149	64.1	
	Yes	1461	56.7	1087	32.4	<0.0001
Current Smoker or tobacco chewer	No	1875	72.7	2418	72.2	
	Yes	516	20.0	765	22.8	0.0312
Current Smoker & tobacco chewer	No	2322	90.1	3054	91.1	
	Yes	45	1.7	94	2.8	0.0117
Self reported DM	No	1892	73.4	2905	86.7	
	Yes	570	22.1	263	7.8	<0.0001
Diabetes mellitus♦	No	1801	69.9	2862	85.4	
	Yes	672	26.1	343	10.2	<0.0001
Family H/o HTN	No	1967	76.3	2697	80.5	
	Yes	607	23.5	647	19.3	<0.0001
Urine-protein	Absent/trace	2045	79.3	2981	89.0	
	> = 1+	489	19.0	310	9.3	<0.0001
CKD♦♦	No	1801	69.9	2814	84.0	
	Yes	606	23.5	358	10.7	<0.0001

**Table 3 Prevalence of risk factors in HTN population (Continued)**

Center type	Urban	1355	52.6	1284	38.3	
	Rural	974	37.8	1618	48.3	
	Mixed population	249	9.7	449	13.4	<b>0.0051</b>

P value < 0.05 is significant.

\* - includes categories of occupation – agriculture workers, laborers, cowherds.

\*\* - includes, homemakers (housewives), retired, unemployed and others.

† - Body Mass Index - ≥ 23 Kg/M<sup>2</sup> includes overweight and obese as per Asian cutoff.

†† - Obese as per Asian cutoff.

††† - Obese as per conventional cutoff.

⊙ - Waist circumference ≥ 90 cms in males or ≥ 80 cms in females.

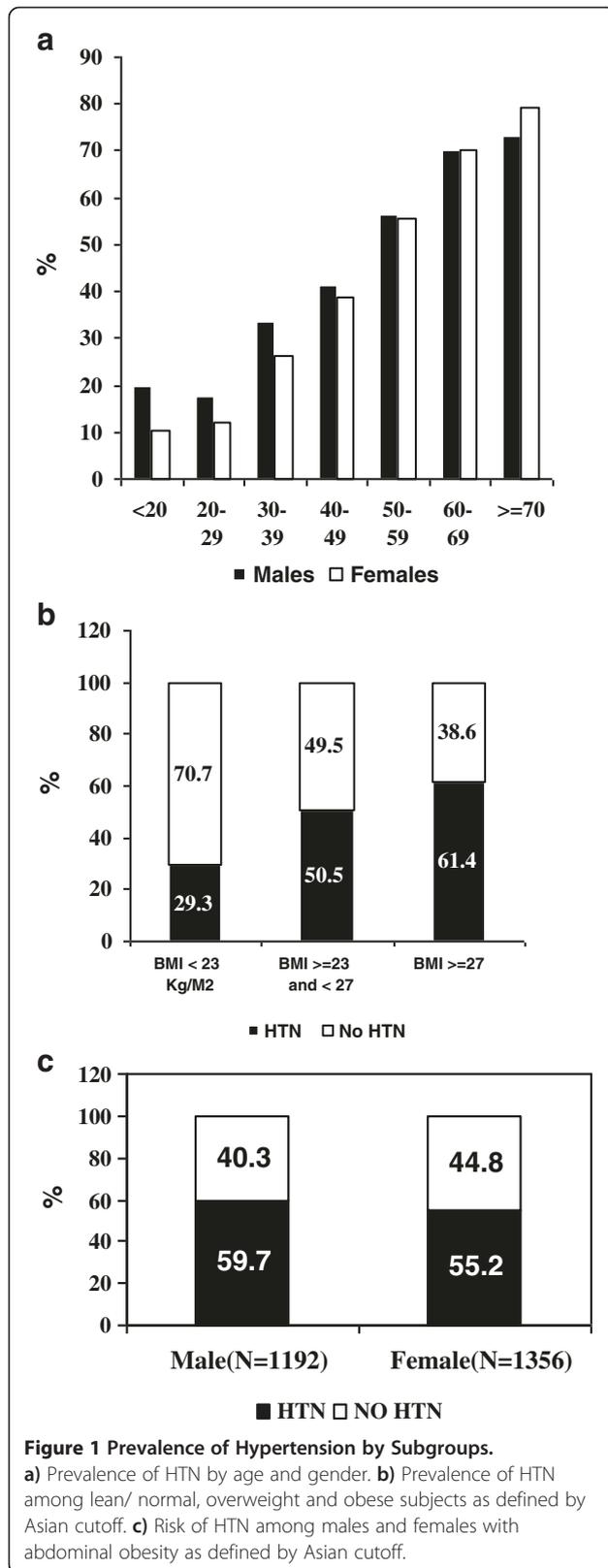
♦ - Diabetes Mellitus (DM) = Fasting blood sugar ≥ 126 or non-fasting blood sugar ≥ 200 or if self reported D.M or on anti diabetic medication.

