Hypertension in seven Latin American cities: the Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study

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Background Little information is available regarding hypertension, treatment, and control in urban population of Latin America.

Objective We aimed to compare blood pressure (BP) distribution, hypertension prevalence, treatment, and control in seven Latin American cities following standard methodology.

Methods The Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study was a cross-sectional, epidemiologic study assessing cardiovascular risk factors using stratified multistage sampling of adult populations (aged 25–64 years) in seven cities: Barquisimeto (Venezuela; $n = 1848$); Bogotá ($n = 1553$); Buenos Aires ($n = 1482$); Lima ($n = 1652$); Mexico City ($n = 1720$); Quito ($n = 1638$); and Santiago ($n = 1655$). The prevalence of hypertension and high normal BP were determined based on 2007 European Society of Hypertension and European Society of Cardiology definitions.

Results BP increased with age in men and women; pulse pressure increased mainly in the upper age group. The hypertension prevalence ranged from 9% in Quito to 29% in Buenos Aires. One-quarter to one-half of the hypertension cases were previously undiagnosed (24% in Mexico City to 47% in Lima); uncontrolled hypertension ranged from 12% (Lima) to 41% (Mexico City). High normal BP was also evident in a substantial number of each city participants ($\approx$5–15%). Majority of population has other cardiovascular risk factors despite hypertension; only 9.19% of participants have no risk factors apart from hypertension.

Conclusion From 13.4 to 44.2% of the populations of seven major Latin American cities were hypertensive or had high normal BP values. Most hypertensive patients have additional risk factors. Public health programs need to target prevention, detection, treatment, and control of total cardiovascular risk in Latin America. *J Hypertens* 27:000–000 © 2009 Wolters Kluwer Health | Lippincott Williams & Wilkins.

Introduction

Hypertension is a major public health concern worldwide. The 2007 Guidelines for the Management of Arterial Hypertension from European Societies of Hypertension and Cardiology recognize three categories of hypertension (grade 1–3) and an additional high normal blood pressure (BP) category [1]. The patients with high normal BP include individuals with mildly elevated BP who are also at increased risk for cardiovascular disease and who may benefit from interventions designed to prevent progression to hypertension grade 1. In 2000, worldwide prevalence of hypertension was estimated to be approximately 26%. Currently, two-thirds of the 972 million adults with hypertension reside in economically developing countries; moreover, it has been estimated that by the year 2025, the prevalence of hypertension will have risen by 24% in economically developed countries, but in economically developing countries, an 80% rise is

predicted [2]. This will inevitably strain healthcare systems and cause substantial increases in healthcare costs [3].

Hypertension is considered the single most preventable cause of premature death [4,5] and in Latin America, it is strongly linked to premature death from stroke and ischemic heart disease [6]. In fact, hypertension is the risk factor most strongly associated with first acute myocardial infarction (MI) in Latin American countries [odds ratio (OR), 2.81; 95% confidence interval (CI) 2.39–3.31] [7], an association that is stronger than that in worldwide analyses (OR, 2.48; 99%CI 2.30–2.68) [8]. Even high normal BP (SBP 130–139 mmHg or DBP 85–90 mmHg) has been found to increase risk for cardiovascular disease 2.33 times above the risk with optimal BP (<120/80 mmHg) [9]. Furthermore, the end-organ damage (e.g., kidney, peripheral vascular) associated with hypertension emphasizes the importance of prevention, detection, and treatment efforts [1].

Compounding the predictions of a large increase in the prevalence of hypertension in developing countries, solid epidemiologic data to support public health efforts in Latin America have been lacking; previous studies are hard to compare due to differences in methodology and population characteristics [10]. The Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study was designed to systematically evaluate and compare cardiovascular risk factors in seven major Latin American cities. An initial report from this study has previously been published [11]. Here, the BP distribution, prevalence of hypertension and high normal BP, levels of awareness, treatment and hypertension control, and assessment of stratification of total cardiovascular risk are reported.

Patients and methods

The CARMELA study is a cross-sectional, observational study with the added value of being conducted mostly by practicing clinicians integrated in a sub-continental network, using stratified multistage sampling and conducted between September 2003 and August 2005 in Barquisimeto, Venezuela; Bogotá, Colombia; Buenos Aires, Argentina; Lima, Peru; Mexico City, Mexico; Quito, Ecuador; and Santiago, Chile. The velocity of sampling recruitment was different in each city; at the end, a total of approximately 1600 participants (male and female) per city between the ages of 25 and 64 years were enrolled, taking about 200 people from each 10-year age and sex group to provide accurate prevalence estimates in each of the eight age-sex groups. Detailed methodology and study design are presented elsewhere [11]. The study was conducted according to the Declaration of Helsinki and the Guides for Good Clinical Practice. A customized questionnaire was used to collect information on demographics, hypertension, and other common cardiovascular risk factors. Participants visited designated healthcare institutions for standardized clinical measurements, obtained by health personnel trained, certified, and supervised by CARMELA investigators.

