Hypertension Prevalence, Awareness, Treatment, and Control in Selected LMIC Communities

Results From the NHLBI/UHG Network of Centers of Excellence for Chronic Diseases

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ABSTRACT

Background: Hypertension is the leading cause of cardiovascular disease and premature death worldwide. The prevalence of this public health problem is increasing in low- and middle-income countries (LMICs) in both urban and rural communities.

Objective: The aim of this study was to examine hypertension prevalence, awareness, treatment, and control in adults 35 to 74 years of age from urban and rural communities in LMICs in Africa, Asia, and South America.

Methods: The authors analyzed data from 7 population-based cross-sectional studies in selected communities in 9 LMICs that were conducted between 2008 and 2013. Age- and sex-standardized prevalence rates of prehypertension and hypertension were calculated. The prevalence rates of awareness, treatment, and control of hypertension were estimated overall and by subgroups of age, sex, and educational level.

Results: In selected communities, age- and sex-standardized prevalence rates of hypertension among men and women 35 to 74 years of age were 49.9% (95% confidence interval [CI]: 42.3% to 57.4%) in Kenya, 54.9% (95% CI: 51.3% to 58.4%) in South Africa, 52.5% (95% CI: 50.1% to 54.8%) in China, 32.5% (95% CI: 31.7% to 33.3%) in India, 42.3% (95% CI: 40.4% to 44.2%) in Pakistan, 45.4% (95% CI: 43.6% to 47.2%) in Argentina, 39.9% (95% CI: 37.8% to 42.1%) in Chile, 19.2% (95% CI: 17.8% to 20.5%) in Peru, and 44.1% (95% CI: 41.6% to 46.6%) in Uruguay. The proportion of awareness varied from 33.5% in India to 69.0% in Peru, the proportion of treatment among those who were aware of their hypertension varied from 70.8% in South Africa to 93.3% in Pakistan, and the proportion of blood pressure control varied from 5.3% in China to 45.9% in Peru.

Conclusions: The prevalence of hypertension varies widely in different communities. The rates of awareness, treatment, and control also differ in different settings. There is a clear need to focus on increasing hypertension awareness and control in LMICs.

Cardiovascular disease (CVD) is the leading cause of death worldwide, and hypertension is the most important preventable risk factor for CVD [1]. High blood pressure (BP) is associated with at least 7.6 million deaths per year worldwide (13.5% of all deaths) [2]. High BP causes significant morbidity, accounting for 7.0% of all global disability-adjusted life-years lost, mostly in low- and middle-income countries (LMICs) [1]. Suboptimal BP represents about 10% of the world's overall health care expenditures [3]. However, more than 90% of the expenditures on antihypertensive treatment, amounting to about $50 billion each year [4], are spent in high-income countries [5].

Additionally, it is estimated that 3 in 4 patients with hypertension live in LMICs [2]. Recently, many countries have undertaken large-scale health surveys and epidemiological studies that include measures of cardiovascular risk factors [6]. Hypertension prevalence is difficult to determine in such population surveys, however, because many of them are based on self-report only. Moreover, hypertension awareness and control are not possible to examine with self-report data. Thus, using data from multiple

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sources seems to be a useful way of retrieving information to tackle this relevant problem in public health.

The National Heart, Lung, and Blood Institute and UnitedHealth Group Chronic Disease Initiative has funded a global network of Centers of Excellence (COEs) to help combat chronic diseases in developing countries [7]. Each center includes a research institution in a developing country paired with at least 1 partner academic institution in a developed country. These COEs develop infrastructure for research and training and conduct population-based and clinical research to monitor, prevent, or control chronic diseases. In 7 of the studies conducted by these centers, BP measurements were taken in random samples from the general population according to standardized procedures. We sought to evaluate the original data from those studies, with the aim of generating valuable information about the prevalence, awareness, treatment, and control of hypertension in selected communities in Africa, Asia, and Latin America [8–10].

POPULATION AND METHODS

In this study, we conducted a cross-sectional analysis using baseline data from 7 population-based surveys from 44 communities in Kenya, South Africa, India, Pakistan, Peru, and the southern cone of Latin America, including Argentina, Chile, and Uruguay, and 120 villages from 5 provinces in China. The general characteristics of the surveys included are shown in Table 1 [11–15].

Study participants

We included men and women between 35 and 74 years of age who were randomly selected from the general population in each of the studies. The response rate of each study included in the analysis was greater than 70%.

Data collection

Standard sphygmomanometers or automatic BP monitors were used for BP measurements by trained research personnel in all studies. In 6 studies, BP was measured at clinic visits, and in 2 studies, BP measurements were taken both at home and at clinic visits. All surveys included at least 2 BP measurements, recorded with the participant in a seated position after at least 5 min of rest, and the average value was calculated to define the BP measurement at baseline. The rest period between BP measurements was 30 s in 1 study and varied between 2 and 10 min in the rest of the surveys.

Hypertension was defined as systolic BP (SBP) $\geq$140 mm Hg and/or diastolic BP (DBP) $\geq$90 mm Hg or as report of current use of antihypertensive medication. Hypertension awareness was defined as the number of patients who reported either having been diagnosed with hypertension by health professionals or taking medications for high BP divided by the total number of hypertensive patients. The prevalence of treatment was calculated in 2 different ways: (1) as the number of hypertensive patients who reported taking medications for high BP divided by the total number of hypertensive patients who were aware of their condition and (2) as the number of hypertensive patients who reported taking medications for high BP divided by the total number of hypertensive patients. Hypertension control was also expressed in 2 different ways: (1) as the number of hypertensive patients with SBP $<$140 mm Hg and DBP $<$90 mm Hg divided by the total number of hypertensive patients who reported taking medications at the time of the interview and (2) as the number of hypertensive patients with SBP $<$140 mm Hg and DBP $<$90 mm Hg divided by the total number of hypertensive subjects. Pre-hypertension was defined as SBP between 120 and 139 mm Hg and/or DBP between 80 and 89 mm Hg in the absence of a diagnosis of hypertension or treatment with medication for high BP.

Education was categorized into 3 groups: no formal education, any school, and university or higher. Age was categorized into 4 groups: 35 to 44, 45 to 54, 55 to 64, and 65 to 74 years of age. Body mass index was categorized into 3 groups: $<$25, 25 to 30, and $>$30 kg/m^2. Central obesity was defined as waist circumference $\geq$102 cm for men and $\geq$88 cm for women [16]. For India and Pakistan, central obesity was defined waist circumference $\geq$90 cm for men and $\geq$80 cm for women [17].

Statistical analysis

Datasets and data dictionaries from each study were collected and analyzed centrally by the Administrative Coordinating Center of the COE program. A standardized process of harmonization was carried out, which yielded a common database of parallel variables that were selected and recoded as a basis for aggregated research [18]. Results are presented as absolute frequencies and percentages for categorical variables and as mean $\pm$ SD for continuous variables. Weighted prevalence and its 95% confidence interval (CI) were calculated for each site using appropriate weights according to the sampling method used in each of the 7 studies [19]. To enable comparison among sites, we conducted age and sex direct standardization using the World Health Organization world population in 2010 [20,21]. All data analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC) and Stata version 13.0 (StataCorp LP, College Station, TX).

