Prevalence of Pragmatically Defined High CV Risk and its Correlates in LMIC

A Report From 10 LMIC Areas in Africa, Asia, and South America

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ABSTRACT

Background: Currently available tools for assessing high cardiovascular risk (HCR) often require measurements not available in resource-limited settings in low- and middle-income countries (LMIC). There is a need to assess HCR using a pragmatic evidence-based approach.

Objectives: This study sought to report the prevalence of HCR in 10 LMIC areas in Africa, Asia, and South America and to investigate the profiles and correlates of HCR.

Methods: Cross-sectional analysis using data from the National Heart, Lung, and Blood Institute—UnitedHealth Group Centers of Excellence. HCR was defined as history of heart disease/heart attack, history of stroke, older age (≥50 years for men and ≥60 for women) with history of diabetes, or older age with systolic blood pressure ≥160 mm Hg. Prevalence estimates were standardized to the World Health Organization's World Standard Population.

Results: A total of 37,067 subjects ages ≥35 years were included; 53.7% were women and mean age was 53.5 ± 12.1 years. The overall age-standardized prevalence of HCR was 15.4% (95% confidence interval: 15.0% to 15.7%), ranging from 8.3% (India, Bangalore) to 23.4% (Bangladesh). Among men, the prevalence was 1.7% for the younger age group (35 to 49 years) and 29.1% for the older group (≥50); among women, 3.8% for the younger group (35 to 59 years) and 40.7% for the older group (≥60). Among the older group, measured systolic blood pressure ≥160 mm Hg (with or without other conditions) was the most common criterion for having HCR, followed by diabetes. The proportion of having met more than 1 criterion was nearly 20%. Age, education, and body mass index were significantly associated with HCR. Cross-site differences existed and were attenuated after adjusting for age, sex, education, smoking, and body mass index.

Conclusions: The prevalence of HCR in 10 LMIC areas was generally high. This study provides a starting point to define targeted populations that may benefit from interventions combining both primary and secondary prevention strategies.

Cardiovascular diseases (CVD), along with their risk factors, are a major global health issue. In 2010, ischemic heart disease and stroke accounted for 1 in 4 deaths worldwide [1]. In addition, high blood pressure, smoking, and high body mass index (BMI) were top causes of Disability-Adjusted Life-Years globally [2]. Furthermore, these estimates have increased in the last decades [1–3], particularly in low- and middle-income countries (LMIC) [4–6].

Risk assessment based on total risk instead of single risk factors has become a key component of prevention strategies in many clinical guidelines [7–12]. Such strategies allow the identification of those most likely to benefit from interventions while avoiding overtreatment in those with low risk that are thus likely to be cost-effective in resource-limited settings. Unfortunately, most available risk prediction tools for CVD require laboratory-based measures that are not easily available in resource-limited areas in LMIC [13–16]. Some non-laboratory-based assessment tools have been developed and compared with more sophisticated methods had reasonable prediction power for cardiovascular events and mortality

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[15,17,18]. However, most previous tools were developed for the purpose of predicting events and thus excluded patients with existing CVD. These patients are at very high risk of disease recurrence [19–23] and require acute clinical treatments and follow-up, whereas people who do not have such diseases but are at high risk of developing CVD do not. Nevertheless, there are common sets of essential pharmaceutical and lifestyle interventions that apply to both groups. Therefore, from a public health and implementation point of view, particularly considering practical field conditions for community-wide activities and at the primary care level, we need a simple measure that can combine both patients with existing CVD and those at high absolute risk of developing them into 1 indicator of high cardiovascular risk (HCR). Simplified and pragmatic approaches to define HCR are needed to curb the rising epidemic of CVD, particularly to inform future primary and secondary prevention strategies.

We have developed and validated in China [24] a practical tool to assess HCR based on age, sex, disease history (heart disease, stroke, and diabetes), and measurement of blood pressure only, making it easy to accommodate and implement in resource-limited settings. With minimal training, this tool can be adopted at the primary care level by health care workers or even volunteers. In this study, we used existing cross-sectional data from study sites in 10 LMIC in Africa, Asia, and South America to assess the prevalence of HCR among adults according to this evidence-based yet pragmatically defined assessment tool. We also examined the components and profiles of HCR and its sociodemographic and lifestyle correlates.

METHODS

Data source, country selection, and study population

This study is a cross-sectional analysis using data from the National Heart, Lung, and Blood Institute—UnitedHealth Group Centers of Excellence program [25]. The countries fulfilling the following criteria were included: 1) having a population-based sample; and 2) having data available for all of the following variables—age, sex, measured systolic blood pressure, personal history of diabetes, personal history of stroke, and personal history of heart disease/heart attack. Only subjects with complete data on these variables were included. Moreover, this study only included subjects ages ≥35 years because the prevalence of HCR was relatively low in younger subjects.

According to these criteria, data from 7 centers with samples from 10 countries in 3 world regions were included in the analysis: Africa (Cape Town, South Africa), Asia (Bangladesh, China, India, and Pakistan), and South America: Argentina (Bariloche and Marcos Paz), Chile (Temuco), Peru (Lima, Tumbes, Puno), and Uruguay (Pando-Barros Blancos) (Table 1). In each country, participants from selected urban and/or rural study sites were surveyed according to standardized protocols. Survey instruments and methods were similar but not identical across studies, as each setting had further questions based on their particular needs and objectives; information for this study was collected in a similar fashion. Details about each study design, sampling methods, and procedures have been published elsewhere [25–30].