Blood pressure measurement

The American Heart Association guidelines for BP measurement were followed. A trained observer using a calibrated mercury sphygmomanometer measured BP while the participant was seated and at rest. Two readings were taken 5 min apart; if they differed by more than 5 mmHg, measurements were repeated until two close readings were obtained. The average values were used for statistical analysis. Using European Society of Hypertension and European Society of Cardiology (ESH/ESC) guidelines, hypertension was defined as SBP at least 140 mmHg or DBP at least 90 mmHg or current antihypertensive medication use; grade 1 was defined as SBP 140–159 mmHg and/or DBP 90–99 mmHg; grade 2 was defined as SBP 160–179 mmHg and/or DBP 100–109 mmHg; grade 3 was defined as SBP at least 180 mmHg and/or DBP at least 110 mmHg; high normal BP was defined as SBP 130–139 mmHg and/or DBP 85–89 mmHg [1]. Previously undiagnosed hypertension was hypertension in participants who reported that they were not hypertensive, did not know, or were hypertensive only during pregnancy. Hypertension was defined taken into consideration BP levels (SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg) or current pharmacological treatment.

All clinical measurements were standardized; anthropometry, BP readings, blood lipid and glucose, and common carotid artery ultrasonography were carried out in one single clinical visit, as previously published [11].

Statistical analysis

Statistical processing addressed the nonequal probability character of the sample and the structure of the design to generate data adjusted for the age and sex distribution of the population of each city. Weighted means and prevalence along with their 95% CIs were estimated by survey analysis procedures (SAS Software, Release 9.1, Cary, North Carolina, USA), taking into account the multistage stratified sampling design via CLUSTER and STRATA statements. SBP, DBP, and pulse pressure (PP) levels along with prevalence of hypertension were analyzed. Generalized analysis of variance (ANOVA) models were used for city, age, and sex group comparisons. Sex-by-age class and city-by-age class interaction ANOVA models were also performed. Trend tests for age class were reported. Furthermore, prevalence of stratification of cardiovascular risk, according to ESH/ESC 2007 guidelines, and prevalence of levels of assessment, awareness, treatment, and control of hypertension by city were also assessed. A two-way ANOVA by city and age class for men and women groups, respectively, was also performed on SBP, DBP, and PP values. P values less than 0.05 were considered significant.

Results

A total of 11 550 participants between the ages of 25 and 64 years were enrolled in CARMELA. Subgroups of participants were evaluated based on stratification by sex and age group (25–34, 35–44, 45–54, and 55–64 years). Number of participants per cities, sex and age distribution, and general characteristics of sample are shown in Table 1. Other cardiovascular risk factors are reported elsewhere [11].

Blood pressure distribution

Weighted means (95%CI) for SBP, DBP, and PP are shown in Tables 2–4, respectively, for each city and for the whole participants according to sex and age groups. Men tended to have higher SBP and DBP than women (both P value <0.0001). Overall, mean SBP and DBP were 116.1 mmHg (95%CI 115.7–116.6) and 75.8 mmHg (95%CI 75.5–76.1), respectively. Mean SBP differed by only approximately 10 mmHg across cities as did DBP [SBP range: 113 mmHg (Bogotá) to 123 mmHg (Buenos Aires); DBP range: 72 mmHg (Quito) to 81 mmHg (Buenos Aires), both P value <0.0001]. Mean SBP and DBP values increased with age in both sexes; however, the increase with age was more marked in women than in men. The greatest increases in mean SBP with age were seen in men (21 mmHg) and women (26 mmHg) of Barquisimeto; the smallest increase was in men of Mexico City (12 mmHg) and women of Lima (16 mmHg). SBP and DBP values increased with age in both sexes ($P < 0.0001$); however, the increase with age was more marked in women than in men (i.e., sex-by-age class interaction P value is <0.0001 both for SBP and DBP). The greatest increases in mean DBP with age were seen in men of Lima (10 mmHg) and women of Bogotá and Quito (12 mmHg); the smallest increase was in men of Santiago (5 mmHg) and women of Mexico City (8 mmHg).

PP was on average approximately 40 mmHg for men and women for the whole participants. PP increased with age but higher increment is shown in the participants of 55–64 years of age group. A higher increment is shown in Barquisimeto and lower in Mexico City, both in men and women (Table 4).

Prevalence of hypertension

Across the seven cities, the overall weighted prevalence of hypertension was 16.3% ($P < 0.0001$ for cities and age for men and women; $P < 0.0001$ for trend in age category and sex). Hypertension (Table 5) clustered into high and low prevalence groups: Barquisimeto, Buenos Aires, and Santiago had the highest prevalence of hypertension, whereas Lima, Mexico City, Bogotá, and Quito had a lower prevalence. In all cities, the prevalence of hypertension increased with advancing age; more than 40% of all participants 55–64 years of age were hypertensive ($P < 0.0001$).