RESULTS

Characteristics of the study population

Our pooled database contained 42,011 participants from 7 epidemiological studies conducted in 9 countries. We then excluded participants who were not between 35 and 74 years of age (n = 7,468). We further excluded 883 subjects from the analysis because of incomplete data on SBP or DBP in the pooled dataset. Our final analysis included 33,660 subjects. The final sample sizes for individual studies ranged from 239 in selected communities in Kenya to 14,813 in India. Our inclusion and exclusion scheme is shown in Figure 1. In all countries, the proportion of men

TABLE 1. General characteristics of the studies from 9 countries included in the analysis

	Africa		Asia			South America			
	Kenya	South Africa	China	India*	Pakistan	Argentina	Chile	Peru	Uruguay
Survey year	2012–2013	2008–2009	2012	2010–2012	2010–2011	2010–2011	2010–2011	2010–2012	2010–2011
Number of communities included in the survey	1	4	120 villages (5 provinces)	28 villages and 2 cities	3	2	1	4	1
Urban/rural or semirural, n	0/1	4/0	0/120	2/28	3/0	2/0	1/0	2/2	1/0
Sampling method	Random	Multistage probability	Random	Random	Multistage probability	Multistage probability	Multistage probability	Stratified random	Multistage probability
Number of respondents	300	1,099	5,922	19,549	4,016	3,990	1,950	3,601	1,584
Response rate, %	100	86.0	78.0	83.6–94.1	94.1	73.4†	73.4†	75.0	73.4†
BP device	Automated BP monitor	Automated BP monitor	Automated BP monitor	Automated BP monitor	Electronic sphygmomanometer	Standard aneroid sphygmomanometer	Standard aneroid sphygmomanometer	Automated BP monitor	Standard aneroid sphygmomanometer
BP measurement setting	Home and clinic	Home and community	Clinic	Home and camps	Home and camps	Clinic	Clinic	Clinic	Clinic
Number of BP measurements	3	3	2	3	3	3	3	3	3
Resting time before BP measurement, min	15–30	5	15	5–10	5	5	5	5	5
Resting time between BP measurements, min	10–20	2	5	0.5–5	0.5	5	5	5	5

BP, blood pressure.

*Includes data from 1 study in Bangalore and 1 study in New Delhi and Chennai.

†Pooled estimate for Argentina, Chile, and Uruguay.

in the sample was lower than that of women. The number of participants included with no formal education ranged from 0% in communities in Kenya to almost 33% in communities in Pakistan. Conversely, the percentage of subjects with university-level education or higher varied from 0% in communities in Kenya and South Africa to 32.5% in Temuco, Chile. The percentage of current smokers varied between 25.9% and 38.5% across sites. The percentage of current alcohol drinkers was lowest in communities from Pakistan (1.7%) and ranged from 7.1% to 56.1% in the rest of the sites (Table 2).

BP measures

There was significant variation in SBP and DBP among sites. The mean values of SBP and DBP were highest in communities in Kenya and China, for both men and women, and lowest in Peru. Other features of the study population, including heart rate, height, weight, and waist circumference by sex, are shown in Table 3.

Crude and standardized prevalence of hypertension

Table 4 shows the age- and sex-standardized and weighted prevalence of hypertension, overall and by sex, age group, and educational level, for each study. Figure 2 shows the age-standardized prevalence of hypertension by sex for each study. In Africa, in the village from Kenya, the age- and sex-standardized prevalence of hypertension among adults 35 to 74 years of age was 49.9% (95% CI: 42.3% to 57.4%), while in South Africa, the pooled age- and sex-standardized prevalence from the 4 urban communities included in the survey was 54.9% (95% CI: 51.3% and 58.4%). In Asia, in the communities included in China, the prevalence of hypertension was 52.5% (95% CI: 50.1% to 54.8%), while in those communities included in India and Pakistan, it reached 32.5% (95% CI: 31.7% to 33.3%) and 42.3% (95% CI: 40.4% to 44.2%), respectively. In Latin America, in the 4 cities from 3 countries of the southern cone (Argentina, Chile, and Uruguay), the prevalence of hypertension was 45.4% (95% CI: 43.6% to 47.2%), 39.9% (95% CI: 37.8% to 42.1%), and 44.1% (95% CI: 41.6% to 46.6%), respectively. In the study from Peru that included 4 communities, 2 urban and 2 semirural or rural, the age-standardized prevalence of hypertension was 19.2% (95% CI: 17.8% to 20.5%).

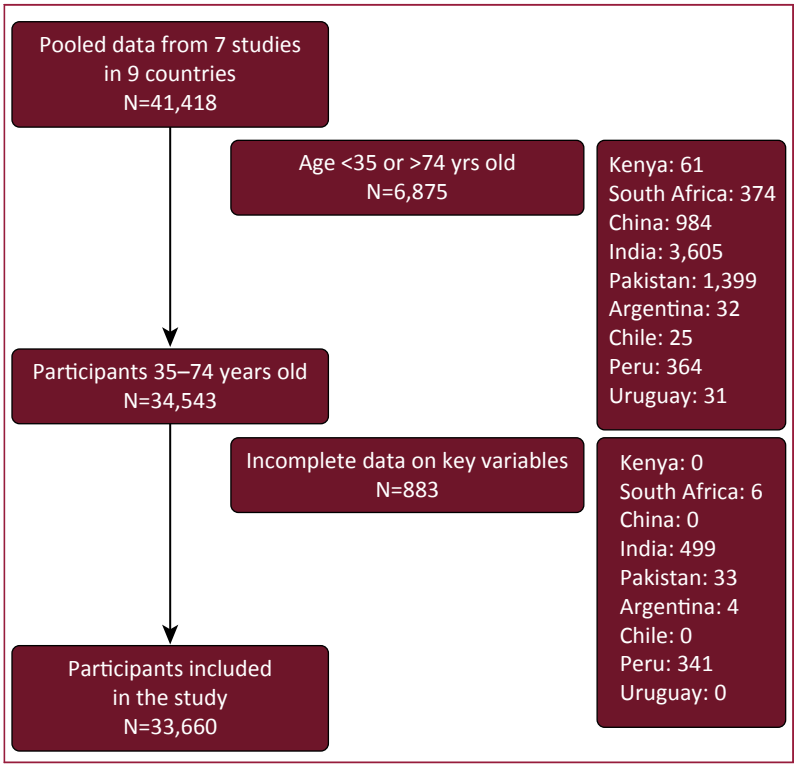

FIGURE 1. Population from the harmonized common database included in the study.

Crude and standardized prevalence of pre-hypertension

Table 5 shows the age- and sex-standardized and weighted prevalence of pre-hypertension, overall and by sex, age group, and educational level for each study. Figure 3 shows the age-standardized prevalence of pre-hypertension by sex. The overall age- and sex-standardized prevalence of pre-hypertension ranged from 24.0% in the sites from Peru and 24.6% in South Africa to values near or greater than 30% in those communities included in Pakistan, Uruguay, Chile, Argentina, China, Kenya and India.