Definition and components of high cardiovascular risk

Study subjects were defined as HCR if they met 1 or more of the following criteria: personal history of heart disease or heart attack; personal history of stroke (including all types but not including transient ischemic attack); older age (men ages ≥50 years or women ages ≥60 years) and personal history of diabetes (including all types); and older age and systolic blood pressure ≥160 mm Hg. These criteria were chosen based on the available evidence linking them with the absolute risk of developing cardiovascular outcomes in 10 years [24]. Subjects with personal history of cardiovascular disease, namely heart disease/attack or stroke, are at high risk of recurrence regardless of age. Other factors such as diabetes and high blood pressure among older adults increase the absolute risk of cardiovascular outcomes [31–34]. Previous studies have suggested higher cardiovascular risk for men at a younger age than for women [35–37], thus the age threshold is different for men and women.

The 4 criteria were assessed in a similar fashion following standardized procedures across studies. The first criterion was self-report on physician-diagnosed personal history of either heart disease and/or heart attack (Table 1). The presence of stroke (any type) and diabetes (type 1 or 2) was based on self-reported diagnosis, too. Self-reported diagnosis was collected with questionnaires developed for each study setting and applied in the local language. Blood pressure was measured with standard procedures across countries. In general, participants had to rest between 5 and 30 min before blood pressure was assessed, and where there were more than 1 blood pressure measurement, subjects rested between 30 s and 20 min. In addition, blood pressure was measured with an automated monitor, electronic sphygmomanometer, or standard aneroid sphygmomanometer. For this study, whenever there was more than 1 blood pressure record, we used the average of all available measurements. Because we aimed to study HCR, not hypertension per se, we did not consider as high blood pressure a systolic blood pressure reading of 140 to 159 mm Hg. If we used such a threshold, even with the age and sex criteria, the absolute risk of cardiovascular events would not reach 10% in 10 years. Therefore, a higher cutoff point of 160 mm Hg was used. Diastolic blood pressure was not used because previous reports demonstrated that diastolic blood pressure was not as predictive of risks as systolic blood pressure, especially among older people [38–41]. In addition, we did not include diastolic

TABLE 1. Characteristics of datasets included in the analyses

	Center of Excellence									
	Africa	Asia					South America			
	South Africa	Bangladesh	China	India (Bangalore)	India (New Delhi)		Argentina			Peru
Country	South Africa	Bangladesh	China	India	India	Pakistan	Argentina	Chile	Uruguay	Peru
Survey year	2008–2009	2011–2012	2012	2011–2012	2010–2011	2010–2011	2010–2011	2010–2011	2010–2011	2012–2012
Study settings	Cape Town	Dhaka, Chandpur	Liaoning, Hebei, Shanxi, Shaanxi, Ningxia	Tamil Nadu, Karnataka, Sevagram	Chennai, Delhi	Karachi	Bariloche, Marcos Paz	Temuco	Pando-Barros Blancos	Lima, Tumbes, Puno
Rural or urban	Urban	Both	Rural	Rural	Urban	Urban	Urban	Urban	Urban	Both
Subjects ≥35 yrs	752	3,760	5,298	8,616	8,736	2,681	3,982	1,940	1,579	3,621
Subjects included	691	3,756	5,293	8,616	6,299	2,380	3,941	1,940	1,579	2,572
Age range	35–81	40–106	35–94	35–101	35–94	35–97	35–79	35–77	35–76	35–92
Definition of heart disease	Heart attack	Heart disease	Heart disease	Heart attack	Heart attack	Heart attack	Both	Both	Both	Heart disease
Measurements for blood pressure	1	3	1	3	2	2	1	1	1	3

blood pressure for simplicity in implementation —a main goal of this definition. In a similar fashion, medication use was not considered in this definition. It is worth reiterating that this definition of HCR aims to be pragmatic to aid easy identification at the primary care and community level, be holistic to include existing CVD and multiple factors to capture absolute risks, and to provide evidence for future primary and secondary prevention of CVD.

We assessed the prevalence of each component (criteria) in the HCR definition as well as the profile of HCR. For the older group (men ≥50 and women ≥60), they could have up to 4 components whereas for the younger age group (men 35 to 49 and women 35 to 59 years old), they could only have up to 2 components: having heart disease and/or stroke.

Independent variables

Other variables included age (as a continuous variable and in 10-year groups), sex (male and female), study site, smoking status (current, former, none), education (none, any school [1 to 11 years of schooling], university/higher [12 or more years of schooling]), and BMI (under/normal weight [BMI <25], overweight [BMI ≥25 and <30], and obesity [BMI ≥30]).

Study samples

The number of subjects eligible for the study as well as the final number included in the analysis are shown in Table 1. Overall, there were 40,965 subjects ages 35 years or older in the selected study settings. After removing observations with missing values in the variables included in the HCR definition, almost all subjects in Argentina (99.0%), Bangladesh (99.9%), Chile (100%), China (99.9%), India, Bangalore (100%), and Uruguay (100%) were included in the analysis. However, there were fewer subjects included from other settings: 91.9% in South Africa; 88.8% in Pakistan; 72.1% in India, New Delhi; and 71.0% in Peru.