Table 1 Numbers of participants, sex and age distribution, and general characteristic in the samples from the seven cities

	Barquisimeto 1848	Bogota 1553	Buenos Aires 1482	Lima 1652	Mexico City 1722	Quito 1638	Santiago 1655	All participants 11550
Men (Women)	713 (38.58%)	738 (47.52%)	734 (49.53%)	769 (46.55%)	833 (48.37%)	813 (49.63%)	783 (47.31%)	5383 (46.60%)
Mean age±SD (years)	45.07 ± 11.30	45.14±11.33	44.56±11.66	43.64±11.56	44.52±11.26	44.41±11.20	44.77±11.20	44.59 ± 11.36
Mean height in meters (95% CI)	1.6 (1.60–1.61)	1.59 (1.58–1.60)	1.65 (1.65–1.66)	1.59 (1.59–1.60)	1.62 (1.62–1.63)	1.59 (1.58–1.60)	1.63 (1.62–1.63)	1.61 (1.61–1.62)
Mean weight in kg (95% CI)	69.6 (68.3–70.8)	66.7 (65.8–67.6)	72.3 (71.4–73.2)	69.1 (68.2–70.0)	74.5 (73.4–75.6)	66.7 (65.9–67.5)	73.6 (73.0–74.3)	70.8 (70.2–71.3)
Mean BMI (kg/m²) (95% CI)	27 (26.5–27.4)	26.3 (26.1–26.5)	26.3 (26.0–26.6)	27.1 (26.8–27.4)	28.2 (27.9–28.5)	26.3 (25.9–26.6)	27.8 (27.5–28.0)	27.1 (27.0–27.3)
Mean SBP (mmHg) (95% CI)	120.8 (119.8–121.8)	112.5 (111.7–113.3)	122.9 (121.9–123.9)	116 (115.2–116.9)	115.4 (114.8–116.1)	113.4 (112.5–114.2)	117.8 (116.8–118.9)	116.1 (115.7–116.6)
Mean DBP (mmHg) (95% CI)	75.8 (74.9–76.7)	74.5 (73.9–75.1)	81.1 (80.4–81.8)	72.1 (71.6–72.7)	77.3 (76.8–77.9)	71.6 (71.0–72.2)	78 (77.4–78.7)	75.8 (75.5–76.1)
Mean pulse pressure (95% CI)	45 (44.3–45.6)	38 (37.5–38.6)	41.8 (41.2–42.3)	43.9 (43.2–44.5)	38.1 (37.6–38.6)	41.8 (41.3–42.2)	39.8 (39.2–40.4)	40.3 (40.0–40.7)
Mean heart rate (95% CI)	69.7 (69.2–70.2)	73 (72.4–73.7)	71.3 (70.8–71.9)	70.1 (69.8–70.5)	71 (70.5–71.5)	72 (71.7–72.3)	68.5 (68.1–69.0)	70.9 (70.6–71.1)

CI, confidence interval.

Table 2　Weighted mean systolic blood pressure (95% confidence interval) in mmHg, by age, sex, and city

Age (years)	Barquisimeto	Bogota	Buenos Aires	Lima	Mexico City	Quito	Santiago	All participants
Men (overall)	123.5 (122.0–124.9)	114 (113.0–115.0)	127.2 (126.1–128.4)	118.4 (117.4–119.5)	115.7 (114.9–116.4)	114.5 (113.5–115.5)	121.1 (119.8–122.4)	118.1 (117.6–118.7)
25–34	117.8 (115.4–120.3)	110.4 (108.6–112.1)	121.6 (120.2–123.0)	113.6 (112.0–115.2)	112.5 (111.6–113.5)	110.4 (109.1–111.7)	115.7 (114.1–117.3)	113.7 (113.0–114.4)
35–44	122.5 (120.3–124.8)	111.7 (110.1–113.4)	123.1 (121.0–125.3)	116.5 (114.4–118.6)	114.7 (113.4–116.0)	113 (111.5–114.5)	119.6 (117.0–122.1)	116.2 (115.3–117.1)
45–54	128.7 (125.4–132.0)	117.8 (115.9–119.8)	131.6 (128.9–134.3)	121.3 (119.3–123.3)	118.2 (116.8–119.7)	119 (117.0–121.0)	123.6 (121.2–126.0)	121.5 (120.6–122.5)
55–64	138.3 (134.2–142.4)	123.6 (120.8–126.3)	137.4 (135.1–139.7)	130.3 (127.4–133.2)	124.3 (121.9–126.7)	123.8 (121.1–126.5)	133.3 (129.8–136.8)	129.2 (127.9–130.6)
Women (overall)	119 (117.9–120.2)	111.4 (110.3–112.5)	119.2 (117.9–120.5)	113.7 (112.5–114.9)	115.2 (114.3–116.1)	112.3 (111.3–113.2)	114.9 (113.4–116.3)	114.3 (113.8–114.9)
25–34	110.7 (108.8–112.5)	104.1 (103.0–105.2)	112.2 (110.5–113.8)	107.3 (105.8–108.8)	109.9 (108.7–111.2)	105.6 (104.7–106.5)	106.6 (104.7–108.5)	107.5 (106.8–108.2)
35–44	116.1 (114.4–117.8)	108.5 (107.1–109.9)	116.1 (114.0–118.1)	110.5 (108.4–112.6)	114.5 (113.2–115.8)	110.3 (108.9–111.7)	111.8 (109.5–114.0)	111.7 (110.9–112.6)
45–54	127.2 (124.8–129.6)	118.4 (116.4–120.4)	120.2 (117.8–122.6)	119.8 (117.8–121.8)	118.6 (117.4–119.7)	119.3 (117.4–121.1)	119.2 (116.8–121.6)	119.4 (118.5–120.2)
55–64	137 (134.4–139.6)	128 (125.7–130.4)	131.2 (128.5–134.0)	127.6 (124.8–130.4)	126.1 (124.3–128.0)	127.2 (124.4–130.0)	131.6 (128.6–134.6)	128.9 (127.8–130.0)

Analysis of variance (ANOVA) P values less than 0.0001 for both city and age category in men and women. P value for trend in age categories less than 0.0001 in men and women.