Awareness, treatment, and control

Table 6 shows the age- and sex-standardized prevalence of hypertension awareness, treatment, and control, overall and by sex, age group, and educational level for each study. Awareness of hypertension was higher in the sites in Peru, Chile, South Africa, Pakistan, Uruguay, and Argentina (69.0%, 65.9%, 61.5%, 62.4%, 64.5%, and 52.7%, respectively) and was lower in the sites in China and India (38.9% and 33.5%, respectively). Across all sites analyzed, the proportion of participants aware of their condition who were receiving treatment was about or higher than 75%, while between 33% and 63% of the total number of hypertensive subjects were receiving pharmacological treatment in different communities. BP control rates among treated subjects varied broadly between 16.2% in the communities in China to 71.2% in communities from Peru. Among all hypertensive participants, the control rate varied from very low rates in communities in China (5.3%) and India (10.1%) to 45.9% in Peru. No data were available for Kenya.

DISCUSSION

In this multinational study with pooled data from the National Heart, Lung, and Blood Institute and

TABLE 2. Characteristics of the study participants

	Africa		Asia			South America			
	Kenya	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Number of participants	239	736	4,938	14,813	2,584	3,954	1,925	2,918	1,553
Sex									
Male	89 (37.2)	269 (36.5)	2,395 (48.5)	7,056 (47.6)	1,213 (46.9)	1,576 (39.9)	918 (47.7)	1,404 (48.1)	642 (41.3)
Female	150 (62.8)	467 (63.5)	2,543 (51.5)	7,757 (52.4)	1,371 (53.1)	2,378 (60.1)	1,007 (52.3)	1,514 (51.9)	911 (58.7)
Age group, yrs									
35–44	39 (16.3)	260 (35.3)	320 (6.5)	5,760 (38.9)	1,096 (42.4)	884 (22.4)	461 (24.0)	729 (25.0)	344 (22.1)
45–54	58 (24.3)	251 (34.1)	638 (12.9)	4,391 (29.6)	792 (30.7)	1,140 (28.8)	536 (27.8)	822 (28.2)	396 (25.5)
55–64	72 (30.1)	149 (20.3)	2,155 (43.6)	2,847 (19.2)	463 (17.9)	1,179 (29.8)	494 (25.7)	826 (28.3)	441 (28.4)
65–74	70 (29.3)	76 (10.3)	1,825 (37.0)	1,815 (12.3)	233 (9.0)	751 (19.0)	434 (22.5)	541 (18.5)	372 (24.0)
Education									
None	0 (0)	95 (12.9)	1,088 (22.1)	4,354 (29.4)	850 (32.9)	52 (1.3)	9 (0.5)	168 (5.8)	12 (0.8)
Any school	239 (100)	641 (87.1)	3,835 (77.8)	9,046 (61.1)	1,407 (54.4)	3,120 (79.6)	1,277 (67.0)	2,123 (72.7)	1,359 (88.7)
University/higher	0 (0)	0 (0)	7 (0.1)	1,413 (9.5)	327 (12.7)	750 (19.1)	621 (32.5)	627 (21.5)	161 (10.5)
Body mass index, kg/m^2									
<25	48 (20.1)	227 (30.8)	2,942 (59.6)	9,165 (68.5)	839 (42.7)	945 (24.0)	368 (19.1)	818 (28.0)	416 (26.9)
25–30	116 (48.5)	151 (20.5)	1,662 (33.7)	2,913 (21.8)	684 (34.8)	1,409 (35.7)	873 (45.4)	1,286 (44.1)	518 (33.5)
≥30	75 (31.4)	358 (48.6)	332 (6.7)	1,302 (9.7)	442 (22.5)	1,592 (40.3)	683 (35.5)	814 (27.9)	612 (39.6)
Central obesity	*	422 (57.4)	*	5,792 (39.4)	1,777 (69.3)	2,172 (55.0)	1,073 (55.8)	1,234 (42.3)	968 (62.5)
Current smoking	*	190 (25.9)	1,492 (30.2)	5,703 (38.5)	756 (29.3)	1,038 (26.3)	525 (27.3)	*	426 (27.9)
Current alcohol intake	17 (7.1)	*	1,068 (21.6)	2,401 (16.2)	45 (1.7)	1,622 (41.4)	738 (38.6)	1,637 (56.1)	723 (47.1)

Values are n (%).
*Information not available.

UnitedHealth Group COE program, we examined hypertension prevalence, awareness, treatment, and control for sites across Latin America, Africa, and Asia. We analyzed data from 7 population-based studies conducted in 148 villages and 18 cities from 9 LMICs that represent 40% of the world population. Our key findings are that there is high heterogeneity in terms of prevalence of hypertension not only across communities and regions but also among urban, rural, and semirural areas and that awareness and control are still dismally low, except in a few locations. Our findings are consistent with the considerable variation among countries and geographic regions observed in other studies [20,22–24]. For example, in Africa, the age-standardized prevalence of hypertension was high in the village included in the Kenyan study (49.9%) and in urban settings in South Africa (54.9%), in accordance with other studies [25]. In Asia, the estimated age- and sex-standardized prevalence for rural population in the 5 provinces included in the study from China was also high (52.5%), while in the studies from India and Pakistan, prevalence rates of 32.5% and 42.3%, respectively, were seen. These results show a high degree of heterogeneity, as in previous studies in China [26–34] and India [23,35–37]. In the southern cone of Latin America, the prevalence of hypertension was high in the cities included in Argentina, Chile, and Uruguay (45.4%, 39.9%, and 44.1%, respectively). However, in the communities included in Peru, the age- and sex-standardized prevalence of hypertension was comparatively low (19.2%), which may be related to the fact that all the population included in the southern cone was urban, whereas 2 of the 4 communities in Peru were semirural. The CARMELA (Cardiovascular Risk Factor Multiple Evaluation in Latin America) study showed a prevalence of hypertension in Lima of 12.6% from 2003 to 2005 [38].

In the communities from China and India, and the sites from the southern cone of Latin America, the age- and sex-standardized prevalence of hypertension was higher in men compared with women, while the opposite was seen in Kenya, South Africa, and Pakistan. In those towns from Peru, the prevalence was similar in both sexes. These findings are consistent with several studies, some of them showing sex differences while others did not [39].

The overall prevalence of hypertension treatment among those participants who were aware of their condition was higher than the results obtained in other studies. However, the prevalence of treatment among all hypertensive patients was lower, consistent with the findings of other investigators [40–42]. There was a gap between both detection and control of hypertension across

