Original Investigation

Prevalence, Awareness, Treatment, and Control of Hypertension in Rural and Urban Communities in High-, Middle-, and Low-Income Countries

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IMPORTANCE Hypertension is the most important preventable cause of morbidity and mortality globally, yet there are relatively few data collected using standardized methods.

OBJECTIVE To examine hypertension prevalence, awareness, treatment, and control in participants at baseline in the Prospective Urban Rural Epidemiology (PURE) study.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional study of 153 996 adults (complete data for this analysis on 142 042) aged 35 to 70 years, recruited between January 2003 and December 2009. Participants were from 628 communities in 3 high-income countries (HIC), 10 upper–middle-income and low–middle-income countries (UMIC and LMIC), and 4 low-income countries (LIC).

MAIN OUTCOMES AND MEASURES Hypertension was defined as individuals with self-reported treated hypertension or with an average of 2 blood pressure measurements of at least 140/90 mm Hg using an automated digital device. Awareness was based on self-reports, treatment was based on the regular use of blood pressure–lowering medications, and control was defined as individuals with blood pressure lower than 140/90 mm Hg.

RESULTS Among the 142 042 participants, 57 840 (40.8%; 95% CI, 40.5%-41.0%) had hypertension and 26 877 (46.5%; 95% CI, 46.1%-46.9%) were aware of the diagnosis. Of those who were aware of the diagnosis, the majority (23 510 [87.5%; 95% CI, 87.1%-87.9%] of those who were aware) were receiving pharmacological treatments, but only a minority of those receiving treatment were controlled (7634 [32.5%; 95% CI, 31.9%-33.1%]). Overall, 30.8%, 95% CI, 30.2%-31.4% of treated patients were taking 2 or more types of blood pressure–lowering medications. The percentages aware (49.0% [95% CI, 47.8%-50.3%] in HICs, 52.5% [95% CI, 51.8%-53.2%] in UMICs, 43.6% [95% CI, 42.9%-44.2%] in LMICs, and 40.8% [95% CI, 39.9%-41.8%] in LICs) and treated (46.7% [95% CI, 45.5%-47.9%] in HICs, 48.3%, [95% CI, 47.6%-49.1%] in UMICs, 36.9%, [95% CI, 36.3%-37.6%] in LMICs, and 31.7% [95% CI, 30.8%-32.6%] in LICs) were lower in LICs compared with all other countries for awareness (P <.001) and treatment (P <.001). Awareness, treatment, and control of hypertension were higher in urban communities compared with rural ones in LICs (urban vs rural, P <.001) and LMICs (urban vs rural, P <.001), but similar for other countries. Low education was associated with lower rates of awareness, treatment, and control in LICs, but not in other countries.

CONCLUSIONS AND RELEVANCE Among a multinational study population, 46.5% of participants with hypertension were aware of the diagnosis, with blood pressure control among 32.5% of those being treated. These findings suggest substantial room for improvement in hypertension diagnosis and treatment.

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High blood pressure is the leading cause of cardiovascular disease (CVD) and deaths globally. It is associated with at least 7.6 million deaths per year worldwide (13.5% of all deaths), making it the leading risk factor for CVD.[1] The majority of CVD occurs in low-, low-middle-, and upper-middle-income countries (LIC, LMIC, and UMIC).[1,2] The importance of blood pressure as a modifiable risk factor for CVD is well-recognized and many effective and inexpensive blood pressure-lowering treatments are available. Therefore, hypertension control and prevention of subsequent morbidity and mortality clearly should be achievable.

Information on hypertension prevalence, awareness, treatment, and control in multiple countries and different types of communities is necessary to provide a baseline for monitoring and also to inform the development of new strategies for improving hypertension control. A number of initiatives from the World Health Organization (WHO) have documented prevalence of hypertension and some have recorded treatment rates.[3-5] The largest systematic analysis of health surveys from 199 countries for individuals aged 25 years and older was conducted in 2008 and reported the prevalence and mean of hypertension.[6] However, most studies were limited to few countries and were conducted at least 2 decades ago, few reported awareness, and none reported on variations between urban vs rural settings, economic status and other variables, rates of blood pressure control, or the types of treatments used. Such information is key to developing strategies for better detection and control of hypertension globally.

ACE *angiotensin-converting enzyme*
ARB *angiotensin receptor blocker*
CVD *cardiovascular disease*
DBP *diastolic blood pressure*
HIC *high-income country*
LIC *low-income country*
LMIC *low–middle-income country*
SBP *systolic blood pressure*
UMIC *upper–middle-income country*

The overall Prospective Urban Rural Epidemiology (PURE) study is a prospective, standardized collaborative study[7,8] in which we report a cross-sectional analysis of baseline data to assess the prevalence, awareness, treatment, and control of hypertension by the economic status of countries and by sex, age group, location (urban vs rural), and education of the participants.