♦♦ - MDRD-GFR < 60 ml/min/1.73 m<sup>2</sup> or proteinuria ≥ 1+ on dipstick.

with age was observed, with 70% of males and females 60 to 70 years of age having hypertension. In the > 70 years age group there was a higher percentage of females having HTN. (Figure 1a) Mean BMI, waist and hip circumference were 24(5.3) Kg/M<sup>2</sup>, 83.2(13.9) cm, and 92.5(12) cm respectively. Forty three percent showed indications of abdominal obesity. Forty three percent of the subjects had < 8th grade education, 32.1% had “a 9th grade to some college” education, and 24.3% had graduate or postgraduate educations. About one fifth (21.8%) were involved in manual labor (agricultural workers, laborers, and cowherds), 33.6% had salaried jobs/ their own business, 2.4% were students and 41.3% were involved with sedentary occupations (homemakers, unemployed, retired or other occupations), with 63.6% earning less than \$125 per month. Another fifth (21.6%) were current smokers or tobacco chewers; only 2.3% did both. Seventeen percent of subjects had diabetes (14% self-reported), 21.2% reported having a family history of HTN, 13.5% had proteinuria, and 16.3% had CKD. Self reported ischemic heart disease (heart attack, angioplasty or bypass surgery) was observed in 5.4% of the subjects, self-reported stroke in 1.3% and self-reported peripheral vascular disease in 2.4%. Serum creatinine levels averaged 1.0 mg/dL.

The prevalence of hypertension at various centers is depicted in Figure 2. Among the rural centers, Kote had the lowest prevalence of HTN, with the other rural centers having rates comparable to those in some of the urban centers. Given that Kote screened 1/3 of the total rural population, the result of lower rural prevalence compared to urban prevalence is probably due to Kote, and highlights the need for center as an adjuster in the multivariate model.

Only 54% of the HTN subjects were aware of their hypertension and reported positively to the question “Have you ever been told that you have high blood pressure?” or “Do you have a past history of hypertension?”. 21.7% of the hypertensive population was on treatment.



### Comparisons of HTN groups

The mean age of hypertensive subjects was 52.1 years (SD 14.02 years), significantly higher than the non-hypertensive subjects ( $p < 0.0001$ ). Eighty percent of subjects with HTN were  $\geq 40$  years of age as compared to 49.2% of those without HTN ( $p < 0.0001$ ). Figure 1a shows increasing prevalence of HTN with age; in the 6<sup>th</sup> and 7<sup>th</sup> decade  $\geq 70\%$  of males and females in the screened population had hypertension. The mean systolic and diastolic blood pressure of the hypertensive group were 141(20) and 88(11) mmHg respectively, while that of the non hypertensive group was 116(11) and 74(8) mmHg respectively ( $p < 0.0001$ ). Approximately fifty seven percent of subjects with hypertension were males and to 42.5% were females ( $p = 0.0007$ ). For the HTN group, the mean BMI was 25.7(5.4) Kg/M<sup>2</sup>, the mean waist circumference was 88.3(13.3) cm, the hip circumference 96.1(12.2) cm, and 56.7% had abdominal obesity; these numbers were significantly higher than in the non-hypertensive group ( $p < 0.0001$  for all 4 parameters). There was a significant difference in the distribution of educational, occupational, and income levels between the groups, as well as who smoked and/or chewed tobacco. Family history of HTN was reported more often in the HTN group (23.5% vs. 19.3%,  $p < 0.0001$ ).