TABLE 3. Anthropometric and blood pressure measures by sex

	Africa		Asia			South America			
	Kenya	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Men									
SBP, mm Hg	146.2 (140.0—152.4)	135.8 (132.9—138.7)	142.8 (141.9—143.7)	127.7 (127.2—128.2)	127.2 (126.0—128.3)	129.1 (128.2—130.0)	129.7 (128.5—131.0)	122.1 (121.3—123.0)	131.7 (130.1—133.2)
DBP, mm Hg	83.6 (80.5—86.7)	85.2 (83.6—86.8)	87.3 (86.8—87.9)	82 (81.7—82.3)	82.9 (82.2—83.6)	86.7 (86.1—87.3)	83.4 (82.6—84.3)	75.8 (75.3—76.4)	83.6 (82.6—84.5)
Heart rate, beats/min	82.0 (79.5—84.5)	67.4 (65.9—68.9)	74.4 (73.9—74.9)	79.1 (78.7—79.6)	80.1 (79.4—80.8)	67.4 (66.9—67.9)	65.7 (65.1—66.4)	68.3 (67.7—68.8)	68.3 (67.4—69.1)
Height, cm	157.0 (155.2—158.8)	169.5 (168.7—170.4)	165.8 (165.5—166.0)	163.3 (163.2—163.5)	166.4 (166.0—166.8)	170.7 (170.3—171.1)	168.8 (168.2—169.3)	162.8 (162.5—163.2)	171.1 (170.6—171.7)
Weight, kg	70.3 (68.0—72.6)	70.9 (68.9—73.0)	66.2 (65.8—66.6)	59.9 (59.6—60.3)	69.2 (68.3—70.2)	83.7 (82.8—84.7)	81.4 (80.4—82.4)	71.6 (71.0—72.3)	81.7 (80.3—83.1)
Waist circumference, cm	*	88.4 (86.7—90.1)	*	84.8 (84.4—85.1)	93.4 (92.7—94.2)	98.6 (97.8—99.3)	98.5 (97.7—99.3)	93.2 (92.7—93.8)	98.5 (97.4—99.7)
Women									
SBP, mm Hg	149.7 (144.9—154.6)	129.1 (126.9—131.3)	147.2 (146.3—148.0)	125.1 (124.6—125.5)	123.6 (122.4—124.9)	126.0 (125.1—126.8)	122.7 (121.5—123.9)	113.3 (112.4—114.3)	127.5 (126.1—128.8)
DBP, mm Hg	86.1 (83.6—88.6)	84.6 (83.4—85.8)	86.4 (85.9—87.0)	80.2 (80.0—80.5)	82.1 (81.4—82.8)	81.8 (81.3—82.3)	79.3 (78.5—80.0)	71.4 (70.8—71.9)	79.8 (79.1—80.6)
Heart rate, beats/min	82.2 (80.2—84.2)	72.4 (71.3—73.5)	77.7 (77.3—78.2)	81.8 (81.3—82.2)	82.3 (81.7—82.9)	67.7 (67.3—68.2)	69.4 (68.8—70.0)	71.9 (71.4—72.4)	70.7 (70.0—71.3)
Height, cm	156.8 (155.8—157.8)	158.5 (157.9—159.1)	153.5 (153.2—153.7)	150.7 (150.6—150.9)	152.3 (152.0—152.7)	156.8 (156.4—157.1)	155.7 (155.3—156.2)	150.3 (150.0—150.6)	157.7 (157.3—158.1)
Weight, kg	68.9 (67.3—70.6)	85.5 (83.6—87.5)	58.5 (58.1—58.9)	53.5 (53.1—53.8)	63.6 (62.7—64.4)	70.7 (70.0—71.4)	71.0 (70.1—71.9)	64.7 (64.1—65.3)	73.3 (72.2—74.4)
Waist circumference, cm	*	99.7 (98.4—100)	*	79.3 (79.0—79.6)	89.6 (88.9—90.3)	92.0 (91.3—92.6)	94.3 (93.5—95.2)	91.1 (90.5—91.6)	98.4 (97.3—99.5)

Values are unit of measurement (95% confidence interval).
*Information not available.

TABLE 4. Age- and sex-standardized prevalence of hypertension

	Africa		Asia			South America			
	Kenya	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Unstandardized weighted total	53.6 (47.2—59.9)	55.3 (51.7—58.9)	65.6 (64.3—66.9)	32.1 (31.3—32.9)	40.8 (38.9—42.7)	45.5 (43.7—47.4)	38.5 (36.2—40.8)	22.4 (20.9—23.9)	46.5 (43.9—49.1)
Age- and sex-standardized total	49.9 (42.3—57.4)	54.9 (51.3—58.4)	52.5 (50.1—54.8)	32.5 (31.7—33.3)	42.3 (40.4—44.2)	45.4 (43.6—47.2)	39.9 (37.8—42.1)	19.2 (17.8—20.5)	44.1 (41.6—46.6)
Sex									
Men	45.5 (33.0—58.0)	53.4 (47.6—59.2)	53.6 (50.4—56.9)	33.5 (32.3—34.7)	38.2 (35.5—40.9)	50.9 (48.1—53.8)	42.2 (38.9—45.4)	18.2 (16.3—20.2)	44.5 (40.6—48.3)
Women	53.2 (44.3—62.0)	56.3 (52.0—60.6)	49.8 (46.4—53.2)	31.8 (30.7—32.9)	46.8 (44.0—49.6)	39.9 (37.8—42.0)	37.7 (34.9—40.4)	20.2 (18.3—22.0)	43.7 (40.6—46.7)
Age group, yrs									
35—44	35.0 (18.9—51.1)	36.5 (30.4—42.6)	38.2 (32.9—43.5)	21.7 (20.5—22.8)	27.4 (24.6—30.1)	28.5 (25.1—31.9)	21.9 (18.1—25.6)	9.2 (7.1—11.3)	22.2 (17.8—26.7)
45—54	62.0 (49.0—75.0)	61.2 (54.8—67.5)	48.6 (44.3—52.8)	32.6 (31.1—34.1)	42.8 (39.3—46.3)	43.3 (40.0—46.6)	37.6 (33.4—41.7)	16.4 (13.9—19.0)	43.2 (38.3—48.2)
55—64	53.7 (41.7—65.7)	69.5 (61.9—77.1)	66.6 (64.6—68.6)	42.5 (40.5—44.4)	57.7 (53.1—62.2)	60.3 (57.2—63.3)	56.1 (51.7—60.5)	26.6 (23.6—29.6)	63.3 (58.8—67.9)
65—74	54.2 (42.6—65.8)	69.4 (58.8—80.0)	73.8 (71.7—75.9)	48.6 (46.1—51.0)	61.0 (54.0—67.9)	74.8 (71.2—78.4)	71.3 (67.1—75.5)	42.6 (38.5—46.8)	78.0 (73.7—82.2)
Education									
None	*	62.6 (51.8—73.3)	51.4 (40.7—62.0)	27.1 (25.6—28.6)	39.1 (35.6—42.7)	44.0 (25.9—62.0)	64.8 (31.8—97.7)	20.6 (6.0—35.3)	59.8 (45.1—74.4)
Any school	49.9 (42.3—57.4)	53.8 (49.9—57.6)	51.9 (49.5—54.3)	33.2 (32.1—34.3)	43.4 (40.8—46.1)	47.0 (44.9—49.0)	41.6 (38.8—44.4)	19.5 (17.9—21.1)	45.3 (42.6—48.0)
University/higher	*	*	57.7 (38.1—77.3)	43.0 (40.1—45.9)	39.4 (33.7—45.1)	41.1 (37.5—44.8)	36.0 (32.4—39.5)	18.0 (1.0—21.1)	33.5 (26.9—40.1)

Values are percentage (95% confidence interval).

*Not applicable.

