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Prevalence, Treatment, and Control Rates of Conventional and Ambulatory Hypertension Across 10 Populations in 3 Continents

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Disclosures
None.

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Abstract

Hypertension is a major global health problem, but prevalence rates vary widely among regions. To determine prevalence, treatment, and control rates of hypertension, we measured conventional blood pressure (BP) and 24-hour ambulatory BP in 6546 subjects, aged 40 to 79 years, recruited from 10 community-dwelling cohorts on 3 continents. We determined how between-cohort differences in risk factors and socioeconomic factors influence hypertension rates. The overall prevalence was 49.3% (range between cohorts, 40.0%–86.8%) for conventional hypertension (conventional BP \geq 140/90 mm Hg) and 48.7% (35.2%–66.5%) for ambulatory hypertension (ambulatory BP \geq 130/80 mm Hg). Treatment and control rates for conventional hypertension were 48.0% (33.5%–74.1%) and 38.6% (10.1%–55.3%) respectively. The corresponding rates for ambulatory hypertension were 48.6% (30.5%–71.9%) and 45.6% (18.6%–64.2%). Among 1677 untreated subjects with conventional hypertension, 35.7% had white coat hypertension (23.5%–56.2%). Masked hypertension (conventional BP $<$ 140/90 mm Hg and ambulatory BP \geq 130/80 mm Hg) occurred in 16.9% (8.8%–30.5%) of 3320 untreated subjects who were normotensive on conventional measurement. Exclusion of participants with diabetes mellitus, obesity, hypercholesterolemia, or history of cardiovascular complications resulted in a $<$ 9% reduction in the conventional and 24-hour ambulatory hypertension rates. Higher social and economic development, measured by the Human Development Index, was associated with lower rates of conventional and ambulatory hypertension. In conclusion, high rates of hypertension in all cohorts examined demonstrate the need for improvements in prevention, treatment, and control. Strategies for the management of hypertension should continue to not only focus on preventable and modifiable risk factors but also consider societal issues.

Keywords

blood pressure; diabetes mellitus; hypertension; prevalence; special populations

Hypertension, a noncommunicable disease, is a major risk factor for cardiovascular disease.¹ According to the Global Burden of Disease, heart disease was the leading cause of death in 2010, responsible for \approx 232 million disability-adjusted life years worldwide.² The number of cardiovascular deaths is expected to double by 2030.³ The global cost of cardiovascular diseases was US\$863 billion in 2010 and \approx 45% of the total cost is because of loss of productivity from disability or premature death, or loss of work time because of illness or the need to seek care.⁴ Consequently, many studies have concluded that reducing

cardiovascular risk on a global basis, through control of hypertension, is critical to world health.⁵

Prevalence rates of hypertension are usually based on the conventional blood pressure (BP). This excludes a substantial number of individuals who have masked hypertension that has been shown to confer cardiovascular risk similar to that of sustained hypertension.⁶ However, prevalence rates based on the conventional BP include a considerable number of subjects with white coat hypertension. Recently, we showed that cardiovascular risk in most subjects with white coat hypertension is comparable to that of age- and risk-matched normotensive subjects.⁷

The main goal of this study was to compare prevalence, treatment, and control rates of conventional and ambulatory hypertension among cohorts of the International Database on Ambulatory blood pressure monitoring in relation to Cardiovascular Outcomes (IDACO). However, as efforts to control hypertension have also focused on reducing the prevalence of cardiovascular risk factors⁸ and hypertension rates vary among regions, probably because demographic, social, and economic differences influence lifestyle and risk factors,^{9,10} we determined how differences in modifiable risk factors among countries influence hypertension rates. To assess the influence of socioeconomic factors, we used the Human Development Index (HDI), a statistic developed by the United Nations.^{11,12} This strategy might inform the prioritization of allocation of resources for hypertension prevention in different countries, considering traditional risk factors and socioeconomic factors.

Methods

Study Population

The IDACO database¹³ currently includes 12 725 participants, representing 12 randomly recruited population cohorts.^{14–22} Studies qualified for inclusion if they involved a random population sample, if baseline information was available on the conventional and ambulatory BPs and cardiovascular risk factors, and if subsequent follow-up included both fatal and nonfatal outcomes. All studies received ethical approval, and participants gave written informed consent.