Table 3　Weighted mean diastolic blood pressure (95% confidence interval) in mmHg, by age, sex, and city

Age (years)	Barquisimeto	Bogota	Buenos Aires	Lima	Mexico City	Quito	Santiago	All participants
Men	78.5 (77.2–79.7)	76.2 (75.3–77.2)	84.2 (83.3–85.0)	73.9 (73.1–74.8)	78.1 (77.7–78.6)	72.7 (71.8–73.5)	81.2 (80.4–82.0)	77.7 (77.3–78.1)
25–34	75 (73.0–76.9)	74.2 (72.7–75.8)	79.4 (78.0–80.7)	71 (69.6–72.4)	76.3 (75.4–77.3)	69.7 (68.5–71.0)	78.1 (76.8–79.5)	74.9 (74.2–75.5)
35–44	79.5 (77.5–81.5)	75.4 (73.9–77.0)	83.3 (81.6–85.1)	74 (72.4–75.6)	77.6 (76.6–78.6)	72.2 (71.1–73.4)	81.5 (79.8–83.3)	77.4 (76.7–78.1)
45–54	82.6 (80.6–84.6)	78.3 (76.8–79.7)	88 (86.0–89.9)	76.2 (74.6–77.7)	80.1 (78.9–81.2)	75.9 (74.6–77.2)	83.8 (82.2–85.4)	80.3 (79.6–81.0)
55–64	81.9 (79.7–84.1)	80.6 (79.0–82.2)	89 (87.3–90.7)	78.2 (76.3–80.1)	82.3 (80.8–83.8)	77.7 (76.1–79.2)	83.9 82.2–85.7)	82 (81.2–82.8)
Women	74 (73.0–75.1)	73.1 (72.4–73.8)	78.5 (77.7–79.3)	70.4 (69.6–71.1)	76.6 (76.0–77.3)	70.5 (69.9–71.1)	75.1 (74.2–76.0)	74.2 (73.7–74.6)
25–34	69.6 (67.7–71.5)	68.9 (67.7–70.0)	74.6 (73.5–75.7)	66.5 (65.4–67.6)	74 (73.1–75.0)	66.4 (65.5–67.3)	69.9 (68.4–71.4)	70.1 (69.5–70.8)
35–44	74.2 (72.7–75.8)	71.3 (70.3–72.4)	78.1 (76.7–79.6)	69.5 (68.0–71.0)	76.2 (75.2–77.3)	69.8 (68.9–70.6)	75 (73.5–76.5)	73.3 (72.7–74.0)
45–54	78.2 (76.6–79.9)	78.4 (77.2–79.6)	78.8 (77.2–80.5)	74.5 (73.1–75.9)	78.5 (77.5–79.5)	75.1 (73.9–76.3)	78.3 (76.8–79.8)	77.6 (77.0–78.2)
55–64	78.9 (77.3–80.6)	80.9 (79.4–82.5)	84 (82.4–85.5)	76.4 (74.6–78.2)	81.8 (80.6–82.9)	78.4 (76.7–80.1)	81.3 (79.9–82.7)	80.6 (79.9–81.2)

Analysis of variance (ANOVA) P values less than 0.0001 for both city and age category in men and women. P value for trend in age categories less than 0.0001 in men and women.

Table 6 (*continued*)

	Treated	Optimal BP	Normal BP	High normal BP	Grade 1 hypertension	Grade 2 hypertension	Grade 3 hypertension	Total
All participants								
No other risk factor	0.12	6.65	1.65	0.41	0.30	0.05	0.01	9.19
1–2 risk factors	2.03	34.68	12.53	3.64	2.25	0.48	0.16	55.78
3 or more risk factors, or MS, or OD, or diabetes	4.40	10.33	5.65	5.80	3.73	1.06	0.30	31.27
Established CV disease (MI, stroke, or angina)	1.10	1.40	0.65	0.22	0.24	0.13	0.02	3.76
Total	7.65	53.07	20.48	10.07	6.51	1.71	0.50	100.00

OD: subclinic organ damage measured only by carotid wall thickening [intima−media thickness (IMT) >0.9 mm] or plaque. MS: metabolic syndrome defined by European Society of Hypertension and European Society of Cardiology (ESH/ESC) guidelines. Established cardiovascular disease explored by past personal medical history. General association *P* value for each single city and between-cities heterogeneity all <0.0001. BP, blood pressure; CV, cardiovascular; MI, myocardial infarction.

Isolated systolic hypertension in nontreated participants represented 16.8% of the overall hypertensive participants. The highest proportion was observed in Lima (34.8%), followed by Quito (25.8%), Barquisimeto (24.6%), Buenos Aires (12.2%), Santiago (12%), Bogota (8.7%) and Mexico City (8.6%); between city heterogeneity *P* value <0.0001.