Confirmed and self-reported diabetes (26.1% and 22.1%, respectively) were both higher in the HTN group ( $p < 0.0001$ ). proteinuria was observed among 19% of HTN subjects as compared to 9.3% of non hypertensive subjects ( $p < 0.0001$ ). CKD (MDRD GFR  $< 60$  ml/min/1.73 m<sup>2</sup> or GFR  $\geq 60$  ml/min/1.73 m<sup>2</sup> and urine protein  $\geq 1+$ ) was found in 23.5% of HTN subjects and 10.7% of non-hypertensive subjects ( $p < 0.0001$ ).

A significantly higher prevalence of cardiovascular complications was observed among subjects with HTN as compared with those without (see Table 4). Self reported ischemic heart disease (heart attack, angioplasty or bypass surgery) was observed in 8.9% ( $p < 0.0001$ ), stroke in 1.9% ( $p = 0.0002$ ) and peripheral vascular disease in 3.4% ( $p = 0.005$ ) of HTN subjects, respectively.

Hypertension was significantly higher in the urban population compared to the rural population ( $p < 0.0001$ ), and the center distribution showed statistically significant differences among the three center types (urban, rural, mixed) ( $p = 0.005$ ).

### Predictors of hypertension

We combined the variables described above into a multivariate model, and this analysis confirmed the indications of the independent tests. Those greater than 40 years of age were 2.24 times more likely to have HTN and males 1.17 times more likely to have HTN than females. This cutoff was chosen after repeated univariate

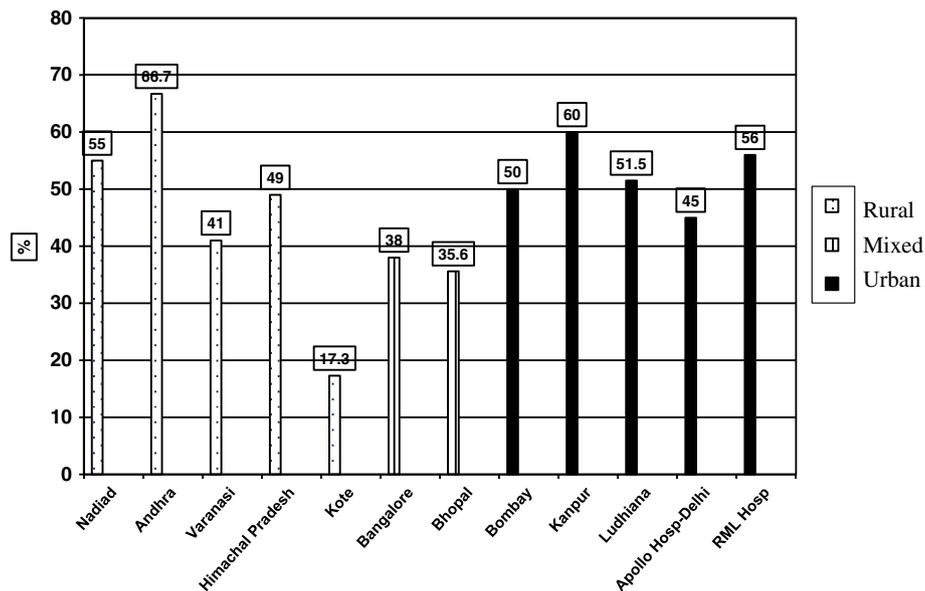


Figure 2 Prevalence of hypertension by center.

modeling at each year of age showed 40 to depict the largest contrast in HTN prevalence. Continuous measures of waist circumference retained a positive association with HTN ( $p < 0.0001$ ). Having a 9th grade +/some college education resulted in a lower chance of being hypertensive (OR: 0.76, 95%CI: 0.64- 0.90,  $p = 0.0016$ ) compared to having a less than 9th grade education. Those involved in sedentary ( $p < 0.0001$ ) occupations versus an agricultural occupation were more likely to have HTN. Individuals with diabetes were 1.71 times more likely to become hypertensive, those with proteinuria 1.40 times more likely, and higher serum creatinine predisposed one to being hypertensive. Family history of hypertension was not significantly related to HTN multivariately, but was left in the final model ( $p = 0.20$ ). Table 5 has a complete list of odds ratios and p-values. The strongest predictors of hypertension were age more than 40 years, sedentary life style, diabetes, high serum creatinine, and the presence of urine protein. There was

significant center to center variation in the prevalence of hypertension when the 12 centers were compared with the center Bombay (an urban center with 50% prevalence of hypertension, ( $p < 0.0001$ )).