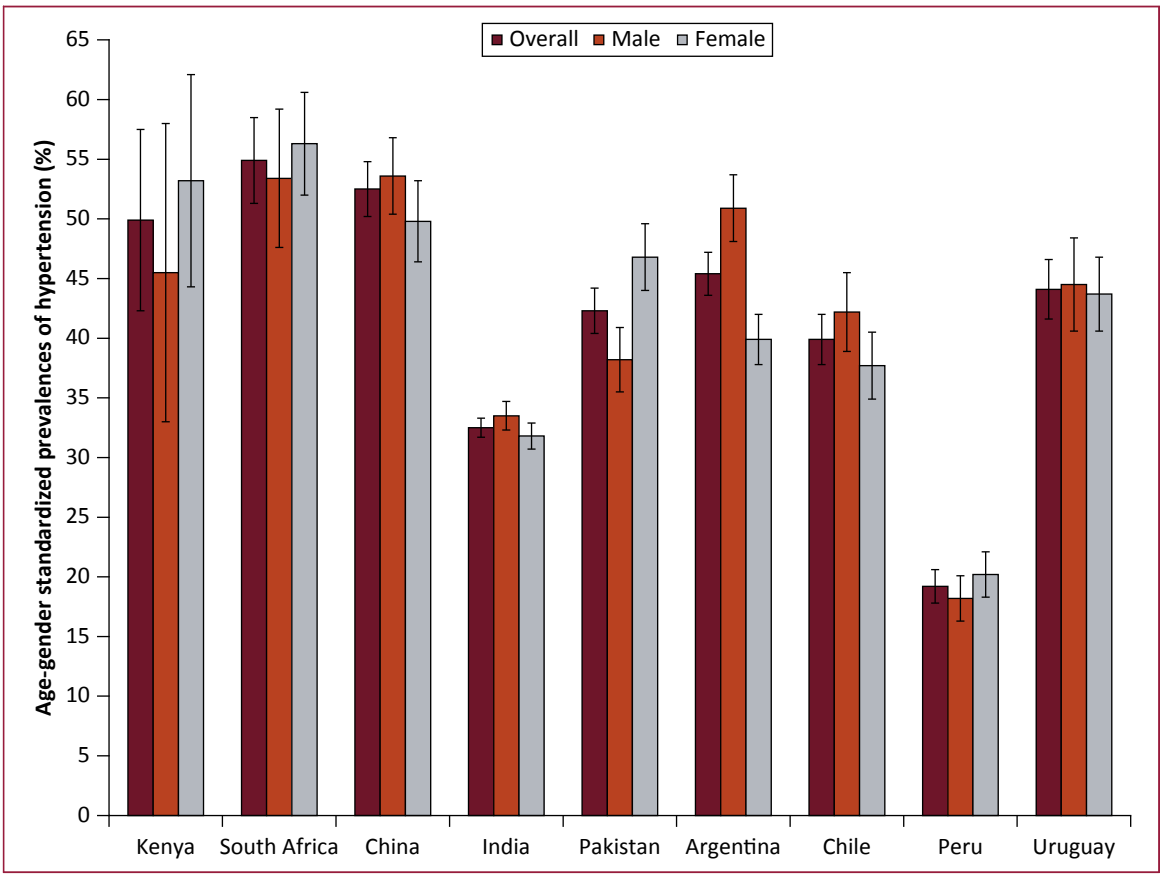

FIGURE 2. Age- and sex-standardized prevalence of hypertension by country (95% confidence interval).

all countries studied, but the magnitude of the gap varied widely among different settings. This may be associated with differences in individual habits and risk behaviors, access to the health system and medication, and other contextual factors such as culture, beliefs, practices, and value judgments. However, these variables were not measured in this study and hence could not be adjusted for. As a whole, women had significantly higher rates of awareness, treatment, and control than men in all countries, which may be related to higher health-seeking behavior [43]. Only in the rural villages of China did men seem to show slightly better control. Of note, the global rate of control in the villages in China was extremely low, as was shown in other studies conducted in different regions of this country [26–34,38]. There was no clear gradient according to educational level, in contrast to other studies [42]. However, this result should be interpreted with caution because the education categories considered in the analysis may have had limited discriminative value.

Strengths and limitations

Some strengths of this report should be highlighted. This study was based on a set of harmonized data from epidemiological studies conducted over the same period of time across LMICs in 3 continents as part of a collaborative network to address noncommunicable diseases. Rigorous procedures were followed during the harmonization process to ensure optimal matching and definition of variables. In all cases, the appropriate sampling weights were applied to ensure valid estimates for each site. Standardization of the estimated prevalence using the World Health Organization world population distribution for the countries involved also allows comparison among studies adjusting for age and sex, 2 variables that are known to affect the presence of hypertension. Finally, all surveys included in this study were conducted under rigorous research protocols that ensured accuracy and reliability of the estimates.

This study also had some limitations. There was heterogeneity among the individual studies in terms of population, sample size, sampling methods, and data collection. Some of the studies included exclusively urban locations, others were conducted in rural settings, and others included a mix of urban and rural or semirural communities, which may differ in terms of culture, social context, health systems, and geographic location. Both the number of sites and the sample size at each site also varied greatly. Although all the original studies were population

TABLE 5. Age- and sex-standardized prevalence of pre-hypertension

	Africa		Asia			South America			
	Kenya	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Unstandardized weighted total	31.0 (25.1—36.8)	24.0 (21.0—27.1)	25.7 (24.5—26.9)	34.7 (33.9—35.5)	28.2 (26.4—29.9)	31.2 (30.2—32.3)	31.9 (29.6—34.2)	24.2 (22.7—25.8)	29.7 (27.2—32.2)
Age- and sex-standardized total	34.0 (26.6—41.3)	24.6 (21.4—27.9)	33.6 (31.3—35.9)	34.7 (33.9—35.5)	28.1 (26.4—29.9)	32.8 (31.0—34.6)	32.1 (29.9—34.3)	24.0 (22.5—25.6)	30.6 (28.1—33.2)
Sex									
Men	37.8 (24.7—50.9)	27.3 (22—32.6)	33.4 (30.2—36.6)	36.7 (35.5—37.9)	33.1 (30.4—35.8)	34.1 (31.3—36.9)	37.7 (34.3—41.0)	34.3 (31.7—36.9)	35.7 (31.6—39.7)
Women	32.5 (24.1—40.8)	22.0 (18.3—25.7)	34.8 (31.2—38.3)	32.8 (31.7—33.9)	23.9 (21.5—26.4)	31.5 (29.3—33.7)	26.6 (23.7—29.5)	13.9 (12.2—15.7)	25.7 (22.5—28.8)
Age group, yrs									
35—44	48.8 (31.3—66.2)	32.5 (26.6—38.4)	41.9 (36.5—47.2)	38.2 (36.9—39.6)	30.2 (27.4—33.1)	37.5 (33.9—41.1)	35.7 (31.4—40.0)	21.8 (19.0—24.7)	37.9 (32.7—43.0)
45—54	23.8 (12.2—35.3)	22.8 (17.3—28.3)	36.1 (32.0—40.2)	34.6 (33.1—36.2)	29.5 (26.3—32.7)	35.9 (32.7—39.1)	32.6 (28.6—36.5)	24.9 (22.0—27.8)	31.9 (27.2—36.5)
55—64	31.1 (20.0—42.1)	17.8 (11.4—24.1)	26.3 (24.4—28.2)	31.4 (29.6—33.2)	25.4 (21.4—29.3)	28.6 (25.7—31.4)	32.8 (28.7—36.9)	26.7 (23.7—29.7)	23.5 (19.5—27.5)
65—74	28.5 (18.0—39.0)	17.2 (8.4—26.0)	19.4 (17.5—21.3)	30.4 (28.2—32.6)	26.1 (19.8—32.4)	18.5 (15.3—21.8)	19.2 (15.5—22.9)	24.1 (20.5—27.6)	18.4 (14.4—22.4)
Education									
None	*	20.6 (11.1—30.0)	38.1 (26.7—49.5)	38.1 (26.7—49.5)	26.8 (23.4—30.2)	20.4 (6.0—34.7)	35.2 (2.3—68.2)	17.2 (8.0—26.4)	10.6 (0.0—25.2)
Any school	34 (26.6—41.3)	25.4 (21.9—28.9)	33.8 (31.4—36.1)	33.8 (31.4—36.1)	28.1 (25.7—30.5)	31.9 (29.8—34)	32.3 (29.5—35.2)	24.1 (22.3—26)	29 (26.2—31.7)
University/higher	*	*	43.0 (29.3—56.8)	34.5 (31.6—37.3)	28.2 (22.9—33.5)	35.8 (31.9—39.7)	32.1 (28.4—35.8)	23 (19.9—26.2)	42.6 (35.3—49.9)