Methods

The PURE study was approved by the ethics committees in all participating centers. All participants provided consent (either written or a thumbprint if unable to read). The PURE study involves urban and rural communities within 17 countries including 3 high-income countries (HICs): Canada, Sweden, United Arab Emirates; (7 UMICs) Argentina, Brazil, Chile, Poland, Turkey, Malaysia, South Africa; (3 LMICs) China, Colombia, Iran; and (4 LICs) Bangladesh, India, Pakistan, Zimbabwe (eTable 8 in Supplement). Categorization of economic level of a country was based on information from the World Bank in 2006.[9] The overall aim of PURE was to examine the relationship of societal influences on lifestyle behaviors, cardiovascular risk factors, and incidence and mortality of chronic diseases. The methods of the PURE study have been described previously.[10,11] Briefly, countries and communities were chosen purposively to participate in PURE. For practical reasons, our goal was not to select strict proportionate sampling, but instead to show economic and sociocultural diversity and inclusion of sites in which investigators were committed to collecting high-quality data at a modest budget and to following up participants for at least 10 years. Within communities, the sampling framework used aimed to recruit an unbiased sample of households.[10] Inclusion of a broad sample of several countries of low- and middle-income status, countries in which data on chronic disease are relatively sparse, was a key goal. Within each country, an urban and rural stratified sample of communities was selected with the aim to include a diverse range of communities (eTable 8 in Supplement). In the analysis by region, South Asia includes cohorts from Bangladesh, India, and Pakistan; Africa includes South Africa and Zimbabwe; North America and the European Union includes Canada, Sweden, and Poland; the Middle East includes Iran, Turkey, and the United Arab Emirates; South America includes Argentina, Brazil, Chile, and Colombia; while China and Malaysia included cohorts from their respective countries only.

Households were eligible if 1 or more members of the household was aged between 35 and 70 years and the household members intended to stay at that address for a further 4 years. Medical history and risk factors were recorded and a basic physical examination was conducted on participants between the ages of 35 and 70 years who provided written informed consent.[10,11]

Measurement of Risk Factors

CVD risk factor history, including smoking, history of hypertension, diabetes, psychosocial factors, alcohol consumption, and physical measures were recorded as described in the INTERHEART study,[12] as were sociodemographic characteristics including date of birth. With participants for whom date of birth was unknown, self-reported age was recorded in years. Younger age was defined as less than 50 years, and older was defined as aged 50 years or older. In these analyses, prevalent diabetes and CVD are defined on the basis of self-reported medical diagnoses, which have demonstrated substantial and moderate agreement,[13] respectively with data from disease registers in a large Finnish study (κ, 0.58 and 0.75).[14] We also verified, during a central adjudication process, medical or hospital records in a sample of 455 events during follow-up with agreement rates of 89%.[11] Education was categorized as high (trade school, college or university); medium (secondary school or high school), low (primary education or no education), or unknown.

Sitting blood pressure was measured by trained research assistants at all centers following a standardized procedure using an Omron digital blood pressure measuring device (Omron HEM-757) provided for all sites. The mean of 2 measures was used for all analyses. The main hypertension defi-

Table 1. Characteristics of Participants by Country and Hypertension Level According to Various Definitions