### Discussion

The main finding of this study is that hypertension prevalence in our SEEK cohort is 43.5%, and 41.5% of subjects had blood pressure in the range of “pre-hypertension”.

The major predictors of hypertension included age  $>40$  years, male gender, BMI of  $\geq 23$  Kg/M<sup>2</sup>, waist circumference, sedentary occupation, proteinuria, and increased serum creatinine, proteinuria and CKD were observed in 19% and 23.5% of HTN subjects, respectively. Nearly two-thirds of the cohort with hypertension was overweight or obese compared to only approximately 40% of those without HTN. Collectively, these observations support the idea that hypertension is an important public health issue in developing countries and it has important associations with both kidney disease and obesity. In China, the largest and most populous country in Asia, HTN was identified as the major causes of death [20-22].

Both Asia and Africa are witnessing this increasing prevalence due to acculturation. Rapid and often uncontrolled urbanization leads to exposure to many health risks, including poor sanitation and environmental risk factors. However, it also leads to changes in dietary and lifestyle changes leading to decreased physical activity and increased risk of obesity and greater risk of hypertension. Most of the increase in the prevalence of HTN in the developing countries especially in the South East Asia has been attributed to the increase in obesity [23].

Table 4 Cardiovascular Disease in the SEEK Cohort (self reported history)

Characteristics	HTN Yes		HTN No		Total population		p-value
	N = 2578		N = 3351		N = 5929		
	n	%	n	%	n	%	
Ischemic heart disease*	229	8.9	90	2.7	319	5.4	$<0.0001$
Stroke	50	1.9	27	0.8	77	1.3	0.0002
Peripheral vascular disease	87	3.4	57	1.7	144	2.4	0.0051

\*Self reported positive history of heart attack, angioplasty or coronary by-pass operation.

**Table 5 Multi-variate regression analysis for association of risk factors with HTN (adjusted for all characteristics with p value < 0.05 on univariate analysis)**

Variable	Adjusted odds ratio	p-value
> = 40 years (ref: less than 40 years)	2.24 (1.93- 2.59)	<0.0001
Male (ref: female)	1.17 (1.00- 1.38)	0.0564
9th Grade/Some College (ref: less than 9th grade)	0.76 (0.64- 0.90)	0.0016
College Grad/Post Grad (ref: less than 9th grade)	0.85 (0.70- 1.04)	0.1159
Own Business/Salaried (ref: unemployed)	1.07 (0.87- 1.32)	0.5149
Student (ref: unemployed)	0.80 (0.43- 1.48)	0.4751
Sedentary* (ref: physical job)	1.79 (1.45- 2.20)	<0.0001
BMI > =23 kg/m <sup>2</sup> (ref: BMI less than 23)	1.37 (1.15- 1.64)	0.0004
Waist Circumference (ref: normal WC)	1.03 (1.03- 1.04)	<0.0001
Diabetes Mellitus♦ (ref: no DM)	1.71 (1.44- 2.04)	<0.0001
Family History of HTN (ref: No FH of HTN)	1.11 (0.95-1.31)	0.1963
Serum Creatinine (ref: normal creatinine)	1.61 (1.34- 1.93)	<0.0001
Urine protein > = 1+ (ref: no urine protein)	1.40 (1.14- 1.73)	0.0016

p value < 0.05 significant,

\*Includes, homemakers (housewives), retired, unemployed and others.

♦Diabetes Mellitus (DM) = fasting blood sugar ≥ 126 or non-fasting blood sugar ≥ 200 or if self reported D.M or on ant diabetic medication.

Serum creatinine and waist circumference are taken as a continuous variable.

The increased prevalence of HTN in urban compared to the rural populations has been also shown in several other studies [24-26] including a recent meta-analysis [27]. It showed that the prevalence of HTN varied between 4.5 to 45% in rural populations, and a higher prevalence (13.9–48.2%) in the urban populations, with a significant increasing trend over time.