Participants from Quito and Bogota were most likely to have optimal and normal BP. High normal BP was widely evident in each city, with higher prevalence in Mexico City and Buenos Aires followed by Santiago, Barquisimeto, Lima, Bogota, and Quito. Ten percent of all participants have high normal BP (Table 6).

The proportion of patients at risk of each city (those with treated or untreated hypertension or high normal BP) varied considerably: 44.2% in Buenos Aires, 34.4% in Barquisimeto, 33.4% in Santiago, 26.3% in Mexico City, 21.6% in Bogota, 21.4% in Lima, and 13.4% in Quito; in all the participants 26.8%.

Total cardiovascular risk

Table 6 shows stratification of cardiovascular risk in CARMELA participants at different BP levels. Of all the participants, 9.19% have no other risk factor apart from hypertension; at the same time, 55.78% have one or two risk factors; 31.27% have three or more risk factors, or metabolic syndrome or diabetes or organ damage measured by carotid wall thickening [intima−media thickness (IMT) >0.9 or plaque]; 3.76% have established cardiovascular disease (MI, stroke, or angina). Average risk is present in 8.84% of all participants; low added risk in 53.18%; moderate added risk 23.15%; and high or very high added risk in 14.83% according to ESH/ESC guidelines. Santiago, Barquisimeto, and Buenos Aires have high prevalence of high or very high added risk (17.93; 17.91, and 17.79%, respectively); at the same time, Quito, Bogota, Mexico City, and Lima have the lowest (11.05, 12.62, 13.96, and 14.56%, respectively).

Awareness, treatment, and control of hypertension

Table 7 shows levels of assessment, awareness, treatment, and control of hypertension, for each city and all participants. BP is reported to be measured ever in approximately 90% of participants in the study; the higher value was in Buenos Aires and Mexico City (97.5%) and the lower in Lima (73.4%). Prior diagnosis of hypertension had a weighted prevalence of 64.4% for all participants; the higher values for Mexico City (75.7%) and lower for Lima (53.1%). Treated and controlled hypertension defined as BP less than 140/90 mmHg had a weighted prevalence of 24%, ranging from 12.0% (8.4–15.7%) for Lima to 41.0% (36.2–45.8%) for Mexico City.

Table 7 Weighted prevalence of levels of assessment, awareness, treatment, and control of hypertension

	Barquisimeto	Bogota	Buenos Aires	Lima	Mexico City	Quito	Santiago	All participants
Percentage of overall population								
Blood pressure ever measured	95.6 (94.4–96.8)	93.3 (91.2–95.4)	97.5 (96.5–98.4)	73.4 (70.3–76.6)	97.5 (96.3–98.6)	87.9 (85.5–90.4)	88.7 (86.7–90.7)	89.5 (88.3–90.8)
Percentage of population with hypertension[a] (n = 2631)								
Prior diagnosis[b]	72.0 (67.8–76.2)	68.8 (62.2–75.5)	64.1 (59.9–68.2)	53.1 (46.5–59.6)	75.7 (70.1–81.2)	67.6 (60.2–74.9)	60.1 (55.4–64.7)	64.4 (62.0–66.9)
Unknown hypertension[c]	28.0 (23.7–32.2)	31.2 (24.5–37.8)	35.9 (31.8–40.1)	46.9 (40.4–53.5)	24.3 (18.8–29.9)	32.4 (25.1–39.8)	39.9 (35.3–44.6)	34.3 (31.9–36.8)
Treated and controlled[d]	20.7 (17.4–24.0)	30.6 (25.8–25.5)	18.0 (14.8–21.2)	12.0 (8.4–15.7)	41.0 (36.2–45.8)	28.0 (19.9–36.1)	20.3 (16.4–24.2)	24.0 (21.8–26.1)

All prevalence at issue showed a between-cities heterogeneity $P < 0.0001$. CARMELA, the Cardiovascular Risk Factor Multiple Evaluation in Latin America. [a] Blood pressure $\geq 140/90$ mmHg or receiving pharmacologic treatment for hypertension. [b] Individuals reporting they had been told they were hypertensive. [c] Individuals first diagnosed with hypertension at the time of the CARMELA assessment. [d] Treated and controlled defined as blood pressure $<140/90$ mmHg.

Discussion

As expected, SBP and DBP increased with age for all participants and the same pattern is shown for each city; however, variability among cities was present. Men had higher SBP and DBP. PP increased according to age and increment was higher in the upper age group.

CARMELA study like most epidemiological studies [12–14] defined hypertension in patients with BP at least 140/90 mmHg or current antihypertensive pharmacological treatment in one single visit to clinic, and BP was taken in sitting position in two or more occasions following standardized procedure.

The overall weighted prevalence of hypertension in the seven cities was 16.3%; unfortunately, due to an oversight during the editing of the manuscript, the CARMELA main paper published in the *American Journal of Medicine* [11] reported an overall prevalence (i.e., for all cities) of 18% instead of 16.3%.

Within the urban Latin American cities studied, the prevalence of hypertension varied, with more than triple the prevalence in Buenos Aires (29%) than in Quito (9%). Three cities, Buenos Aires, Barquisimeto, and Santiago, had prevalence rates of hypertension that approximated worldwide prevalence [2]. As in developed countries [1], the prevalence of hypertension in both sexes increased with increasing age in CARMELA. Overall, at least one-third of participants 55–64 years of age were hypertensive. High normal BP was also noted in about 10.5% of CARMELA participants, comparable to rates in the United States [15]. Including both hypertensive and high normal BP participants, up to half of the population 25–64 years of age in each city, are in need of either pharmacologic treatment or lifestyle changes to prevent morbidity and mortality from cardiovascular disease.