Values are percentage (95% confidence interval).

*Not applicable.

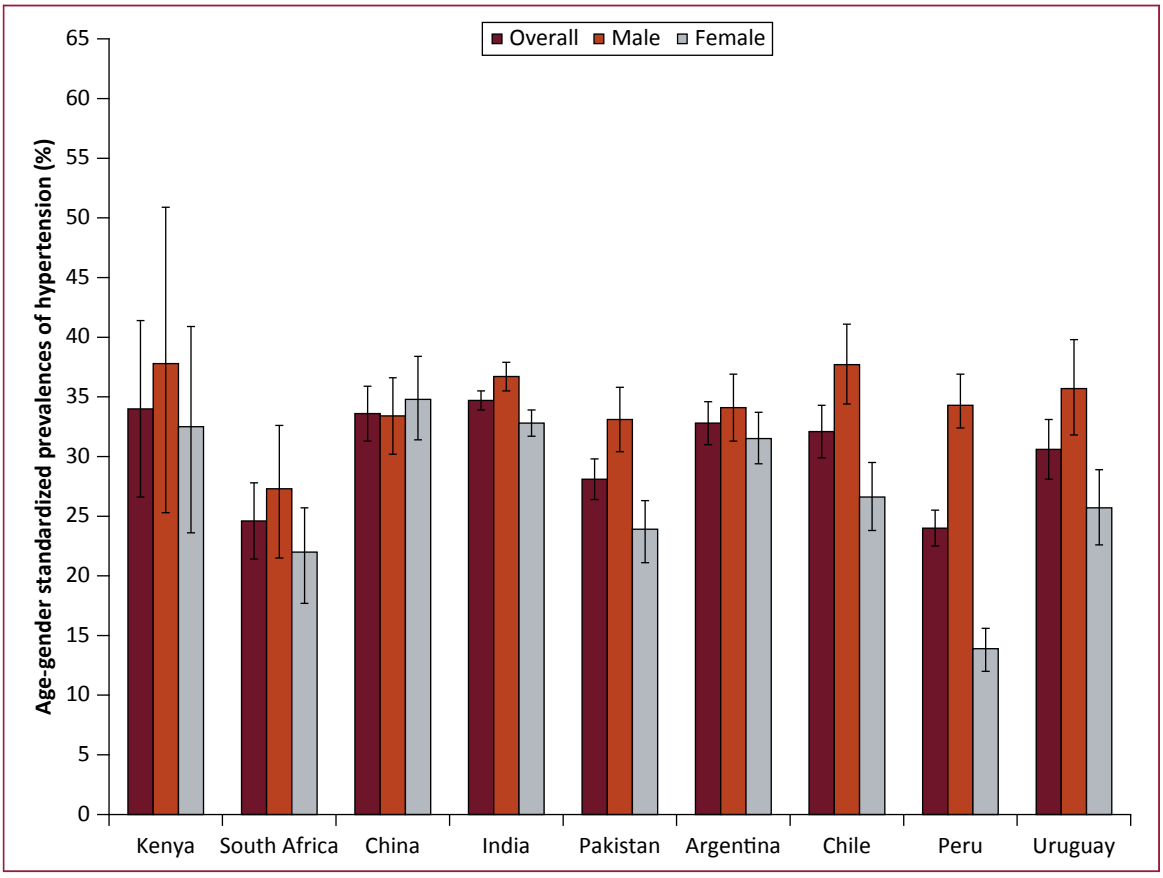

FIGURE 3. Age- and sex-standardized prevalence of pre-hypertension by country (95% confidence interval).

based and used random sampling techniques, the number of sampling stages and conditions of proportionality differed by study. Additionally, although in all studies, multiple measurements of BP were taken after a rest period of at least 5 min, different kinds of BP monitors were used, and BP was measured under different conditions, either at home or at clinic visits, and the time interval between measurements was not the same for all studies. Actually, we found that the response rates in those studies in which BP measurements were taken at clinics were lower (73.4% to 78%) than those where BP measurements were taken at home or camps in the community (84% to 91%). Although this difference may have introduced some bias in the final results, it is remarkable that response rates were high for all the studies, given the population-based nature of the sampling. Furthermore, differences between countries may be due to other relevant factors, such as multiple cardiovascular risk factors, socioeconomic features, and comorbidities, which were not examined here. Finally, it is important to emphasize that the individual surveys included in this study were not nationally representative, and thus the prevalence estimates reported here should not be applied to countries but only to those communities participating in the original studies.

CONCLUSIONS

The prevalence of hypertension varies widely in different communities across selected LMICs. The prevalence of awareness, treatment, and control also differs in different settings. Our results highlight a clear need to focus on increasing hypertension awareness and control in LMICs. These results should influence how clinicians, epidemiologists, and policy makers address this public health problem to reduce the burden of noncommunicable diseases in developing countries.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Westat for their work on merging the individual datasets, as well as the participants in each study for their collaboration, and the field teams and data managers and statisticians in each country for their hard work.