Statistical procedures

Results were stratified by sex, age group, and site. For age stratification, we used 2 categories: a younger group (men ages 35 to 49 and women ages 35 to 59) and an older group (men age ≥50 and women ages ≥60). Unless otherwise noted, results on prevalence of HCR were standardized according to the World Health Organization's World Standard Population based on the world average population between 2000 and 2025 [42]. Age standardization was conducted within the same broad (younger or older) age group.

We first reported proportions for categorical variables as well as means ± SD for numerical variables. Proportions and 95% confidence intervals (CI) were used to show the distribution of each component of HCR, and the profile of HCR: that is, subjects meeting only 1, 2, 3, or all 4 criteria for HCR. Regression models—crude and adjusted—were constructed to assess the strength of the association between HCR and sociodemographic and health variables (age, sex, study site, education, smoking, and BMI status). We used generalized linear models with Poisson family and log link, including robust standard errors. The association estimates are presented as prevalence ratios (PR) and 95% CI [43,44]. The statistical analyses were conducted with STATA (version 13, StataCorp, College Station, TX, USA) by the first author and independently verified with SAS (version 9.3, SAS Institute Inc., Cary, NC, USA) by another author.

TABLE 2. Characteristics of the study population

		Africa	Asia						South America		
	Overall	South Africa	Bangladesh	China	India (Bangalore)	India (New Delhi)	Pakistan	Argentina	Chile	Peru	Uruguay
	(N = 37,067)	(n = 691)	(n = 3,756)	(n = 5,293)	(n = 8,616)	(n = 6,299)	(n = 2,380)	(n = 3,941)	(n = 1,940)	(n = 2,572)	(n = 1,579)
Variables in the high cardiovascular definition											
Male	46.4	36.0	45.7	47.4	48.0	48.7	47.4	48.4	46.0	48.4	48.5
Age, yrs	53.5 ± 12.1	50.1 ± 10.4	53.7 ± 10.3	63.0 ± 10.0	51.4 ± 12.8	48.8 ± 10.5	48.5 ± 10.8	50.6 ± 10.4	50.0 ± 10.4	55.4 ± 12.5	51.9 ± 11.0
Age categories, yrs											
35–44	27.4	35.5	20.1	5.7	34.8	40.0	40.9	35.6	40.1	23.1	31.9
45–54	27.3	33.7	40.9	11.6	26.0	32.9	31.0	30.0	29.1	25.8	29.0
55–64	24.1	19.8	22.1	38.0	18.8	17.5	17.8	22.3	18.7	26.5	22.6
65–74	16.5	9.8	12.1	32.5	14.9	7.5	8.2	11.7	11.7	16.1	15.4
≥75	4.8	1.2	4.8	12.2	5.6	2.1	2.1	0.4	0.4	8.6	1.1
Heart disease/attack	3.5	5.6	13.0	5.8	0.2	1.2	1.4	2.1	2.4	4.3	3.8
Stroke	2.4	3.9	4.8	7.6	0.5	0.8	1.4	0.9	0.9	0.9	1.9
Diabetes	11.2	12.0	13.2	12.6	4.1	19.2	13.7	7.0	11.2	8.0	11.8
Systolic blood pressure ≥160 mm Hg	9.6	12.3	6.2	24.7	6.4	7.9	7.3	6.2	6.0	2.5	8.1
Systolic blood pressure, mm Hg	129.5 ± 22.3	131.5 ± 24.3	122.4 ± 26.5	145.9 ± 22.5	125.4 ± 20.1	130.2 ± 19.0	126.4 ± 20.1	127.5 ± 18.7	126.0 ± 19.3	118.9 ± 17.3	129.6 ± 20.5
Other variables											
Smoking history	37,019	690	3,747	5,293	8,616	6,299	2,380	3,933	1,938	2,572	1,551
Current	33.6	25.8	58.7	28.8*	51.7	22.5	27.5	28.6	30.7	12.1	30.2
Former	21.0	10.4	9.0	71.2	2.9	2.6	1.8	26.5	23.5	33.3	27.3
None	45.5	63.8	32.3		45.4	74.9	70.8	44.9	45.8	54.6	42.6
Education	36,983	691	3,756	5,284	8,616	6,299	2,380	3,906	1,922	2,572	1,557
None	19.2	12.7	0.0	26.5	43.0	15.2	30.5	0.9	0.4	6.6	0.6
Any school	65.5	87.3	47.6	73.4	55.1	66.4	55.8	76.4	63.5	73.8	87.9
University/higher	15.3	0.0	52.4	0.2	1.9	18.4	13.7	22.6	36.1	19.6	11.5
Body mass index	26,490	691	3,756	5,291	8,615	4,941	1,795	3,933	1,939	2,572	1,572
Under/normal weight	43.6	31.0	72.6	60.7	84.0	45.6	41.5	26.0	20.0	28.4	28.6
Overweight	33.9	20.4	20.6	32.7	13.1	34.4	35.8	38.3	45.4	43.8	34.5
Obese	22.5	48.6	6.8	6.5	2.9	20.1	22.7	35.8	35.0	27.8	37.0

Results are presented as counts, %, or mean ± SD.

*Did not ask for nonsmokers.

Ethics

Each individual study received its own institutional review board approval. Informed consent was obtained from all participants before any data were collected. We used pooled and deidentified data to conduct this study.