Most previous Latin American studies of hypertension measured BP only once, sometimes in public markets; some were based only on hypertension by history, without clinical or laboratory verification of other risk factors, introducing biases. But some studies are properly designed and allow comparison with the present study.

In urban population of Chile (Concepcion, San Pedro and Chiguayante), of 8472 participants, the prevalence of hypertension was estimated in 21.7% of participants of 15 years of age and more [16]. Prevalence increased with age from 5.1% in the 25–34 years of age group to 51.6% in the 55–64 years of age group; its values were similar to CARMELA results for Santiago (Table 5).

In a large sample of 15 000 participants of 20 years and more in Barquisimeto (BP measured while participants were sitting in their own homes), general prevalence of hypertension was reported in 23.59% (men: 27.75%;

women: 21.39%). Prevalence increased with age and went from 7.97% in participants of 20–29 years of age group to 54.19% in 60–69 years of age group [17]. These results are similar to those of CARMELA study for the same city.

The 11.7% prevalence of hypertension in Mexico City in the CARMELA study is lower than the approximately 19% reported in the Mexico City Diabetes study [14] and in the 2000 National Health Survey in Mexico (26.3%) [18], but similar to the age-group-specific reported prevalence in the Mexico City Diabetes study [19] and slightly less than the 16.9% prevalence reported in Mexican-Americans in the 2003–2004 National Health and Nutrition Examination Survey (NHANES) study [20]. Whereas the prevalence of hypertension was derived from the average of at least two measurements in the CARMELA, NHANES, and the Mexico City Diabetes studies, prevalence in the National Health Survey in Mexico was based on a single measurement only, increasing the likelihood that overestimation contributed to the high prevalence of hypertension in that study.

Despite differences in methodology between studies, the prevalence rates of hypertension in Buenos Aires, Barquisimeto, and Lima reported here are similar to previously reported rates in urban populations in Argentina [13,21], Barquisimeto [17], Chile [16], and Peru [22]. However, the prevalence rate in Bogotá reported here is higher and in Quito lower than those in other reports [22,23].

CARMELA study found that only a small fraction (9.19%) of the population has no other risk factor apart from elevation in BP. In fact, approximately 50–60% of all the participants have one or two risk factors and approximately 25–37% have three or more risk factors, or metabolic syndrome, or diabetes mellitus, or atherosclerotic disease detected by ultrasonography of carotids. The subclinical organ damage used for stratification of risk in CARMELA study was restricted to IMT thickness and presence of plaque in carotid arteries; it was not included in other explorations for detecting cardiac or renal organ damage. This fact might have limited the overall state of risk in the population of the study, but presence of vascular damage detected by ultrasonography has been extensively reported to correlate positively with other cardiac or cerebrovascular damage [24,25]. In the APROS study [26], 1074 untreated individuals with low-to-medium risk essential hypertension were identified on the basis of diagnostic routine procedures, including medical history, physical examination and clinic BP measurement, routine blood chemistry and urine analysis, and electrocardiogram. The extent of risk for the 1074 individuals was reassessed by adding the results of ultrasound examinations of heart and carotid arteries: left ventricular hypertrophy (defined as left ventricular mass index $>120 \, \text{g/m}^2$ in men and $>100 \, \text{g/m}^2$ in women), carotid intima–media thickening (defined as diffuse thickening if $\geq 0.8 \, \text{mm}$), and presence of plaque (defined as focal thickening $>1.3 \, \text{mm}$). Fifty-three percent of patients previously classified as 'low' or 'medium' risks were reclassified as 'high' risk. When the reclassification was based on either cardiac or carotid ultrasound alone, the number reclassified as high risk was reduced by approximately one-third with echocardiography alone and by approximately one-half with carotid ultrasound alone. In the CARMELA study, only carotid ultrasonography was carried out and this is the main limitation for risk evaluation; however, about 14% of CARMELA study participants were classified as high or very high risk and about 31% have three or more risk factors, diabetes, metabolic syndrome, or carotid arterial damage; in the APROS study, 27.4% were classified as high risk with the carotid ultrasound evaluation and it rose to 36.9% with the echocardiography evaluation in hypertensive population; meanwhile, CARMELA was carried out in general population. In the clinical situation, with accessibility of wider resources, the use of ultrasound for evaluation of cardiac and carotid artery as well as renal function tests, in addition to ordinary clinical evaluation, should be included for the appropriate monitoring of risk.

In the Italian study on cardiovascular profile of patients under specialist care, hypertension was the only risk factor in 13.7% of patients and 70% of patients had one or two additional risk factors; about 60% of patients fell into high or very high cardiovascular risk category [27]. However, these two studies are not strictly comparable [26,27] (general population versus specialist clinical care); both indicate the importance of considering total cardiovascular risk either as individual patient or general population. In this sense, total cardiovascular risk in urban population of Latin America is high and has important public health implications for the region, as antihypertensive therapy should form part of a multifactorial approach to prevent cardiovascular morbidity and mortality.