Excess body weight has been identified as an important independent risk factor for hypertension and related complications of CVD [28]. Several reports suggest that among the Chinese and South Asian population a higher prevalence of dyslipidemia, metabolic syndrome, type II diabetes mellitus and CVD are observed at a much lower value of BMI than the Europeans [28,29]. The normal range of BMI cutoff points derived in the western

population may be misleading when used for these ethnic groups [29]. An Asian cut off for obesity and abdominal obesity among different ethnic populations was also defined by the International Diabetes Federation consensus group in 2004 [17]. This cut-off was much lower for the Chinese, Japanese, South Asian population as compared to the European population [30]. He et al. observed that waist circumference adds additional risk information to that of BMI in Chinese adults [31]. Obesity by conventional standards (17.9%) and Asian standards (33%) was prevalent among HTN subjects. However, 68.7% of the HTN population was overweight or obese compared to 42.9% of those without HTN. Further, we observed overweight or obese (BMI ≥ 23 Kg/M<sup>2</sup>) individuals to have 1.37 times higher prevalence of HTN compared to those with lean or normal BMI (< 23 Kg/M<sup>2</sup>). In the KEEP study, 50.8% of HTN subjects were obese using the conventional cut off [32] Also, waist circumference as a continuous variable revealed a significantly higher positive association with HTN. Given the propensity of Indian population to develop hypertension at a much lower body weight and waist circumference, urgent and concerted prevention policy development and implementation including educational intervention for improving diet and exercise is necessary.

Association of HTN with diabetes mellitus, proteinuria and CKD was high in our cohort. Kidney disease can be the cause or consequence of hypertension. Proteinuria is the earliest indication of kidney disease among diabetic subjects and has been observed in about 20- 40% of diabetic subjects without known kidney disease [33,34]. But prevalence of albuminuria among hypertensive individuals screened in large populations has been reported in 8–11.5% in the AusDIAB and Prevention of Renal and Vascular End Stage Disease (PREVEND) studies [35-37]. The relationship between hypertension and proteinuria has however not been explored in many epidemiologic studies reported from India [10,12,13]. Since these were screening camps, and the fact the renal involvement can be a cause or effect of hypertension, it is difficult to assess if the renal involvement is a predictor or a complication of HTN in our cohort. However, it is important to note this association was observed in a significant number of subjects in the cohort. With adequate management of both HTN and proteinuria, further complications of CVD, retinopathy as well as ESRD can be prevented. Training general practitioners to carry out a simple urine dip-stick test among hypertensive and diabetic subjects would help in detecting these cases early and preventing the progression.

Despite the design of the study wherein a bias may exist for more people with higher awareness of HTN to come to attend the screening camps, we observed a low awareness and control of HTN. Our study demonstrates

a much lower HTN awareness than that reported from the USA by Burt et al., an awareness rate of 73% in the National Health and Nutrition Examination Surveys (NHANES III-1988 –1991, [38,39]. Low awareness of HTN may reflect disparities in health care access, lack of education, the effect of poverty, or a combination of these and other factors. Low awareness of HTN has been observed in other developing countries including China and Pakistan [40-42]. In part, this is because of the low level of literacy and education, but also seems to reflect low level of access to medical care. Indeed, in South Asian countries, awareness correlated with poor access to treatment and therefore to control of hypertension [42]. The challenge posed by low level of awareness must be overcome for prevention through strategies targeted at education and promotion. This lack of awareness underscores the importance of organizing an aggressive community based screening as well as health education campaign to improve awareness of morbidity and mortality due to HTN among the population. Greater commitment and availability of resources targeted at health education will likely to be needed.

Our findings indicate that prevalence of HTN was high in the screened population at 43.5%, with significant center to center variation in prevalence. This effect was observed independently of other risk factors for hypertension and could perhaps reflect regional differences in salt intake and/or other lifestyle practices. The fact that HTN increased with age and was higher for males was consistent with other reports [43,44]. In the meantime, the prevalence of hypertension of the SEEK study that we carried out in Thailand and Saudi Arabia were found to be 27.5% and 27.7% [45,46].

Our higher prevalence of HTN compared to some of the other reported series from India and other Asian countries like Pakistan and China may be related to the design of the study (camp module) as opposed to the domiciliary screening method used by others [4,13,42]. These differences in prevalence may also be related to the instrument used for the measurement of BP, the definition of hypertension used, and the genetic/anthropologic make up of the population screened. The findings also corroborate those by Keraney et al. where they reported that the “Global burden of Hypertension” will affect more than a quarter of the world’s adult population with HTN in 2000, and was projected to be increased by 60% by about 2025, the population burden being higher in the developing countries [4].