Country[a]	No. of Participants	No. (%) Rural	No. (%) Women	Mean (SD) Age, y	Mean (SD) Systolic BP, mm Hg	Mean (SD) Diastolic BP, mm Hg	Self-reported Hypertension Characteristics, No. (%) Receiving Treatment	Receiving Treatment or BP ≥140/90 mm Hg	Receiving Treatment or BP ≥160/100 mm Hg
HIC	15 418	4426 (28.7)	8398 (54.5)	52.91 (9.2)	130.5 (19.7)	81.8 (12.3)	2763 (18.0)	6263 (40.7)	3716 (24.1)
Canada	10 349	3095 (29.9)	5552 (53.6)	53.36 (9.1)	129.2 (19.4)	79.6 (11.3)	1959 (19.0)	3865 (37.5)	2367 (22.9)
Sweden	4151	902 (21.7)	2193 (52.8)	52.65 (9.0)	132.7 (19.6)	86.7 (13.0)	572 (13.8)	1921 (46.3)	1041 (25.1)
United Arab Emirates	918	429 (46.7)	653 (71.1)	49.14 (10.2)	135.1 (21.4)	83.9 (11.9)	232 (25.3)	477 (52.0)	308 (33.6)
UMIC	36 463	17 074 (46.8)	21 900 (60.1)	51.19 (9.4)	134.5 (23.1)	83.4 (20.4)	8290 (22.7)	18 123 (49.7)	11 727 (32.2)
Argentina	7424	3871 (52.1)	4568 (61.5)	51.15 (9.8)	135.2 (21.7)	82.8 (12.6)	1844 (24.8)	3777 (50.9)	2440 (32.9)
Brazil	5549	1925 (34.7)	3071 (55.3)	52.21 (9.3)	132.3 (23.8)	86.7 (38.0)	1788 (32.2)	2918 (52.6)	2113 (38.1)
Chile	3186	640 (20.1)	2115 (66.4)	51.88 (9.7)	130.8 (22.1)	82.1 (20.5)	753 (23.6)	1485 (46.6)	1003 (31.5)
Malaysia	11 324	6853 (60.5)	6448 (56.9)	51.13 (9.2)	135.2 (22.8)	81.7 (15.5)	2090 (18.5)	5321 (47.0)	3221 (28.4)
Poland	1947	755 (38.8)	1215 (62.4)	53.82 (8.9)	145.2 (21.8)	86.1 (11.5)	628 (32.4)	1307 (67.3)	880 (45.2)
South Africa	3031	1633 (53.9)	2058 (67.9)	49.25 (9.2)	138.0 (25.7)	89.2 (15.2)	408 (13.5)	1726 (57.1)	1042 (34.4)
Turkey	4002	1397 (34.9)	2425 (60.6)	49.70 (9.0)	129.5 (22.2)	80.4 (13.1)	779 (19.5)	1589 (39.7)	1028 (25.7)
LMIC	58 476	29 353 (50.2)	34 403 (58.8)	50.68 (9.6)	132.1 (22.4)	82.1 (13.7)	8294 (14.2)	23 269 (39.9)	13 344 (22.8)
China	45 108	22 722 (50.4)	26 551 (58.9)	50.96 (9.6)	133.7 (22.4)	82.9 (13.2)	6311 (14.0)	18 915 (42.0)	10 693 (23.7)
Colombia	7355	3649 (49.6)	4715 (64.1)	50.73 (9.5)	128.8 (23.3)	81.1 (16.9)	1241 (16.9)	2757 (37.5)	1723 (23.4)
Iran	6013	2982 (49.6)	3137 (52.2)	48.48 (9.2)	124.5 (18.7)	77.6 (11.5)	742 (12.3)	1597 (26.6)	928 (15.4)
LIC	31 685	16 707 (52.7)	17 906 (56.5)	48.55 (10.3)	126.38 (21.8)	80.4 (13.0)	3121 (9.9)	10 185 (32.2)	5557 (17.5)
Bangladesh	2754	1437 (52.2)	1508 (54.8)	46.00 (9.4)	127.0 (23.3)	84.5 (14.9)	155 (5.7)	1079 (39.3)	598 (21.7)
India	26 861	14 362 (53.5)	15 167 (56.5)	48.77 (10.4)	126.0 (21.1)	79.6 (12.6)	2698 (10.1)	8240 (30.7)	4432 (16.5)
Pakistan	1288	370 (28.7)	670 (52.0)	47.38 (8.7)	124.16 (21.1)	82.7 (12.3)	153 (11.9)	432 (33.5)	242 (18.8)
Zimbabwe	782	538 (68.8)	561 (71.7)	51.96 (9.5)	142.53 (32.1)	88.8 (16.3)	115 (14.7)	434 (55.6)	285 (36.4)
All countries	142 042	67 560 (47.6)	82 607 (58.2)	50.58 (9.7)	131.28 (22.4)	82.0 (15.5)	22 468 (15.8)	57 840 (40.8)	34 344 (24.2)

Abbreviations: BP, blood pressure; HIC, high-income country; LIC, low-income country; LMIC, low–middle-income country; UMIC, upper–middle-income country.

[a] Categorization of economic level of a country was based on information from the World Bank in 2006. Participants from all countries were recruited between 2005 and 2010.

nition used in this article was individuals who reported having hypertension and receiving blood pressure-lowering treatment or had an average systolic blood pressure (SBP) of at least 140 mm Hg, an average diastolic blood pressure (DBP) of at least 90 mm Hg (categorized as stage 1), or both an SBP and DBP that exceeded the previously shown levels. We also used a similar definition similar to categorize stage 2 participants but included individuals with SBP of at least 160 mm Hg, DBP of at least 100 mm Hg (or both, as previously shown). Categorizing stage 1 vs stage 2 was done to demonstrate the distribution of definite hypertension. All participants were asked whether they had a medical diagnosis of hypertension (awareness), whether they were receiving blood pressure-lowering medications (treatment), and a list of all their medications were recorded. Control was the proportion of participants with hypertension who had an average systolic and diastolic blood pressure of less than 140/90 mm Hg.

Statistical Analysis

Results are presented as the numbers (and corresponding percentages) for categorical variables and mean (SD) for continuous variables. To enable comparison with other global estimates of hypertension, we conducted age and sex direct standardization[15] using the WHO world population.[16] To enable comparison between subgroups and to control for clustering, results were adjusted using a generalized linear mixed-effect model. Specifically, we used the GLIMMIX procedure in SAS assuming community as a random effect and other factors such as age, sex, location, education and income status of the country as fixed effects in the model. For binary outcomes, we used the binomial distribution option with the logit link function.

Interaction between variables was also tested by including an appropriate term in the model. When interactions were found to be significant, strata-specific models were used for adjusted rates. Means were compared using *t* tests or medians and/or proportion compared with appropriate nonparametric tests. To ensure that all tests took into account the effect of clustering, different groups were compared based on the *P* values obtained from the mixed-effect model and the linear test of trend was performed using model coefficients from mixed models and an appropriate contrast statement. A *P* value of less than .01 was considered to be statistically significant with a 2-sided alternative. All statistical analyses were calculated using SAS software version 9.2 (SAS Institute Inc) and all figures were drawn using S-PLUS software version 6.2 (TIBCO Software Inc).