Because disregarding treated subjects and women could affect our results, we excluded 2 IDACO cohorts as they did not include subjects taking antihypertensive drugs (n=981)²³ or recruited only 70-year-old men (n=1143).¹⁷ Because the age range largely differed among cohorts and the prevalence rates of hypertension strongly depend on age, we selected 7843 subjects aged 40 to 80 years, an age range that was covered by all the cohorts. In addition, we applied the following exclusion criteria: (1) conventional BP unavailable (n=208), (2) nighttime BP not recorded (n=598),¹⁶ and (3) ambulatory BP recordings including <10 daytime readings (n=95) or <5 nighttime readings (n=396).¹³ Thus, the number of subjects included in our analyses was 6546.

BP Measurement

Trained observers measured the conventional BP with a manual mercury sphygmomanometer^{14,16,19–21}, an automated device based on the Korotkoff sound technique

(USM-700F; UEDA Electronic Works, Tokyo, Japan),¹⁵ or automated oscillometric devices (OMRON HEM-705CP, Omron Healthcare, Kyoto, Japan and Dinamap 8100, Critikon Inc, Tampa, FL),^{18,22} using the appropriate cuff size, with the subjects in the sitting position. Conventional BP was the average of 2^{14–21} or 3²² consecutive readings obtained either at the participants' homes^{16,18–21} or at an examination center.^{14,15,22} Terminal digit preference was limited, suggesting accurate BP measurements (Table S1 in the online-only Data Supplement).

We programmed portable monitors to obtain ambulatory BP readings at 30-minute intervals throughout the entire day or at intervals ranging from 15 to 30 minutes during daytime and from 20 to 45 minutes at night (Table S2). The monitors used an oscillometric technique (SpaceLabs 90202 and 90207; SpaceLabs Inc, Redmond, WA) in Noorderkempen,¹⁶ EPOGH (European Project on Genes in Hypertension),^{20,21} Montevideo,¹⁸ Maracaibo,²² and JingNing.¹⁹ Takeda TM-2421 recorders (A&D, Tokyo, Japan) and the ABPM-630 devices (Nippon Colin, Komaki, Japan), used in Copenhagen¹⁴ and Ohasama,¹⁵ respectively, implemented both oscillometric and auscultatory techniques, but we analyzed only the oscillometric data. An SAS macro was used to process all ambulatory recordings that remained unedited. Only the Ohasama recordings were sparsely edited according to previously published criteria.²⁴ Within-subject means of the ambulatory BP were weighted by the time interval between successive readings.

Cross-Classification Based on Conventional and Ambulatory BPs

Conventional hypertension was a BP of ≥ 140 mm Hg systolic or ≥ 90 mm Hg diastolic or use of antihypertensive drugs.²⁵ Ambulatory hypertension was a 24-hour ambulatory BP ≥ 130 mm Hg systolic or ≥ 80 mm Hg diastolic or use of antihypertensive drugs²⁵; for the daytime BP, these thresholds were 135 and 85 mm Hg, and for the nighttime BP, these thresholds were 120 and 70 mm Hg, respectively. When systolic BP and diastolic BP fell in different categories (ie, normotensive versus hypertensive), we considered the participant as hypertensive. We cross-classified untreated subjects based on their conventional and 24-hour ambulatory BPs into sustained normotensives, sustained hypertensives, white coat hypertensives, and masked hypertensives. Sustained normotension and sustained hypertension were consistently normal or elevated BP on both conventional and ambulatory measurements. White coat hypertension was conventional hypertension in the presence of a normal ambulatory BP. Masked hypertension was ambulatory hypertension in participants with a normal untreated conventional BP.

Other Clinical Data

We used questionnaires administered at enrollment to each participant to obtain information on medical history and smoking and drinking habits. Body mass index was body weight in kilograms divided by height in meters squared. We measured serum cholesterol and blood glucose by automated enzymatic methods. Diabetes mellitus was the use of antidiabetic drugs, a fasting glucose of ≥ 7.0 mmol/L, a random glucose of ≥ 11.1 mmol/L, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records.