High prevalence of pre-hypertension (41.5%) in the screened population is also worrisome. A collaborative meta-analysis of individual participant data from one million adults with no previous vascular disease recorded at baseline in 61 prospective observational studies of blood pressure and mortality during 12.7 million

person-years at risk was analyzed. The authors observed that throughout middle and old age, blood pressure is strongly and directly related to vascular (and overall) mortality, without any evidence of a threshold down to at least 115/75 mmHg [47]. The Trial Of Preventing Hypertension (TROPHY) also echoed the same observations that the CVD risk begins to rise even before the diagnosis of HTN is made [48]. The JNC 7 calls for routine blood pressure measurement at least once every 2 years for adults with pre-hypertension [8] and the American Heart Association issued similar recommendations for adults beginning at age 20 years for primary prevention of hypertension [49]. Surveillance of this pre-HTN population particularly among those >40 years of age for early detection of HTN will be essential.

This study had strengths and limitations. Its major strengths were the large sample size and the national distribution of health screening camps, although we did not have representation in the eastern parts of India. We believe that training of staff and use of standardized measurements also reduced the possibility of measurement bias. The main limitation was that we used a camp based methodology for screening rather than domiciliary screening and this may bias in favor of higher rates of disease. Nevertheless, our data adds information on risk factors, the burden of hypertension in the population. Further, this method has been used successfully as a cost effective method of detecting positive cases for screening large populations in the USA for the prevalence of CKD, hypertension and diabetes in the KEEP study [32]. An average of two measurements at a single visit is considered acceptable for an epidemiologic study using screening camps methodology and has been used by other surveys in the USA and other countries [28,50]. We defined HTN as EBP/self reported medications for HTN/self reported HTN as a positive answer to the question “have you ever been told that you have HTN”. This differs from the definition used by some of the previously reported studies that define HTN as EBP and/or self reported medications for HTN. A single spot urine sample and absence of quantification of albuminuria was also a limitation.

## Conclusions

In conclusion, HTN is an important public health problem in India. Reliable information about the prevalence of HTN is germane to the planning of any preventive or therapeutic strategies for HTN in a community. Low level of awareness and control in the HTN population makes it imperative to bring about a change in the way health related education should be brought to this population. An emphasis on education that is related to the control of modifiable predictors of hypertension, such as reducing obesity and abdominal obesity by diet and

increasing physical exercise (especially for those involved in sedentary occupations) should be considered. Limiting salt consumption coupled with other lifestyle changes are likely to be one of the cost-effective population-based strategies and need to be considered as part of the public health agenda in India. If scarce resources are to be utilized optimally, control of HTN will help in improving the management of both CVD and CKD.

## Additional file

**Additional file 1: SEEK Project – Screening Questionnaire.**

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

BVM and AKS – conceived and designed the study; AKS – acquired funding, supervised the overall execution of the study; BVM – cleaned the database; YMKF and SRKR – analyzed and interpreted the data; YMKF, BVM, and AKS – wrote the manuscript; All other co-authors – conducted and supervised the study procedures and the operational execution in the local Indian centers. All authors read and approved the final manuscript.

### Acknowledgements

The SEEK study investigators express their appreciation to Janssen-Cilag India (Kuldeep Pandit and Bhushan Akshikar) and Johnson and Johnson, USA (Dr. Suresh Aravind). The SEEK study group also is grateful to the Indian Society of Nephrology for their strong support of this project.

### Role of funding agency

The funding agency had no role in the design, execution, analysis, and report of the data from the SEEK study.

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Vivekananda Memorial Hospital, H.D.Kote, Saragur, Mysore  
Manipal Institute of Nephrology and Urology, Bangalore  
Deep Hospital, Ludhiana  
Indraprastha Apollo Hospital, New Delhi  
Bombay Hospital, Mumbai  
Fortis Flt. Lt. Rajan Dhall Hospital, New Delhi  
Bhopal Memorial Hospital & Research Center, Bhopal  
PVS Memorial Hospital, Cochin  
Institute of Medical Sciences, BHU, Varanasi  
Muljibhai Patel Urological Hospital, Nadiad  
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Received: 19 November 2012 Accepted: 4 October 2013  
Published: 6 March 2014

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doi:10.1186/1471-2369-15-42  
Cite this article as: Farag et al.: Burden and predictors of hypertension in India: results of SEEK (Screening and Early Evaluation of Kidney Disease) study. *BMC Nephrology* 2014 15:42.

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