TABLE 6. Age- and sex-standardized prevalence of awareness, treatment, and control of hypertension, overall and by participants' characteristics*

	Africa	Asia			South America			
	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Awareness								
Overall	61.5 (56.7—66.3)	38.9 (35.9—41.8)	33.5 (32.0—35.0)	62.4 (59.4—65.4)	52.7 (49.6—55.7)	65.9 (61.8—70.0)	69.0 (64.4—73.5)	64.5 (59.9—69.1)
Sex								
Men	46.1 (38.4—53.7)	31.6 (28.3—34.9)	26.3 (24.3—28.2)	50.0 (45.1—54.9)	43.6 (39.3—47.9)	56.0 (50.3—61.6)	51.4 (44.2—58.7)	49.9 (42.9—56.9)
Women	76.3 (70.7—81.9)	45.5 (40.0—50.9)	40.7 (38.4—43.0)	75.2 (71.6—78.8)	61.9 (57.5—66.2)	76.6 (70.5—82.7)	87.1 (82.0—92.1)	80.1 (74.6—85.6)
Age group, yrs								
35—44	44.4 (35.1—53.7)	17.6 (10.7—24.5)	23.9 (21.2—26.6)	57.6 (51.8—63.4)	40.7 (33.8—47.5)	51.6 (41.9—61.4)	60.6 (50.8—70.4)	56.8 (46.7—66.9)
45—54	64.9 (57.0—72.7)	45.8 (39.6—51.9)	35.7 (33.0—38.4)	61.6 (56.3—66.8)	51.2 (46.3—56.0)	71.6 (65.5—77.7)	76.2 (69.2—83.3)	61.3 (54.1—68.5)
55—64	71.9 (62.9—80.8)	52.2 (49.6—54.7)	43.7 (40.6—46.7)	68.4 (62.8—74.0)	64.8 (60.9—68.7)	74.5 (69.4—79.5)	72.1 (66.4—77.8)	76.7 (71.6—81.8)
65—74	84.8 (74.8—94.7)	60.5 (57.8—63.2)	39.7 (36.2—43.2)	70.7 (63.3—78.0)	72.1 (67.8—76.4)	83.5 (79.3—87.6)	74.3 (68.7—79.9)	78.9 (74.2—83.6)
Education								
None	56.3 (44.8—67.8)	30.6 (23.6—37.6)	21.3 (18.5—24.0)	54.4 (48.2—60.6)	24.3 (1.0—47.6)	53.0 (47.8—58.2)	83.9 (64.9—100)	†
Any school	62.3 (57.0—67.5)	38.9 (35.8—41.9)	35.7 (33.8—37.6)	64.2 (60.4—68.0)	52.5 (49.0—56.0)	66.9 (61.7—72.0)	63.0 (57.6—68.4)	64.0 (59.1—68.9)
University/higher	†	†	52.2 (47.6—56.7)	65.5 (56.1—74.9)	55.6 (48.9—62.3)	64.5 (57.4—71.5)	85.5 (78.7—92.3)	66.0 (50.6—81.3)
Treatment[1]								
Overall	70.8 (63.8—77.8)	81.2 (74.0—88.5)	89.9 (87.7—92.0)	93.3 (90.9—95.8)	78.2 (73.8—82.6)	78.9 (73.7—84.1)	90.8 (87.1—94.4)	87.3 (82.6—92.1)
Sex								
Men	62.3 (48.1—76.5)	78.0 (65.1—90.8)	88.8 (85.1—92.4)	92.4 (87.7—97.0)	70.9 (63.6—78.2)	67.6 (59.2—76.1)	84.4 (75.8—93.0)	83.3 (73.9—92.6)
Women	77.3 (70.8—83.8)	85.5 (76.8—94.2)	90.7 (88.1—93.2)	94.8 (92.4—97.2)	85.3 (80.6—90.0)	89.9 (84.2—95.6)	96.1 (94.0—98.2)	90.6 (86.1—95.2)
Age group, yrs								
35—44	62.8 (44.9—80.8)	74.1 (53.8—94.5)	86.0 (80.8—91.2)	89.8 (83.7—95.9)	66.8 (56.4—77.1)	66.5 (54.0—79.0)	92.2 (82.3—100)	83.4 (70.6—96.1)
45—54	74.6 (64.4—84.8)	84.0 (77.9—90.1)	88.1 (84.6—91.7)	93.6 (89.6—97.7)	76.1 (69.5—82.6)	82.2 (75.7—88.6)	85.8 (78.5—93.2)	88.1 (81.5—94.7)
55—64	68.8 (57.3—80.2)	87.1 (84.7—89.6)	94.5 (92.4—96.7)	98.5 (96.7—100)	90.1 (87.1—93.2)	87.0 (82.4—91.6)	92.2 (87.8—96.7)	87.2 (82.4—92.0)
65—74	81.3 (70.1—92.5)	89.7 (87.5—91.9)	96.3 (94.0—98.6)	96.4 (92.4—100)	96.4 (94.3—98.5)	93.8 (90.8—96.7)	91.8 (87.6—96.1)	94.5 (91.5—97.6)
Education								
None	79.2 (66.1—92.3)	84.9 (75.1—94.7)	85.4 (77.9—92.9)	91.4 (85.5—97.3)	89.2 (79.4—99.0)	71.9 (62.1—81.7)	94.8 (78.2—100)	†
Any school	70.6 (63.1—78.1)	80.7 (73.4—88.0)	90.6 (87.9—93.3)	95.0 (92.2—97.8)	78.1 (73.0—83.2)	75.6 (69.0—82.2)	90.4 (85.7—95.2)	87.0 (81.8—92.2)
University/higher	†	†	92.3 (88.3—96.3)	86.3 (76.7—95.9)	78.9 (70.2—87.5)	84.8 (76.6—93)	91.9 (86.2—97.5)	91.3 (80.3—100)
Treatment[2]								
Overall	45.2 (40.5—50.0)	32.9 (30.1—35.6)	41.0 (39.0—43.0)	56.0 (52.9—59.2)	43.0 (40.2—45.7)	54.3 (50.3—58.2)	63.2 (58.6—67.8)	57.0 (52.4—61.6)
Sex								
Men	30.4 (23.5—37.3)	25.7 (22.7—28.6)	32.0 (29.3—34.6)	42.4 (37.4—47.4)	33.1 (29.4—36.7)	40.0 (34.9—45.1)	43.4 (36.3—50.5)	42.1 (35.4—48.8)
Women	59.4 (53.1—65.6)	39.8 (34.7—44.9)	49.9 (46.9—52.9)	70.3 (66.4—74.1)	53.3 (49.0—57.5)	69.3 (62.8—75.8)	83.6 (78.3—88.9)	72.6 (66.5—78.7)
Age group, yrs								
35—44	29.4 (20.9—37.9)	13.3 (7.1—19.4)	24.7 (21.0—28.3)	48.0 (42.0—54.0)	28.4 (22.3—34.5)	36.5 (27.1—45.9)	57.9 (48.3—67.4)	48.8 (38.6—58.9)
45—54	50.7 (43.1—58.3)	38.7 (32.6—44.8)	41.0 (37.5—44.5)	55.9 (50.4—61.3)	39.9 (35.3—44.5)	59.9 (53.5—66.3)	66.3 (58.6—74.0)	54.2 (46.9—61.6)
55—64	50.0 (40.3—59.7)	45.9 (43.3—48.4)	56.4 (52.4—60.3)	65.9 (60.0—71.7)	58.3 (54.3—62.3)	65.5 (60.2—70.9)	67.0 (61.1—72.9)	67.1 (61.5—72.7)
65—74	68.9 (56.3—81.5)	54.3 (51.5—57.0)	63.2 (57.7—68.6)	66.7 (59.2—74.3)	69.5 (65.1—73.9)	78.3 (73.7—82.9)	68.5 (62.6—74.4)	74.5 (69.5—79.6)
Education								
None	46.9 (35.9—57.9)	27.7 (20.8—34.6)	33.2 (28.5—37.8)	47.1 (40.8—53.4)	24.3 (1.0—47.6)	43.0 (28.2—57.8)	75.5 (49.4—100)	†
Any school	45.4 (40.2—50.6)	32.5 (29.6—35.3)	40.1 (37.6—42.5)	58.8 (54.8—62.8)	42.7 (39.6—45.8)	53.2 (48.4—58.0)	58.0 (52.6—63.3)	56.4 (51.5—61.2)
University/higher	†	†	48.5 (43.7—53.3)	55.0 (44.8—65.2)	45.9 (39.7—52.1)	56.6 (49.7—63.5)	78.8 (71.0—86.5)	60.1 (44.1—76.1)