Definition of Cardiovascular Risk Factors

We identified the following cardiovascular risk factors, based on the European Society of Hypertension and the European Society of Cardiology guidelines²⁵: (1) obesity, defined as body mass index ≥ 30 kg/m², (2) diabetes mellitus, (3) current smoking, (4) dyslipidemia, defined as total cholesterol ≥ 6.2 mmol/L, and (5) history of cardiovascular complications.

We used the inequality-adjusted HDI at the time of recruitment to rate the social and economic developments of a country.¹² The HDI summarizes the average achievement in 3 key dimensions of human development: a long and healthy life, access to knowledge, and a decent standard of living. The HDI measures longevity by life expectancy at birth. Access to knowledge is rated by a combination of mean years of schooling and the expected years of schooling. Standard of living is based on the gross national income per capita. The HDI ranks all countries on a scale from 0 to 1, with higher scores indicating greater human development.

Statistical Analyses

We used SAS software, version 9.4 (SAS Institute, Cary, NC), for database management and statistical analyses. Among-cohort comparisons of means and proportions were tested using ANOVA and Fischer exact test, respectively. After stratification for cohort and sex, we interpolated missing values of body mass index (n=3) and total serum cholesterol (n=86) from their regression slope on age. For each cohort, we calculated prevalence, treatment, and control rates of hypertension in all subjects combined and separately in men and women and in 2 age groups (middle age 40–59 years and older age 60–79 years). We calculated crude rates and rates standardized to sex and age by the direct method. We computed 95% confidence intervals of rates as $R \pm 1.96 \times (R/N)$, where R and N are the rate and the number of individuals used to calculate the rate. To determine the influence of the various risk factors, we calculated prevalence rates in each cohort, first including all participants, then excluding participants with 1 risk factors. We compared hypertension prevalence rates in subjects with and without risk factors using logistic regression analysis stratified for cohort. We assessed the association between the prevalence rates of hypertension and the HDI using meta-regression analysis with cohort entered as a random-effect.

Results

Characteristics of Participants

The total number of subjects included in our analyses was 6546: 2142 from Copenhagen, Denmark (enrollment 1993–1997)¹⁴; 1275 from Ohasama, Japan (1988–1994)¹⁵; 943 from Noorderkempen, Belgium (1985–2008)¹⁶; 962 from Montevideo, Uruguay (1995–1998)¹⁸; 189 from the JingNing county, China (2003–2004)¹⁹; 115 from Novosibirsk, Russia (1999–2001)²⁰; 76 from Pilsen, Czech Republic (2000–2001)²¹; 161 from Padua, Italy (1999–2001)²¹; 139 from Kraków, Poland (1999–2000)²¹; and 544 from Maracaibo,²² Venezuela (1998–2007). Participants recruited in Kraków, Novosibirsk, Pilsen, and Padova took part in the EPOGH.²¹

Overall, the 10 cohorts included 2936 (44.9%) women, 1879 (28.8%) smokers, 577 (8.8%) diabetic patients, 1051 (16.1%) obese subjects, 5040 (77.0%) participants with dyslipidemia, and 539 (8.2%) patients with previous cardiovascular disease (Table S3). Mean age (\pm SD) was 57.8 ± 10.2 years. Conventional systolic and diastolic BPs averaged 134.9 ± 23.6 and 81.1 ± 12.1 mm Hg, respectively. The corresponding values for the 24-hour ambulatory systolic and diastolic BPs were 125.2 ± 13.9 and 74.6 ± 8.7 mm Hg, respectively.

Prevalence, Treatment, and Control Rates of Conventional Hypertension

In the total study population, 3226 of the 6546 participants (49.3%) had conventional hypertension (Table 1). Prevalence rates were consistently higher in older subjects (60–79 years) than in middle-aged participants (40–59 years; Table S4). In Copenhagen, Ohasama, Montevideo, and Maracaibo, conventional hypertension tended to be more prevalent in men than in women, whereas opposite tendencies were observed in Noorderkempen, EPOGH, and JingNing. The sex- and age-standardized prevalence rates of conventional hypertension ranged from 43.0% in Copenhagen to 84.7% in Maracaibo.