Economic transition, industrialization, and globalization bring about changes that predispose individuals to developing hypertension and other cardiovascular risk factors [28]. Changes in diet and physical activity in developing countries have increased the number of younger individuals with hypertension and cardiovascular disease [2]. Reports from several Latin American studies indicate variable prevalence of undiagnosed and undertreated hypertension [10,12]. In the United States, efforts to increase awareness and control hypertension and other cardiovascular risk factors have decreased mortality from stroke and coronary heart disease by 50–60% since 1950 [29]. Population-based efforts and targeted clinical strategies have been promoted in developed countries to

achieve weight loss, reduce intake of dietary sodium, maintain intake of potassium, increase dietary fiber and plant sources of protein, limit alcohol intake, and increase physical activity in addition to promoting appropriate use of, and compliance with, pharmacologic therapy. Of additional benefit, these measures also target obesity and glucose abnormalities [30,31]. Even simple measures like government regulation of salt content in processed foods can have a great impact on the consequences of hypertension [32]. Indeed, it has been shown that by instituting tobacco control measures along with reducing salt intake, 13.8 million deaths might be averted over a 10-year span at a cost of less than $0.40 (US) per person per year in lower income countries [30]. CARMELA results should encourage the implementation of similar governmental health policy, public health, and educational efforts across Latin America.

Latin American countries have a substantial mixture of ethnic groups, including European, African, and Amerindian; there is large variability from one country to another as well as from region to region in the same country [10]. Thus, CARMELA results should aid investigation of unique environmental or genetic influences in each of its seven cities that might support specifically designed efforts to control hypertension in Latin America. Likewise, newly developed population-wide prediction tools for low-income and middle-income countries should aid in delineating specific populations at cardiovascular risk, so that limited resources can be used to target high-risk individuals appropriately [33]. With CARMELA results in mind, recent comprehensive guidelines for management of hypertension should be adapted to specific local needs [1].

In conclusion, CARMELA findings indicate substantial though varied prevalence of hypertension, high normal BP, and previously undiagnosed hypertension together with other cardiovascular risk factors across seven major Latin American cities. Despite differences in prevalence rates across cities, the prevalence of hypertension generally increased with age, more so in women than men. Awareness and control of hypertension vary importantly across cities but in all are insufficient. Stratification of total cardiovascular risk indicates only small fraction of hypertensive population has BP elevation alone; individuals even with optimal or normal BP have important risk factors. Increased cardiovascular morbidity, mortality, and substantial economic burden will be a consequence of these conditions for Latin America in general, unless clinical and public health efforts intervene.

Acknowledgements

References

1   Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, et al., 2007 Guidelines for the Management of Arterial Hypertension. The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2007; **25**:1105–1187.

2   Kearney P, Whelton M, Reynolds K, Muntner P, Whelton P, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; **365**:217–223.

3   Arredondo A, Zúñiga A. Epidemiologic changes and economic burden of hypertension in Latin America: evidence from Mexico. *Am J Hypertens* 2006; **19**:553–559.

4   Ezzati M, Lopez A, Rodgers A, Vander Hoorn S, Murray C, and the Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. *Lancet* 2002; **360**:1347–1360.

5   Williams B. Recent hypertension trials: implications and controversies. *J Am Coll Cardiol* 2005; **45**:813–827.

6   Periago MR, Lenfant C. A standard method for measuring blood pressure in the Americas. *Rev Panam Salud Publica* 2003; **14**:297.

7   Lanas F, Avezum A, Bautista LE, Diaz R, Luna M, Islam S, Yusuf S, and INTERHEART Investigators in Latin America. Risk factors for acute myocardial infarction in Latin America: the INTERHEART Latin American study. *Circulation* 2007; **115**:1067–1074.

8   Yusuf S, Hawken S, Öunpuu S, Dans T, Avezum A, Lanas F, et al., INTERHEART Study Investigators. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case–control study. *Lancet* 2004; **364**:937–952.

9   Kshirsagar AV, Carpenter M, Bang H, Wyatt SB, Colindres RE. Blood pressure usually considered normal is associated with an elevated risk of cardiovascular disease. *Am J Med* 2006; **119**:133–141.

10 Hernandez-Hernandez R, Armas-Padilla MC, Armas-Hernandez MJ, Velasco M. Hypertension and cardiovascular health in Venezuela and Latin American countries. *J Hum Hypertens* 2000; **14 (Suppl 1)**:S2–S5.

11 Schargrodsky H, Hernandez-Hernandez R, Champagne B, Silva H, Vinueza R, Silva Ayçaguer LC, et al. CARMELA: assessment of cardiovascular risk in seven Latin American cities. *Am J Med* 2008; **121**:58–65.

12 Díaz ME. Hypertension and obesity. *J Hum Hypertens* 2002; **16 (Suppl 1)**:S18–S22.

13 de Sereday M, Gonzalez C, Giorgini D, De Loredo L, Braguinsky J, Cobeñas C, et al. Prevalence of diabetes, obesity, hypertension and hyperlipidemia in the central area of Argentina. *Diabetes Metab* 2004; **30**:335–339.