Table 2. Prevalence of Awareness, Treatment, and Control Among the Hypertensive Population in PURE According to 2 Definitions

Variables	No. (%) of Participants				
	Overall	Aware	Treated	Controlled	Proportion With BP <140/90 mm Hg Among Those Receiving Treatment
Self-reported hypertension with treatment or BP ≥140/90 mm Hg					
Income level					
HIC	6263	3070 (49.0)	2924 (46.7)	1189 (19.0)	1189 (40.7)
UMIC	18 123	9516 (52.5)	8761 (48.3)	2833 (15.6)	2833 (32.3)
LMIC	23 269	10 134 (43.6)	8595 (36.9)	2314 (9.9)	2314 (26.9)
LIC	10 185	4157 (40.8)	3230 (31.7)	1298 (12.7)	1298 (40.2)
Sex					
Women	32 649	16 440 (50.4)	14 491 (44.4)	4891 (15.0)	4891 (33.8)
Men	25 191	10 437 (41.4)	9019 (35.8)	2743 (10.9)	2743 (30.4)
Region[a]					
South Asia	9751	3942 (40.4)	3113 (31.9)	1264 (13.0)	1264 (40.6)
China	18 915	7866 (41.6)	6503 (34.4)	1545 (8.2)	1545 (23.8)
Malaysia	5321	2568 (48.3)	2226 (41.8)	680 (12.8)	680 (30.5)
Africa	2160	743 (34.4)	677 (31.3)	140 (6.5)	140 (20.7)
North America and Europe	8682	4428 (51.0)	4158 (47.9)	1599 (18.4)	1599 (38.5)
Middle East	2074	1088 (52.5)	1054 (50.8)	354 (17.1)	354 (33.6)
South America	10 937	6242 (57.1)	5779 (52.8)	2052 (18.8)	2052 (35.5)
All included continents, countries, or regions	57 840	26 877 (46.5)	23 510 (40.6)	7634 (13.2)	7634 (32.5)
Self-reported hypertension with treatment or blood pressure ≥160/100 mm Hg					
Income level					
HIC	3716	2895 (78.0)	2803 (75.5)	1189 (32.0)	1189 (42.4)
UMIC	11 727	8929 (76.2)	8513 (72.6)	2833 (24.2)	2833 (33.3)
LMIC	13 344	9307 (69.8)	8422 (63.2)	2314 (17.4)	2314 (27.5)
LIC	5557	3600 (64.8)	3162 (57.0)	1298 (23.4)	1298 (41.0)
Sex					
Women	20 223	15 194 (75.2)	14 166 (70.1)	4891 (24.2)	4891 (34.5)
Men	14 121	9537 (67.6)	8734 (61.9)	2743 (19.4)	2743 (31.4)
Region[a]					
South Asia	5272	3419 (64.9)	3046 (57.8)	1264 (24.0)	1264 (41.5)
China	10 693	7188 (67.3)	6408 (60.0)	1545 (14.5)	1545 (24.1)
Malaysia	3221	2337 (72.6)	2161 (67.1)	680 (21.1)	680 (31.5)
Africa	1327	670 (50.6)	618 (46.6)	140 (10.6)	140 (22.7)
North America and Europe	5316	4163 (78.4)	4003 (75.4)	1599 (30.1)	1599 (39.9)
Middle East	1236	1028 (83.2)	993 (80.3)	354 (28.6)	354 (35.6)
South America	7279	5926 (81.4)	5671 (77.9)	2052 (28.2)	2052 (36.2)
All included continents, countries, or regions	34 344	24 731 (72.1)	22 900 (66.7)	7634 (22.2)	7634 (33.3)

Abbreviations: BP, blood pressure; HIC, high-income country; LIC, low-income country; LMIC, low–middle-income country; UMIC, upper–middle-income country.

[a] Countries within regional analyses include Bangladesh, India, and Pakistan (for South Asia), South Africa and Zimbabwe (for Africa), Canada, Sweden, and Poland (for North America/European Union), Iran, Turkey, and the United Arab Emirates (for the Middle East), Argentina, Brazil, Chile, and Colombia (for South America), and China and Malaysia, which each include cohorts from their respective countries only.

Results

The PURE study enumerated 382 341 individuals from 107 599 households in 628 communities (348 urban and 280 rural) in 17 countries on 5 continents. Recruitment started in Karnataka, India in January 2003; however, most communities were recruited between January 2005, and December 2009. Among the enumerated individuals, 197 332 (52%) were between 35 and 70 years of age and 153 996 (78%) of these adults consented to participate in both the interview and physical examination. Response rates were calculated as the numbers enrolled or recruited participants divided by the eligible number of individuals in all of the households approached for the study. Rates of response were similar in HIC (84%), UMIC (87%), and LMIC (82%), but lower in LIC (55%). The average age of participants and the percent with primary or less education were similar, but the percentage of women was higher among those enrolled compared with those who were eligible. This pattern was similar in HIC, UMIC, LMIC, and LIC. At the analysis

Table 3. Comparison of Hypertension Prevalence, Awareness, and Treatment by Population Density, Sex, and Age[a]