Of the 3226 hypertensive subjects in the total study population, 1549 (48.0%) received antihypertensive treatment. Treatment rates ranged from 33.5% in Copenhagen to 74.1% in Ohasama (Table 2; Figure S1). Conventional BP was controlled in 598 (38.6%) of the treated hypertensive participants. Control rates varied from 10.1% in Maracaibo to 55.3% in Ohasama.

Prevalence, Treatment, and Control Rates of Ambulatory Hypertension

The number of participants with 24-hour ambulatory hypertension totaled 3189 (48.7%; Table 1). In each cohort, 24-hour ambulatory hypertension tended to be more prevalent in men than in women and in older subjects than in middle-aged subjects (Table S5). The sex- and age-standardized prevalence rates ranged from 38.9% in Noorderkempen to 64.0% in Maracaibo. Diagnoses of hypertension based on conventional and 24-hour ambulatory BPs were concordant in 82.2% of the participants, ranging from 73.9% in Maracaibo to 85.1% in Ohasama.

Among the participants with ambulatory hypertension, 1549 (48.6%) received antihypertensive treatment. Treatment rates ranged from 30.5% in Copenhagen to 71.9% in Ohasama (Table 2; Figure S2). The ambulatory BP was controlled in 706 (45.6%) of the treated hypertensive participants. Control rates varied from 18.6% in JingNing to 64.2% in Ohasama.

The prevalence, treatment, and control rates for daytime and nighttime hypertension are provided in Tables S6 and S7. Diagnoses of hypertension based on daytime and nighttime ambulatory BPs were concordant in 81.9% of the participants, ranging from 77.9% in Copenhagen to 86.5% in Ohasama.

Prevalence of White Coat, Masked, and Sustained Hypertensions

Of the 3320 untreated subjects who were classified as normotensive based on the conventional BP, 561 (16.9%) had masked hypertension, that is, they were hypertensive

based on the 24-hour ambulatory BP. The prevalence of masked hypertension among conventionally normotensive subjects ranged from 8.8% in Noorderkempen to 30.5% in JingNing. Of the 1677 untreated participants who were classified as hypertensive based on the conventional BP, 598 (35.7%) had white coat hypertension, that is, they were normotensive based on 24-hour ambulatory BP. The prevalence of white coat hypertension among conventionally hypertensive subjects varied from 23.5% in JingNing to 56.2% in Ohasama (Table 3). Of the 4997 untreated subjects, 1079 (21.6%) had sustained hypertension. The Maracaibo cohort reported the highest rate of sustained hypertension with 47.3% whereas Ohasama had the lowest rate (8.0%).

Prevalence of Hypertension in Relation to Risk Factors

Overall, the prevalence of hypertension, defined either by conventional BP or by 24-hour ambulatory monitoring, was significantly higher in diabetics than in nondiabetics, in obese as compared with nonobese subjects, in dyslipidemic compared with normolipidemic participants, and in subjects with a history of cardiovascular disease as compared with those without such history. By contrast, conventional and ambulatory hypertension were less prevalent in smokers than in nonsmokers (Table 4).

Tables 5 and 6 illustrate the impact of the risk factors on the prevalence of conventional and ambulatory hypertension in the general population cohorts. Overall, the prevalence of hypertension tended to decrease when subjects with diabetes mellitus, obesity, hypercholesterolemia, or history of cardiovascular disease were excluded from analysis but tended to increase when smokers were excluded. These tendencies were consistent across cohorts with 2 exceptions: the prevalence rates in the Ohasama cohort tended to decrease when smokers were excluded (from 46.4% to 45.7% for conventional hypertension and from 47.8% to 46.7% for ambulatory hypertension) and the ambulatory hypertension rate in Montevideo remained largely unchanged by exclusion of hypercholesterolemic participants (from 49.0% to 49.3%).

Hypertension Prevalence Rates in Relation to the HDI

Results of random-effects meta-regression analysis showed that the sex- and age-adjusted prevalence rates of both conventional and ambulatory hypertension in different cohorts were inversely related to the HDI (Figure). A 0.1 higher HDI was associated with a 15.7% (95% confidence interval, 1.2–30.3; $P=0.034$) lower prevalence rate of conventional hypertension and a 11.0% (confidence interval, 3.7–18.3; $P=0.003$) lower prevalence rate of ambulatory hypertension. The prevalence of the cardiovascular risk factors was, however, not significantly correlated with HDI.