(continued)

TABLE 6–*continued*. Age- and sex-standardized prevalence of awareness, treatment, and control of hypertension, overall and by participants' characteristics*

	Africa	Asia			South America			
	South Africa	China	India	Pakistan	Argentina	Chile	Peru	Uruguay
Control[1]								
Overall	54.2 (45.0—63.4)	16.2 (9.5—22.8)	43.2 (39.4—47.1)	46.2 (41.6—50.8)	37.1 (31.9—42.3)	50.0 (42.8—57.2)	71.2 (65.6—76.7)	51.2 (44.5—57.9)
Sex								
Men	46.9 (28.1—65.8)	19.6 (6.1—33.0)	38.4 (32.4—44.5)	45.8 (37.7—53.9)	30.4 (21.8—39.0)	48.4 (36.7—60.1)	72.6 (66.4—78.7)	45.1 (32.4—57.8)
Women	57.3 (48.6—66.0)	13.5 (5.9—21.0)	46.5 (41.6—51.3)	46.9 (41.7—52.1)	42.9 (36.6—49.1)	52.0 (43.2—60.8)	74.7 (68.1—81.3)	57.2 (49.9—64.4)
Age group, yrs								
35—44	48.7 (25.1—72.4)	15.1 (0.0—35)	49.3 (40.5—58.1)	49.6 (40.1—59.1)	39.8 (27.2—52.4)	54.2 (36.4—72.0)	90.5 (83.0—98.0)	67.0 (49.6—84.3)
45—54	53.3 (39.5—67.1)	18.4 (11.0—25.8)	41.0 (35.5—46.5)	46.8 (38.5—55.1)	37.3 (29.7—44.8)	48.9 (39.7—58.1)	72.3 (62.2—82.4)	41.8 (31.3—52.3)
55—64	52.4 (37.4—67.4)	16.4 (13.5—19.2)	36 (30.7—41.3)	46.7 (38.6—54.7)	31.6 (26.7—36.5)	56.2 (48.8—63.6)	61.7 (53.6—69.8)	36 (29.2—42.8)
65—74	59.1 (43.0—75.2)	16.3 (13.3—19.2)	36.8 (30.4—43.3)	35.2 (24.3—46.1)	34.5 (29.2—39.9)	31.4 (25.5—37.2)	47.2 (39.5—54.9)	52.7 (45.8—59.6)
Education								
None	58.3 (33.7—82.8)	14.9 (1.2—28.6)	48.7 (34.4—63.1)	53.7 (42.8—64.5)	54.7 (41.0—68.4)	†	73.2 (44.7—100)	†
Any school	53.7 (43.9—63.5)	16.6 (9.8—23.3)	42.8 (38.0—47.6)	44.3 (38.4—50.2)	39.3 (33.3—45.2)	51.1 (41.8—60.4)	69.6 (62.5—76.7)	50.8 (43.6—57.9)
University/higher	†	†	45.3 (37.5—53.2)	47.8 (33.1—62.5)	30.2 (20.4—40.0)	52.1 (40.3—63.8)	73.0 (63.5—82.6)	62.9 (46.4—79.4)
Control[2]								
Overall	25.1 (21—29.2)	5.3 (4.1—6.5)	10.1 (9.1—11.1)	24.4 (21.7—27.0)	15.9 (14.1—17.8)	27.1 (23.6—30.7)	45.9 (40.9—50.8)	29.4 (25.1—33.6)
Sex								
Men	15.6 (10.2—21.0)	4.9 (3.5—6.4)	7.1 (6.0—8.2)	17.9 (14.2—21.6)	10.0 (7.8—12.1)	17.8 (13.7—22.0)	29.0 (22.1—35.9)	17.5 (12.2—22.9)
Women	34.1 (28.2—40.0)	5.7 (3.5—7.9)	13.2 (11.5—14.9)	31.0 (27.1—35.0)	22.2 (18.9—25.5)	36.2 (30.0—42.3)	62.6 (55.6—69.7)	41.6 (35.0—48.2)
Age group, yrs								
35—44	15.7 (9.0—22.5)	1.7 (0.0—4.0)	8.2 (6.2—10.1)	22.0 (17.4—26.7)	12.3 (8.2—16.5)	19.1 (11.0—27.2)	49.6 (38.6—60.6)	34.2 (24.3—44.1)
45—54	28.5 (21.8—35.2)	7 (3.8—10.1)	10.8 (9.0—12.5)	24.8 (20.1—29.5)	15.7 (12.6—18.9)	30.7 (24.6—36.7)	49.3 (41.3—57.2)	22.9 (16.7—29.1)
55—64	26.5 (18.1—34.9)	7.5 (6.1—8.8)	12.3 (10.3—14.3)	29.4 (23.8—35.1)	18.6 (15.5—21.7)	37.4 (31.8—42.9)	42.1 (35.8—48.4)	25.2 (20.3—30.1)
65—74	40.9 (27.4—54.5)	8.7 (7.1—10.2)	11.0 (8.8—13.2)	22.8 (14.9—30.7)	24.1 (20.1—28.1)	24.6 (19.8—29.4)	33.5 (27.7—39.4)	39.8 (34.2—45.4)
Education								
None	29.4 (18.3—40.5)	3.1 (2.0—4.2)	5.8 (3.9—7.7)	22.5 (17.3—27.7)	19.4 (0.0—42.4)	†	60.0 (36.4—83.5)	†
Any school	24.8 (20.3—29.3)	5.4 (4.1—6.8)	10.8 (9.4—12.1)	25.1 (21.6—28.6)	16.6 (14.4—18.7)	27.4 (23.0—31.7)	41.6 (36.1—47.1)	29.0 (24.6—33.4)
University/higher	†	†	20.5 (16.8—24.1)	24.9 (15.8—34)	15.1 (11—19.2)	29.1 (22.5—35.7)	56.7 (46.6—66.8)	35.3 (19.6—51.1)

Values are percentage (95% confidence interval). Awareness was defined as self-report of a prior diagnosis of hypertension by a health care professional. Treatment[1] was defined as self-reported use of antihypertensive medications among patients aware of their condition. Treatment[2] was defined as self-reported use of antihypertensive medication among total hypertensive patients. Control[1] was defined as systolic blood pressure (BP) <140 mm Hg and diastolic BP <90 mm Hg among hypertensive patients on antihypertensive medications. Control[2] was defined as systolic BP <140 mm Hg and diastolic BP <90 mm Hg among total hypertensive patients.

*Data not available for Kenya.

†Not applicable.

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