Countries by Income Level	% (95% CI)											
	Prevalence			Awareness			Treatment			Control		
Population Density	Urban	Rural	P Value[b]	Urban	Rural	P Value[b]	Urban	Rural	P Value[b]	Urban	Rural	P Value[b]
HIC	36.4 (28.1-45.6)	40.2 (31.4-49.7)	<.001	48.3 (39.1-57.6)	47.2 (37.9-56.6)	.45	45.6 (35.8-55.8)	44.2 (34.4-54.5)	.35	17.6 (10.6-27.9)	16.1 (9.5-25.9)	.14
UMIC	45.2 (40.0-50.4)	46.9 (41.7-52.2)	.003	52.1 (46.9-57.4)	51.9 (46.6-57.2)	.86	46.1 (40.5-51.9)	46.9 (41.3-52.7)	.29	15.8 (11.9-20.7)	14.7 (11.0-19.4)	.08
LMIC	34.9 (30.3-39.7)	38.7 (33.9-43.7)	<.001	49.3 (44.2-54.4)	37.8 (33.1-42.7)	<.001	41.5 (36.3-47.0)	28.4 (24.0-33.1)	<.001	12.4 (9.3-16.4)	5.4 (4.0-7.4)	<.001
LIC	44.4 (37.1-51.9)	31.5 (25.4-38.4)	<.001	48.4 (41.0-55.8)	31.2 (25.2-38.0)	<.001	36.1 (29.0-43.9)	19.9 (15.2-25.7)	<.001	12.8 (8.4-19.0)	6.9 (4.4-10.7)	<.001
ALL	40.1 (36.7-43.6)	39.2 (35.8-42.6)		49.5 (46.0-53.0)	41.8 (38.4-45.3)		42.3 (38.6-46.1)	33.9 (30.5-37.4)		14.5 (12.0-17.5)	9.8 (8.0-12.0)	
Sex	Women	Men		Women	Men		Women	Men		Women	Men	
HIC	32.3 (24.5-41.2)	44.2 (35.0-53.9)	<.001	49.4 (40.3-58.6)	43.7 (34.9-52.9)	<.001	45.4 (35.8-55.4)	41.9 (32.6-51.8)	.007	18.5 (11.2-29.0)	13.6 (8.0-22.1)	<.001
UMIC	44.3 (39.1-49.6)	47.8 (42.5-53.1)	<.001	58.5 (53.4-63.5)	43.8 (38.7-49.1)	<.001	53.1 (47.5-58.6)	38.2 (33.1-43.7)	<.001	19.2 (14.7-24.8)	10.1 (7.5-13.6)	<.001
LMIC	36.1 (31.4-41.0)	37.3 (32.6-42.4)	.002	47.7 (42.8-52.8)	39.7 (35.0-44.6)	<.001	39.8 (34.8-45.1)	30.2 (25.8-35.0)	<.001	10.0 (7.5-13.3)	8.0 (5.9-10.8)	<.001
LIC	38.7 (31.8-46.1)	36.5 (29.7-43.8)	.003	44.7 (37.6-52.0)	36.4 (29.9-43.5)	<.001	30.9 (24.6-38.0)	26.7 (20.9-33.4)	<.001	10.8 (7.0-16.1)	9.4 (6.1-14.2)	.02
ALL	37.7 (34.4-41.2)	41.4 (37.9-44.9)		50.1 (46.7-53.6)	40.9 (37.6-44.3)		42.1 (38.5-45.8)	34.0 (30.7-37.4)		14.1 (11.6-17.0)	10.1 (8.3-12.3)	
Age[c]	Younger	Older		Younger	Older		Younger	Older		Younger	Older	
HIC	24.1 (17.9-31.7)	52.8 (43.4-62.0)	<.001	31.6 (24.0-40.4)	53.7 (44.5-62.7)	<.001	26.2 (19.0-35.0)	52.2 (42.3-62.0)	<.001	10.8 18.1 (6.2-18.1)	(11.0-28.4)	<.001
UMIC	30.7 (26.5-35.4)	60.8 (55.8-65.6)	<.001	38.9 (34.0-44.1)	57.5 (52.4-62.6)	<.001	31.4 (26.7-36.6)	53.2 (47.6-58.7)	<.001	12.4 (9.2-16.5)	16.2 (12.2-21.1)	<.001
LMIC	24.1 (20.5-28.0)	50.8 (45.7-55.9)	<.001	31.4 (27.2-36.0)	49.4 (44.4-54.5)	<.001	23.2 (19.5-27.4)	41.3 (36.1-46.7)	<.001	6.3 (4.6-8.6)	9.9 (7.4-13.2)	<.001
LIC	26.3 (20.9-32.5)	48.8 (41.4-56.2)	<.001	30.6 (24.7-37.3)	44.2 (37.1-51.5)	<.001	19.4 (14.8-24.9)	32.6 (26.0-39.9)	<.001	8.9 (5.7-13.5)	10.0 (6.5-15.1)	.04
ALL	26.2 (23.6-29.0)	53.3 (49.8-56.8)		33.1 (30.0-36.3)	51.2 (47.8-54.7)		24.8 (22.1-27.8)	44.6 (41.0-48.3)		9.3 (7.6-11.4)	13.1 (10.8-15.9)	

Abbreviations: BP, blood pressure; HIC, high-income country; LIC, low-income country; LMIC, low-middle-income country; UMIC, upper-middle-income country.

[a] Results are adjusted for covariates (age, sex, and population density) and controlled for clustering. Unadjusted results reported by No. (%) are in eTable 7 (in Supplement).