RESULTS

Population characteristics

Overall, there were slightly more women (53.7%) than men. The mean age was 53.5 ± 12.1 years (Table 2). Mean systolic blood pressure was 129.5 ± 22.3 mm Hg. Regarding education, 19.2% reported no education and 65.5% had achieved some school-based education, but not university level or higher. For the overall sample, 28.8% were overweight and 17.7% were obese. Between-site variations were large for all variables.

Age-standardized prevalence of high cardiovascular risk

Across all the study sites, 16.4% (6,071 of 37,067) subjects met the HCR criteria. The age-standardized prevalence of HCR was 15.4% (95% CI: 15.0% to 15.7%) and varied across sites from 8.3% in Bangalore, India, to 23.4% in Bangladesh (Figure 1). Prevalence of HCR for the younger age group was lower than 10% for all except Bangladeshi women. For the older age group, the prevalence was above 20% for most and above 30% for two-thirds of the groups in our study.

Prevalence of components of high cardiovascular risk

Table 3 presents the frequency of each HCR component, overall and stratified by age, sex, and site. In the younger group, the proportion of having had heart disease was

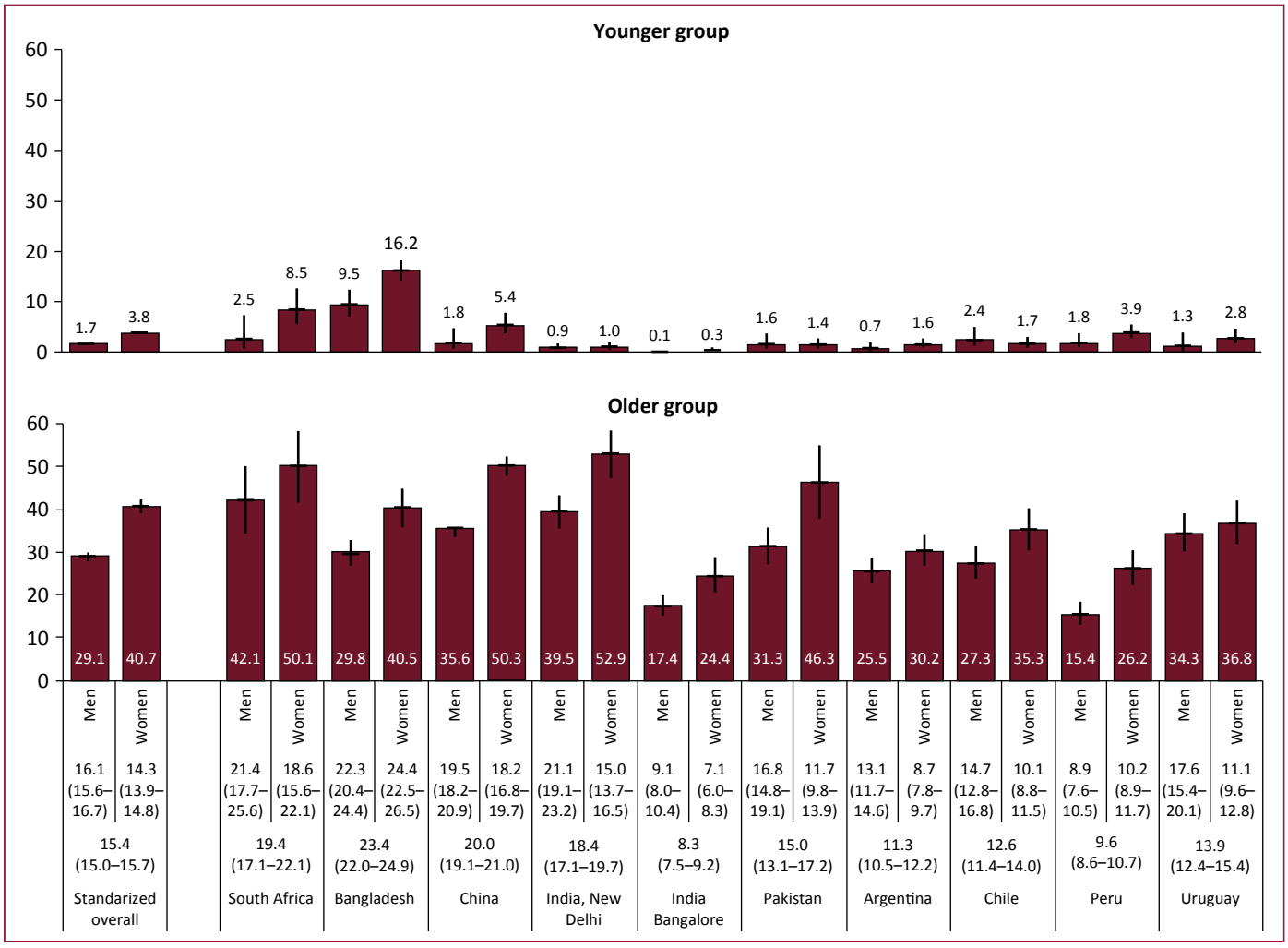

FIGURE 1. Age-standardized prevalence of high cardiovascular risk (HCR) by sex, age group, and study site. Numbers above the study site represent the overall and sex-specific age-standardized prevalence of HCR and 95% confidence interval (CI).

higher than that of stroke. In the older group, the most frequent criterion was having systolic blood pressure over 160 mm Hg (13.6% for men vs. 20.5% for women), followed by diabetes (12.3% for men vs. 17.5% for women). In general, women had higher prevalence of each component than did men for both age groups. Of note, the 4 components were not mutually exclusive and participants could have more than 1 condition.