14 Lorenzo C, Serrano-Rios M, Martinez-Larrad MT, Gabriel R, Williams K, Gonzalez-Villalpando C, et al. Prevalence of hypertension in Hispanic and non-Hispanic white populations. *Hypertension* 2002; **39**:203–208.

15 Muntner P, He J, Roccella EJ, Whelton PK. The impact of JNC-VI guidelines on treatment recommendations in the US population. *Hypertension* 2002; **39**:897–902.

16 Fasce E, Campos I, Ibánez P, Flores M, Zárate H, Román O, Fasce F. Trends in prevalence, awareness, treatment and control of hypertension in urban communities in Chile. *J Hypertens* 2007; **25**:1807–1811.

17 Hernandez-Hernandez R, Chacon-Ramirez R, Hernandez-Faraco A, Aguero RE, Hernández-Faraco G, Armas-Hernandez MJ, et al. Study of the incidence of arterial hypertension in Barquisimeto, Venezuela. *Bol Med Postgrado* 1994; **10**:223–233.

18 Velazquez Monroy O, Rosas Peralta M, Lara Esqueda A, Pastelin Hernandez G, Attie F, Tapia Conyer R. Arterial hypertension in Mexico: results of the National Health Survey 2000. *Arch Cardiol Mex* 2002; **72**:71–84.

19 Rodríguez Saldaña J, Chávez Domínguez R, Marmolejo Henderson R, Reynoso Marenco M. Epidemiology of arterial hypertension in Mexico. Historical aspects. *Med Interna Mex* 1997; **13**:283–288.

20 Ong KL, Cheung BM, Man YB, Lau CP, Lam KS. Prevalence, awareness, treatment, and control of hypertension among United States adults 1999–2004. *Hypertension* 2007; **49**:69–75.

21 Ciruzzi M, Pramparo P, Rozlosnik J, Zylberstjn H, Delmonte H, Haquim M, *et al.* Hypertension and the risk of acute myocardial infarction in Argentina. The Argentine Factores de Riesgo Coronario en America del Sur (FRICAS) Investigators. *Prev Cardiol* 2001; **4**:57–64.

22 Most Recent National Survey(s) for Chronic, Noncommunicable Disease Risk Factors. WHO Global InfoBase Web site. http://www.who.int/ncd_surveillance/infobase/web/InfoBasePolicyMaker/reports/reportViewer.aspx?UN_Code=170&rptCode=BCP&dm=18 [Accessed 7 April 2007].

23 Cornejo C, Vinueza R, Moscoso F, Calero E, Gonzalez G, Perugachi C, *et al.* Prevalence of arterial hypertension in the urban adult population of Ecuador: Quito, Guayaquil, and Cuenca – the PREHTAE study. *CVD Prev* 2000; **3**:47–58.

24 Bots ML. Carotid intima-media thickness as a surrogate marker for cardiovascular disease in intervention studies. *Curr Med Res Opin* 2006; **22**:2181–2190.

25 Bots ML, Dijk JM, Oren A, Grobbee DE. Carotid intima-media thickness, arterial stiffness and risk of cardiovascular disease: current evidence. *J Hypertens* 2002; **20**:2317–2325.

26 Cuspidi C, Mancia G, Ambrosioni E, Pessina A, Trimarco B, Zanchetti A, APROS Investigators. Left ventricular and carotid structure in untreated, uncomplicated essential hypertension: results from the Assessment Prognostic Risk Observational Survey (APROS). *J Hum Hypertens* 2004; **18**:891–896.

27 Mancia G, Volpe R, Boros S, Ilardi M, Giannattasio C. Cardiovascular risk profile and blood pressure control in Italian hypertensive patients under specialist care. *J Hypertens* 2004; **22**:51–57.

28 Strategic Priorities of the WHO Cardiovascular Disease Programme. World Health Organization Web site. http://www.who.int/cardiovascular_diseases/priorities/en/ [Accessed 9 February 2007].

29 Centers for Disease Control and Prevention. Achievements in public health, 1900–1999: decline in deaths from heart disease and stroke – United States, 1900–1999. *MMWR Morb Mortal Wkly Rep* 1999; 48:649–656. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4830a1.htm. Updated 2 May 2001 [Accessed 27 October 2007].

30 Asaria P, Chisholm D, Mathers C, Ezzati M, Beaglehole R. Chronic disease prevention: health effects and financial costs of strategies to reduce salt intake and control tobacco use. *Lancet* 2007; **370**:2044–2053.

31 Khan NA, McAlister FA, Rabkin SW, Padwal R, Feldman RD, Campbell NR, *et al.*, Canadian Hypertension Education Program. The 2006 Canadian Hypertension Education Program recommendations for the management of hypertension: Part II – Therapy. *Can J Cardiol* 2006; **22**:583–593.

32 Murray CJ, Lauer JA, Hutubessy RC, Niessen L, Tomijima N, Rodgers A, *et al.* Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. *Lancet* 2003; **361**:717–725.

33 Mendis S, Lindholm LH, Mancia G, Whitworth J, Alderman M, Lim S, Heagerty T. World Health Organization (WHO) and International Society of Hypertension (ISH) risk prediction charts: assessment of cardiovascular risk for prevention and control of cardiovascular disease in low and middle-income countries. *J Hypertens* 2007; **25**:1578–1582.