[b] For prevalence, awareness, treatment, and control, there are significant interactions ($P < .001$) of economic status of country × location (urban/rural), × sex, and × age group.

[c] Younger and older age categories are specifically younger than aged 50 years and aged 50 years and older.

stage, we excluded individuals who were outside the age criteria, leaving 151 966 participants. Those with incomplete systolic and diastolic blood pressure measures were also excluded, leaving 142 042 to constitute the population used in this report.[17]

Table 1 summarizes the characteristics of the cohort and the prevalence of hypertension according to different definitions. Overall, 57 840 of the participants enrolled in PURE had hypertension (40.8%; 95% CI, 40.5-41.0) and the mean blood pressure was 131/82 mm Hg. The age and sex prevalence standardized to the WHO world population was 27.7%. The distribution, based on different definitions, is detailed online (eTables 1-4 in Supplement).

Awareness, Treatment, and Control of Hypertension

Among participants with hypertension, 26 877 were aware of their condition (46.5%; 95% CI, 46.1%-46.9%), 23 510 were receiving treatment (40.6%; 95% CI, 40.2%-41.0% [87.5%; 95% CI, 87.1%-87.9% of those who were aware]), and 7634 had their blood pressure controlled (13.2%; 95% CI, 12.9%-13.5% [32.5%; 95% CI, 31.9%-33.1% of those receiving medical treatment]). Awareness, treatment, and control of hypertension were lowest in LICs, particularly in Africa (**Table 2**).

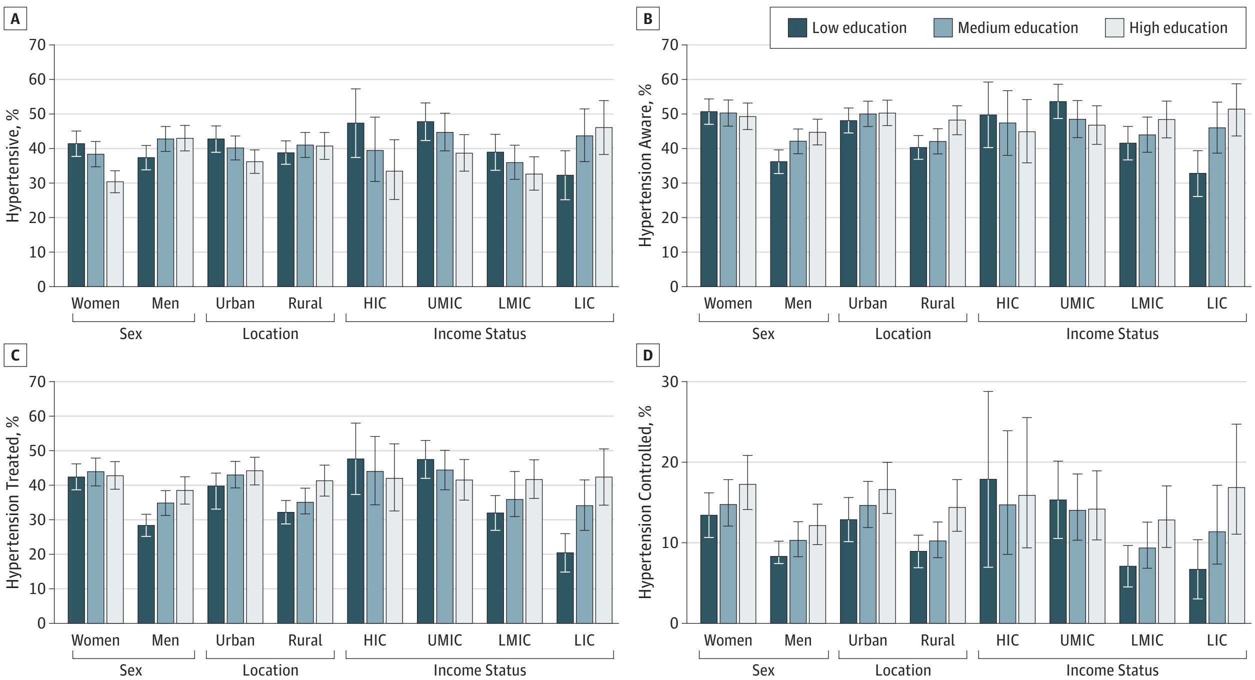
Urban vs Rural

Awareness and treatment rates of hypertension were similar in urban and rural communities of HICs and UMICs, but were significantly lower in rural areas vs urban areas in LICs (awareness in urban LICs, 48.4% [95% CI, 41.0%-55.8%] vs awareness in rural LICs, 31.2% [95% CI, 25.2%-38.0%]; and treatment in urban LICs, 36.1% [95% CI, 29.0%-43.9%] vs treatment in rural LICs, 19.9% [95% CI, 15.2%-25.7%]). The proportion of participants with controlled blood pressure was consistently lower in rural areas vs urban areas in all countries (**Table 3**).