Profile of high cardiovascular risk

Table 4 depicts the proportions of subjects meeting only 1, 2, 3, or all 4 criteria for HCR, stratified by age, sex, and site. Most subjects met only 1 criterion, both in the younger (86.9% men and 92.1% women) and older (81.9% men and 77.3% women) groups. Although very few subjects met 3 or 4 criteria, the proportion of having 2 conditions was sizable in the older group (15.7% for men and 19.2% for women).

Correlates of high cardiovascular risk

Table 5 shows the crude and adjusted prevalence ratio for associated factors and HCR. In multivariable models, subjects in the oldest age group, compared with the youngest individuals, had much higher prevalence of HCR: PR = 19.01 (95% CI: 16.10 to 22.44). Relative to men, women had 21% lower prevalence of HCR. Likewise, those at the highest educational level had 23% lower prevalence. There were large variations across study sites: compared with India (New Delhi), some countries had much higher and others had lower prevalence of HCR. Variations across study sites became smaller after adjusting for other variables.

DISCUSSION

Main findings

Among the study populations 35 years and older from selected sites in 10 LMIC, the overall age-standardized

TABLE 3. Prevalence of each cardiovascular risk component

	Younger group			Older group				
	n	Heart Disease	Stroke	n	Heart Disease	Stroke	Diabetes	SBP ≥160
Crude overall								
Men	6,910	1.4 (1.1–1.7)	0.6 (0.5-0.8)	10,269	4.6 (4.2–5.0)	4.0 (3.7–4.4)	12.3 (11.7–12.9)	13.6 (13.0–14.3)
Women	13,176	2.8 (2.6–3.1)	1.1 (0.9–1.3)	6,712	5.5 (5.0–6.1)	4.1 (3.7–4.6)	17.5 (16.6–18.4)	20.5 (20.0–21.5)
Standardized overall								
Men	6,910	1.4 (1.1–1.7)	0.6 (0.5–0.8)	10,269	4.6 (4.2–5.1)	4.2 (3.8–4.6)	12.2 (11.5–12.9)	14.1 (13.3–14.8)
Women	13,176	3.0 (2.7–3.3)	1.1 (1.0–1.3)	6,712	6.0 (5.3–6.8)	4.3 (3.8–4.9)	18.1 (17.0–19.3)	23.2 (21.9–24.5)
South Africa								
Men	134	1.5 (0.4–5.5)	1.0 (0.2–6.0)	115	7.2 (3.9–12.7)	7.3 (4.3–12.1)	9.6 (5.8–15.5)	27.2 (20.0–35.9)
Women	358	4.9 (3.0–8.6)	5.0 (2.8–8.6)	84	12.9 (7.9–20.3)	1.8 (0.5–6.4)	25.0 (18.8–32.5)	25.4 (18.6–33.6)
Bangladesh								
Men	618	8.6 (6.5–11.3)	2.6 (1.6–4.0)	1,097	12.9 (10.9–15.1)	7.0 (5.6–8.8)	12.8 (10.9–14.9)	8.1 (6.6–9.8)
Women	1,606	14.0 (12.4–15.8)	4.0 (3.1–5.1)	435	14.6 (12.0–17.7)	7.0 (4.9–9.8)	19.0 (15.6–22.9)	18.1 (14.8–21.9)
China								
Men	234	0.4 (0.1–2.4)	1.4 (0.4–4.3)	2,276	4.2 (3.4–5.2)	8.6 (7.5–9.9)	8.3 (7.3–9.5)	22.2 (20.5–23.9)
Women	466	3.6 (2.4–5.3)	1.8 (1.0–3.6)	2,317	7.3 (6.3–8.4)	7.5 (6.4–8.6)	20.3 (18.6–22.0)	31.8 (29.9–33.8)
India, New Delhi								
Men	1,741	0.6 (0.3–1.3)	0.4 (0.2–1.0)	1,314	4.2 (2.9–6.1)	1.9 (1.3–2.8)	26.0 (21.7–30.7)	14.7 (13.0–16.4)
Women	2,704	0.6 (0.2–1.4)	4.6 (0.2–1.0)	540	4.4 (2.9–6.5)	1.0 (0.5–2.0)	39.3 (33.5–45.4)	22.8 (16.9–30.0)
India, Bangalore								
Men	1,994	0.1 (0.0–0.4)	0.0 (0.0–0.4)	2,138	0.2 (0.1–0.8)	1.8 (1.1–2.9)	7.0 (5.6–8.7)	10.4 (8.7–12.3)
Women	3,217	0.2 (0.1–0.7)	0.1 (0.0–0.3)	1,267	0.7 (0.2–3.4)	0.8 (0.3–2.0)	4.3 (3.1–6.0)	19.8 (16.3–23.9)
Pakistan								
Men	593	1.0 (0.3–3.1)	0.6 (0.2–1.8)	539	4.1 (2.6–6.3)	1.8 (1.0–3.3)	19.1 (15.3–23.5)	12.2 (9.0–16.3)
Women	1,086	0.4 (0.1–1.0)	1.0 (0.5–2.1)	162	0.4 (0.1–1.6)	3.5 (1.3–9.0)	28.7 (21.1–37.8)	24.3 (16.2–34.8)
Argentina								
Men	545	0.6 (0.2–1.5)	0.1 (0.0–1.0)	1,026	4.8 (3.6–6.4)	1.6 (1.0–2.6)	10.7 (8.7–13.1)	12.2 (10.3–14.4)
Women	1,621	1.1 (0.6–1.7)	0.6 (0.4–1.1)	749	2.3 (1.4–3.7)	1.4 (0.7–2.6)	13.8 (11.2–16.8)	16.8 (14.3–19.7)
Chile								
Men	367	1.7 (0.8–3.7)	1.0 (0.3–3.2)	552	4.3 (2.9–6.3)	1.2 (0.6–2.5)	15.1 (12.5–18.2)	12.0 (9.5–15.0)
Women	662	1.3 (0.7–2.3)	0.6 (0.3–1.5)	359	4.5 (2.6–7.7)	1.3 (0.5–3.1)	21.1 (17.1–25.8)	16.1 (12.9–20.0)
Peru								
Men	447	1.6 (0.8–3.1)	0.4 (0.1–1.7)	797	4.0 (2.9–5.6)	0.7 (0.3–1.6)	8.5 (6.7–10.6)	3.8 (2.7–5.3)
Women	883	3.5 (2.5–4.8)	0.5 (0.2–1.1)	445	8.2 (5.9–11.2)	2.2 (1.2–3.9)	14.0 (11.1–17.5)	6.8 (4.9–9.4)
Uruguay								
Men	237	0.7 (0.2–2.8)	0.6 (0.1–3.6)	415	8.3 (6.1–11.2)	2.9 (1.7–5.1)	13.6 (10.6–17.4)	17.2 (13.7–21.3)
Women	573	1.9 (1.1–3.3)	1.1 (0.5–2.6)	354	6.5 (4.4–9.4)	4.9 (3.0–8.0)	22.5 (18.4–27.1)	11.3 (8.4–15.0)