Age and Sex

Participants aged 50 years and older consistently had greater awareness of their hypertension compared with younger par-

Figure 1. Prevalence, Awareness, Treatment, and Control of Hypertension by Education



Error bars indicate 95% CIs. For prevalence, awareness, control, and treatment, there is a significant trend by education overall ($P < .001$). Younger and older describe age categories (<50 years and ≥50 years). A, P values were significant in men and women ($P < .001$), older and younger participants ($P < .001$), urban communities ($P < .001$), rural communities ($P = .004$), high-income communities (HICs, $P < .001$), upper–middle-income communities (UMICs, $P < .001$), lower–middle-income communities (LMICs, $P = .048$), and low-income communities (LICs, $P < .001$). There were significant interactions of sex × education ($P < .001$), age × education ($P = .008$), urban and rural location × education ($P < .001$), and economic status of countries × education ($P < .001$). B, P values were significant in men ($P < .001$), older participants ($P < .001$), urban and rural communities ($P < .001$), LICs ($P < .001$), but not in other groups. There were significant interactions of sex × education ($P < .001$), urban and rural location × education ($P = .001$), and economic status of countries × education ($P < .001$). C, P values were significant in men ($P < .001$), older participants ($P < .001$), urban and rural communities ($P < .001$), in LICs ($P < .001$), but not in other groups. There were significant interactions of sex × education ($P < .001$), age × education ($P < .001$), urban and rural location × education ($P = .001$), and economic status of countries × education ($P < .001$). D, P values were significant in women and men ($P < .001$), older participants ($P < .001$), urban and rural communities ($P < .001$), HICs ($P = .01$), LICs ($P < .001$), but not in other groups. There were significant interactions of age × education ($P < .001$), urban and rural location × education ($P = .005$), and economic status of countries × education ($P < .001$).

ticipants and had higher rates of treatment and control when compared with younger participants. Women consistently had greater awareness of their hypertension and higher rates of treatment and control than men (Table 3).

Education

In models mutually adjusted by age, sex, and urban/rural setting, greater education was associated with greater awareness and treatment in men but not women, and greater control in both men and women (**Figure 1**). Greater education was associated with greater awareness and treatment in LICs only and greater rates of control in HICs and LICs. Greater education was associated with greater awareness, treatment, and control in older, but not younger participants (eTables 9, 10, 11, and 12 in Supplement).

Blood Pressure–Lowering Medications

Overall, angiotensin-converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs) were the most commonly used blood pressure–lowering agents (13.6%; 95% CI, 13.3%-13.9%) with a similar proportion of participants with hypertension (self-reported on treatment or BP ≥140/90 mm Hg) using other blood pressure–lowering agents (β-blockers, 8.2% [95% CI, 8.0%-8.4%]; diuretics, 7.0% [95% CI, 6.8%-7.2%]; and calcium antagonists, 8.2% [95% CI, 8.0%-8.4%]). However this pattern varied across countries. Medications most commonly used in HICs and UMICs were ACE inhibitors and ARBs, diuretics and calcium channel blockers in LMICs, and β-blockers in LICs (**Figure 2**).

Among the 23 510 participants who self-reported receiving treatment for hypertension, 7273 reported 2 or more types of blood pressure–lowering medications on their medication lists (30.8% [95% CI, 30.2%-31.4%] or 12.5% of all with hypertension [95% CI, 12.2%-12.8%]). The use of 2 or more medications was significantly lower in LICs compared with HICs, UMICs, or LMICs (combined $P = <.001$; in HICs, 18.1% [95% CI, 17.2%-19.1%]; in UMICs, 14.5% [95% CI, 14.0%-15.1%]; in LMICs, 14.1% [95% CI, 13.7%-14.6%]; and in LICs, only 1.6% [95% CI, 1.4%-1.8%]; eTable 5 in Supplement).

The use of 2 or more medications among hypertensive patients was slightly higher in women compared with men (8.1% [95% CI, 6.3%-10.4%] and 6.9% [95% CI, 5.3%-9.0%], respectively; P <.001 for comparison), older compared with younger participants (9.5% [95% CI, 7.4%-12.2%] and 4.5% [95% CI, 3.5%-5.9%], respectively; P <.001 for comparison) and urban vs rural areas (8.0% [95% CI, 6.2%-10.3%] and 7.4% [95% CI, 5.7%-9.5%], respectively; P = .005 for comparison). The use of 2 or more medications also was greater with increased education (eTable 6 in Supplement).

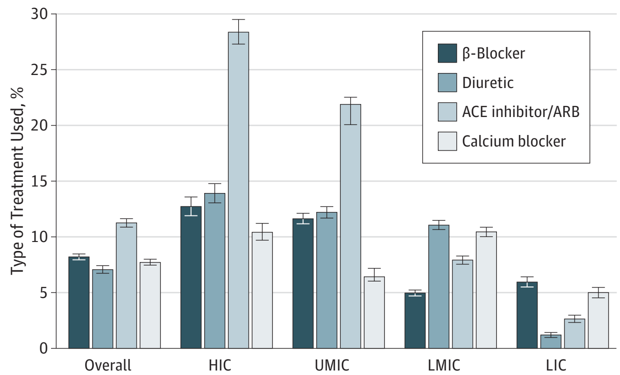
Discussion

This study found a large gap between both detection and control of hypertension across all countries studied. It shows that while initial therapy was started in the large majority of individuals who are detected to have hypertension, control in participants receiving treatment was very poor. The use of combination therapies, generally required to achieve blood pressure control,[18] was low. Awareness, treatment, and control were lower in LICs compared with other countries and in rural settings of LMICs and LICs compared with urban ones. Despite men having higher rates of hypertension, women consistently had higher awareness, treatment, and control of their hypertension, consistent with a large body of research on sex and health-seeking behavior.[19] Also participants with more education had greater awareness, treatment, and control, particularly in LICs.

The rates of hypertension prevalence, awareness, treatment, and control found in this study are generally consistent with findings in those countries with existing data.[6,20] For example, rates of treatment among individuals aware of their hypertension in a 2008/2009 survey in Canada was 82%, which was similar to that from the Canadian cohort in PURE.[21] In the China National Nutrition and Health Survey of 2002, awareness of hypertension was lower (28%) but the proportion of those aware on treatment (78%) was similar.[22] In a study in India from 2004-2007, a survey of 4608 rural and urban women found 42.8% aware of hypertension, which was similar to PURE, but reported lower rates of treatment (38.6% of those aware).[23] The apparently higher prevalence of hypertension measured in this study (40.7%) compared with estimates from the Global Burden of Disease study[24] in 2000 of 26.4% (95% CI, 26.0%-26.8%) for 20- to 80-year olds is due to the older age of the participants in PURE (>35 years). When we age-standardized to the WHO world population,[15] the overall prevalence of hypertension in the PURE study was 27.7%, which is similar to the Global Burden of Disease estimates[24] and to the results of a recent systematic analysis of health surveys from 199 countries for individuals aged 25 years and older in 2008 (SBP ≥140 mm Hg or DBP ≥ 90 mm Hg) of 29% (95% CI, 27%-31%) in men and 25% (95% CI, 23%-27%) in women.[6] This suggests that there is unlikely to have been major biases in the selection of communities and individuals in the countries included in this study and therefore, our data can be considered to be reasonably reflective of the prevalence in the urban and rural areas of these diverse countries.

The widespread lack of hypertension awareness (a measure of hypertension case identification) and poor control (a measure of inadequate treatment) in all countries studied, despite the identification and control of blood pressure being prioritized by many national and global organizations and despite the availability of inexpensive and effective medications, is concerning.[25,26] The low rates of detection may be because few individuals have their blood pressure checked either through routine health assessment or screening programs and may be due to difficulties or costs in accessing health care.

Figure 2. Types of Treatments Used for Hypertension in Countries Overall and by Income Status



Error bars indicate 95% CIs. ACE indicates angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; HIC, high-income country; LIC, low-income country; LMIC, low–middle-income country; UMIC, upper–middle-income country.

The lowest rates of use of blood pressure–lowering medications were observed in LICs. Although low-cost generic blood pressure–lowering medications are available in LICs, possible barriers to use of medications are still affordability (as a proportion of local income), lack of drug inventory, distance to clinics, and the costs to see physicians. Hence, models of care that shift the detection and initial treatment of hypertension to nonphysician health workers should be considered.[27-29] Effectiveness of these models of care have been demonstrated in management of other conditions such as HIV in developing countries.[30-32] However, even among individuals who have received treatment, there is poor blood pressure control. This suggests ineffectiveness in our current treatment approach, which is largely based on the use of single drugs. Instead, strategies such as using combination therapy for the initial treatment of hypertension may be required.[28]

In LICs, awareness, treatment, and control were lower in participants with primary or no education, most likely reflecting a combination of low socioeconomic status, which may influence access to care, lack of knowledge of the sequelae of uncontrolled hypertension, and differing values with respect to the importance of the future.[33,34] Education was used as a surrogate for socioeconomic status in this analysis and although this is limited, similar social patterning of hypertension prevalence has been recently reported in some LICs.[35]

Strengths and Limitations

To our knowledge, this is currently the largest multicountry study in which blood pressure was measured using standardized methods across all study centers. It involves a large number of low- and middle-income countries, involves both urban and rural communities, and participants were identified from communities and not from clinics or hospitals. It also recorded data on the number and types of drugs used, which is generally not collected to this detail in other surveys of hypertension.

This study's major limitation is that the sampling framework in each country was not nationally representative, and therefore caution is needed in extrapolating the information as being representative of the status in each country. Nevertheless, our overall prevalence of hypertension is similar to the global prevalence estimates[24] after adjusting for age, and therefore suggests no major biases due to the nonrandom selection of communities or countries included in PURE. Although a random selection of countries from each part of the world that included different economic levels and identification of a random set of communities within them would be ideal from a methodological perspective, such an approach is not practical given the existing poor research infrastructure in many parts of the world. The response rate was lower in LICs, but the characteristics of enrolled to eligible participants were similar in HICs, UMICs, LMICs, and LICs. Diagnosis of hypertension was based on measures and history taken at a single visit; however, multiple visits are impractical for large-scale studies and our approach is similar to that of many epidemiological studies.

Conclusions

In this cross-sectional analysis of a multinational study population, 46.5% of participants with hypertension were aware of the diagnosis, while blood pressure was controlled among 32.5% of those being treated. These findings suggest that substantial improvement in hypertension diagnosis and treatment is needed.

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