Values are n or PR (95% CI). High cardiovascular risk is defined as personal history of heart disease or heart attack, personal history of stroke, older age (men ages ≥50 years or women ages ≥60 years), and personal history of diabetes, or older age and systolic blood pressure ≥160 mm Hg; therefore, for the younger age group (men 35 to 49 and women 35 to 59 years old), there are only 2 components, whereas for the older group (men ≥50 and women ≥60) there are 4 components.
CI, confidence interval; PR, prevalence ratio; SBP, systolic blood pressure.

prevalence of HCR was 15.4% (95% CI: 15.0% to 15.7%), ranging from 8.3% to 23.4%. Among men, the prevalence was 1.7% for the younger age group (35 to 49 years) and 29.1% for the older group (≥50 years); among women, 3.8% for 35 to 59 years and 40.7% for those ≥60 years. Among the older group, measured systolic blood pressure ≥160 mm Hg (with or without other conditions) was the most common HCR criterion, followed by diabetes. The proportion of having met more than 1 criterion was nearly 20%. Age, education, and BMI were significantly associated with HCR. Large cross-site differences existed and were attenuated after adjusting for age, sex, education, smoking, and BMI.

Rational for the high cardiovascular risk definition

In this study, HCR was pragmatically defined to include both patients with existing CVD and individuals at high risk of developing them. Identification of HCR was based on age, sex, disease history, and measurement of systolic blood pressure only to be suitable for resource-limited settings. Several risk assessment tools have been

TABLE 4. Prevalence of having 1 or more components of HCR

	Younger group		Older group		
	Having only 1	Having 2	Having only 1	Having only 2	Having only 3 or all 4
Crude overall					
Men	86.9 (79.5—91.9)	13.1 (8.1—20.5)	81.9 (80.5—83.3)	15.7 (14.5—17.1)	2.3 (1.9—3.0)
Women	92.1 (89.3—94.2)	7.9 (5.8—10.7)	77.3 (75.7—78.9)	19.2 (17.7—20.8)	3.4 (2.8—4.2)
Standardized overall					
Men	90.3 (85.2—93.7)	9.7 (6.3—14.8)	82.2 (80.7—83.7)	15.6 (14.2—17.1)	2.1 (1.7—2.7)
Women	92.9 (89.6—95.2)	7.1 (4.8—10.4)	77.2 (75.4—78.9)	19.5 (17.8—21.3)	3.3 (2.6—4.2)
South Africa					
Men	100.0	0.0 (0.0—0.0)	85.5 (76.1—91.5)	12.1 (6.3—21.9)	2.5 (0.8—7.4)
Women	88.3 (83.5—91.9)	11.7 (8.1—16.5)	79.0 (68.1—86.9)	16.1 (9.0—27.3)	4.9 (1.8—12.7)
Bangladesh					
Men	84.2 (74.2—90.7)	15.9 (9.3—25.8)	71.6 (66.5—76.2)	21.2 (17.0—26.0)	7.3 (5.0—10.5)
Women	88.6 (84.1—92.0)	11.4 (8.0—15.9)	64.1 (57.3—70.3)	30.0 (23.9—36.9)	5.9 (3.3—10.5)
China					
Men	100.0	0.0 (0.0—0.0)	81.9 (78.9—84.6)	15.9 (13.4—18.8)	2.2 (1.5—3.3)
Women	100.0	0.0 (0.0—0.0)	73.2 (70.6—75.7)	21.8 (19.5—24.4)	5.0 (3.9—6.4)
India, New Delhi					
Men	81.5	18.5	81.5 (77.3—85.1)	18.4 (14.8—22.79)	0.1 (0.0—0.4)
Women	100.0	0.0 (0.0—0.0)	81.0 (74.9—86.0)	16.3 (11.8—22.1)	2.7 (1.8—4.0)
India, Bangalore					
Men	52.2	47.8	90.5 (86.3—93.5)	9.5 (6.5—13.7)	0.0 (0.0—0.0)
Women	100.0	0.0 (0.0—0.0)	92.9 (87.6—96.0)	7.1 (4.0—12.3)	0.1 (0.0—0.7)
Pakistan					
Men	100.0	0.0 (0.0—0.0)	84.7 (79.4—88.9)	11.3 (7.6—16.5)	4.0 (2.6—6.0)
Women	96.0 (77.9—99.4)	4.0 (0.6—22.1)	75.7 (67.8—82.3)	24.3 (17.7—32.3)	0.0 (0.0—0.0)
Argentina					
Men	100.0	0.0 (0.0—0.0)	87.6 (83.3—90.9)	11.5 (8.3—15.8)	0.9 (0.4—2.2)
Women	95.9 (88.5—98.6)	4.1 (1.4—11.5)	85.2 (79.3—89.6)	14.3 (10.0—20.2)	0.5 (0.1—3.1)
Chile					
Men	86.9	13.1	85.1 (79.2—89.6)	13.7 (9.4—19.4)	1.2 (0.3—4.5)
Women	94.4 (76.0—98.9)	5.6 (1.1—24.0)	77.5 (68.1—84.8)	20.9 (13.7—30.3)	1.7 (0.5—5.7)
Peru					
Men	84.5	15.5	90.0 (85.8—93.1)	5.4 (2.9—9.9)	4.6 (3.4—6.1)
Women	100.0	0.0 (0.0—0.0)	82.6 (75.6—87.9)	16.4 (11.2—23.2)	1.1 (0.3—4.0)
Uruguay					
Men	100.0	0.0 (0.0—0.0)	75.4 (68.2—81.4)	22.6 (16.9—29.4)	2.1 (0.7—6.2)
Women	88.5	11.5	78.5 (71.1—84.4)	20.3 (14.6—27.6)	1.2 (0.3—5.2)

Values are PR (95% CI). High cardiovascular risk defined as personal history of heart disease or heart attack, personal history of stroke, older age (men ages ≥50 years or women ages ≥60 years), and personal history of diabetes, or older age and systolic blood pressure ≥160 mm Hg; therefore, for the younger age group (men 35 to 49 and women 35 to 59 years old), there are only 2 components, whereas for the older group (men ≥50 and women ≥60) there are 4 components.
HCR, high cardiovascular risk; other abbreviations as in Table 3.

developed based on different populations [9,45]. Simplified versions without laboratory tests have also been developed and tested in resource-limited areas, showing satisfactory results [15,17,18]. These risk assessment tools focus on prediction of first cardiovascular events. However, according to the high recurrence rate, people with medical history should also be considered as a high-risk population for risk management [46]. This is why this assessment tool included medical history of heart disease and stroke, besides diabetes and high blood pressure, which are 2 established risk factors for CVD. Estimates based on this definition are easier to obtain than more complex lab-based tools and will provide a composite measure of high-risk population needing intervention. The reliability and validity of our assessment tool have been tested in a previous study in China [24]. The concordance rate between this assessment tool and the gold standard in predicting 10-year absolute risk of having a new or recurrent cardiovascular event is 92.9%. Compared with the gold standard, the sensitivity is 77.2%, the specificity is 98.5%, the

TABLE 5. Crude and adjusted PR for associated factors and HCR

	HCR	
	Crude PR (95% CI)	Adjusted PR (95% CI)*
Age, yrs	37,067	34,977
35–44	1	1
45–54	4.33 (3.69–5.10)	3.79 (3.21–4.48)
55–64	14.03 (12.06–16.33)	11.44 (9.78–13.38)
65–74	21.49 (18.49–24.98)	17.79 (15.22–20.80)
≥75	23.07 (19.71–27.01)	19.01 (16.10–22.44)
Sex	37,067	34,977
Male	1	1
Female	0.85 (0.81–0.89)	0.79 (0.75–0.83)
Education	36, 983	34,977
None	1	1
Any school	0.90 (0.85–0.95)	0.96 (0.91–1.02)
University/higher	0.72 (0.67–0.79)	0.77 (0.70–0.84)
Smoking	37,019	34,977
Current	1	1
Former	2.26 (2.15–2.40)	1.25 (1.17–1.33)
None	0.88 (0.83–0.93)	1.13 (1.05–1.21)
BMI	35,105	34,977
Under/normal weight	1	1
Overweight	1.33 (1.27–1.40)	1.42 (1.35–1.50)
Obesity	1.35 (1.27–1.43)	1.71 (1.60–1.83)
Site	37,067	34,977
Argentina	1.09 (0.99–1.21)	0.62 (0.56–0.68)
Bangladesh	1.70 (1.56–1.86)	1.62 (1.46–1.80)
Chile	1.25 (1.10–1.41)	0.69 (0.61–0.77)
China	3.02 (2.81–3.25)	1.22 (1.11–1.35)
India, New Delhi	1	1
India, Bangalore	0.59 (0.54–0.65)	0.52 (0.47–0.58)
Pakistan	0.89 (0.78–1.02)	0.84 (0.73–0.97)
Peru	0.88 (0.77–0.99)	0.48 (0.42–0.54)
Uruguay	1.50 (1.33–1.70)	0.78 (0.69–0.88)
South Africa	1.39 (1.17–1.66)	1.11 (0.94–1.31)

Values are n or PR (95% CI).
BMI, body mass index; other abbreviations as in Tables 3 and 4.
*Adjusted for all variables listed.

positive predictive value is 94.7%, and the negative predictive value is 92.5% [24]. The high specificity shows that individuals identified as non-HCR by our definition are indeed not high risk whereas the lower sensitivity implies that this definition misses some people who are high risk. When resources are limited and the prevalence of HCR is high, the latter is not as serious a concern as false identification is.

Interpretation of results in light of previous evidence on high cardiovascular risk

A sex difference was suggested by our results. For each component of HCR, women had higher prevalence in both younger and older groups. These findings were likely a result of the higher cutoff point for women than men in the definition. On the other hand, high prevalence of cardiovascular risk in women was also reported by other studies [47–49]. The higher prevalence of diabetes among women was also indicated in previous research [50,51].

Most previous studies found that risk factors for CVD tend to cluster among the same individuals. For example, a study in China showed that the prevalence of clustering of CVD risk factors (≥2 of hypertension, diabetes, dyslipidemia, or overweight) was 36% [52]. Also, a study in 8 African countries and 6 countries in the Middle East found a similar pattern; their highest frequency was for subjects with 2 or 3 risk factors [53]. In our study, most people were defined as HCR by meeting only 1 criterion whereas a sizable proportion had 2 conditions. Clustering of high-risk components was lower than for other studies because our definition included existing CVD and the cutoff for systolic blood pressure was set at 160 mm Hg not the typical 140 mm Hg. Given the high prevalence of hypertension and a lower cutoff point, a larger proportion of people would be identified as HCR. Identifying a larger group of people with risks lower than in our definition may mean less cost-effective or feasible intervention for resource-constrained areas.

Age and obesity were associated with higher prevalence of HCR, as expected. Compared with current smokers, former smokers and nonsmokers had higher prevalence of HCR. This result is surprising, and reverse causality is a possible explanation for the higher prevalence among former smokers. Higher education was associated with lower prevalence of HCR the multivariable model. This result is consistent with other studies. Gupta et al. [54] reported that people with low- or middle-educational status were at greater cardiovascular risk than were their peers with higher education. No causal inference can be drawn from our cross-sectional study; nevertheless, our results provide further evidence for the role of improving education in reducing health risks.

Although our study was not designed to make cross-countries comparisons, there are interesting findings that need to be further studied. Study settings in the South American region (Argentina, Chile, Peru, and Uruguay) had lower age-standardized prevalence of HCR, relative to the other study settings both in Asia and Africa. This finding might reflect differences in the epidemiological transition stage that these settings are in. It could also be due to late diagnosis or more effective management of the risk factors included in our HCR definition.

Strengths and limitations

The National Heart, Lung, and Blood Institute—UnitedHealth Group Centers of Excellence database provides us with a unique opportunity to conduct a multicountry study with a considerable sample size. All studies in this program were conducted according to international standards, which is one of the strengths of our study. It also has several important limitations. First,

our assessment tool was only validated in China, but not in other LMIC. Each component in the definition, however, has been well-established by many previous studies, and it is reasonable to assume that this definition would apply to other countries. Our HCR definition included age-dependent criteria (diabetes and systolic blood pressure for the older group only), which is consistent with previous research on differential influences of risk factors on absolute cardiovascular risk by age. However, such an age-dependent definition could limit comparison of differences in HCR by age. Second, because the studies were conducted in 10 countries, heterogeneity of study design and differences in variable definition is a potential limitation. In addition, information about personal history of heart disease, stroke, and diabetes in the HCR definition relied on self-reports as not all datasets had information on verifications by physician diagnoses, medical records, or other more reliable sources. Third, data for each country came from selected urban and/or rural sites only and were not nationally representative, precluding us from making cross-national comparisons. We, therefore, have restricted the presentation and discussion of our findings to 10 study areas instead of 10 countries per se. Nevertheless, our study was based on diverse study populations across a large number of settings in LMIC and can provide initial indications on the pressing global health issue of HCR.

CONCLUSIONS

The prevalence of HCR across selected study sites in 10 LMIC was generally high and a sizable proportion of people with HCR had more than 1 condition. Our study results highlight the large burden of HCR in LMIC. They also call for urgent actions for larger scale screening and intervention strategies for HCR management in these areas. The HCR assessment tool was designed with scalability and sustainability in mind. With such a tool as the starting point, guideline-based yet simplified intervention strategies incorporating both primary and secondary prevention and management of CVD have been developed [30]. When successfully implemented, these high-risk strategies have the potential to substantially reduce the risk of CVD and related costs and consequences. Future studies can evaluate whether these strategies are suitable for the local contexts in different LMIC and are cost-effective in resource-poor settings.

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