Discussion

In this study, we examined prevalence, treatment, and control rates of conventional and ambulatory hypertension in 6546 subjects, aged 40 to 79 years, from 10 population-based cohorts in 3 continents. We determined how between-cohort differences in risk factors and socioeconomic aspects influence hypertension rates. Our key findings were that (1) the number of people with hypertension is high in all 10 cohorts, with estimates ranging

from 40.0% to 86.8% for conventional hypertension and from 35.2% to 66.5% for 24-hour ambulatory hypertension; (2) only 33.5% to 74.1% of the subjects with conventional hypertension and 30.5% to 71.9% of the participants with ambulatory hypertension received antihypertensive drugs; (3) of those treated, BP was controlled in 10.1% to 55.3% of the subjects with conventional hypertension and in 18.6% to 64.2% of the participants with ambulatory hypertension; (4) after removing subjects with 1 traditional risk factors, the conventional (30.5%–77.7%) and ambulatory (23.1%–54.4%) hypertension prevalence rates remained high and the risk factors could not explain differences in prevalence rates among cohorts; and (5) the prevalence rates of both conventional and ambulatory hypertension were inversely related to the HDI, a marker for the social and economic developments of a country.

The prevalence of conventional hypertension in the whole IDACO population was 49.3%, which is higher than reported by previous multicountry studies (26.4% and 42.4%).^{5,26} The overall ambulatory prevalence rate of hypertension in our study was 48.7%. Few previous studies reported hypertension rates based on ambulatory BP monitoring. We estimated the overall prevalence of ambulatory hypertension from 3 multicountry studies by adding individuals with sustained and masked hypertension and individuals treated with antihypertensive drugs. The results showed rates of 35.3%,²⁷ 33.4%,²⁸ and 33.3%.²⁹ Our higher rate might be because of the older age of our subjects (40–79 years).

Yusuf et al²⁶ showed that the risk factor burden, as assessed by the INTERHEART risk score (A Study of Risk Factors for First Myocardial Infarction in 52 Countries and Over 27 000 Subjects), is higher in high-income countries than in low-income countries. However, the rates of major cardiovascular disease and death were substantially higher in low-income countries than in high-income countries.²⁶ Similarly, in our study, lower social and economic developments, as assessed by the HDI, were associated with higher prevalence of both conventional and ambulatory hypertension. This could not be attributed to the higher prevalence of cardiovascular risk factors in countries with lower social and economic developments because the HDI was not significantly related to the prevalence of cardiovascular risk factors. In addition, excluding individuals with cardiovascular risk factors did not remove differences in hypertension prevalence rates between cohorts. Thus, socioeconomic factors did explain some of the variation among IDACO cohorts. Populations in developing countries generally have fewer years of education than populations in developed countries,³⁰ and lower education levels have been shown to be correlated with higher rates of hypertension.^{31,32} Unfortunately, we could not assess the relationship between education and hypertension because we did not have that information from all participating cohorts. We expressed that hypertension remains to be a problem worldwide, being associated with developed or developing conditions of regions.

Overall, fewer than half of all hypertensive subjects in this study received treatment and had BP in the normal range, consistent with results of previous studies.³³ Hypertension treatment and control rates varied among IDACO cohorts, but the reasons for this are unclear. Treatment and control rates were not related to socioeconomic measures. Furthermore, previous studies found similar rates of hypertension treatment and control in developed and developing countries.³⁴ The alarming rates of poor treatment and control of hypertension,

highly correlated with morbidity and mortality because of cardiovascular disease,^{35,36} demand immediate and significant changes in public health actions and medical education.³⁷ This reinforces the notion that prevention and adequate treatment of hypertension are urgently needed.³⁸

Among IDACO cohorts, there were large variations in the prevalence of white coat, masked, and sustained hypertension. We consider that this might be because of differences in age, sex ratio, risk factors distributions, and in the methodology and setting for conventional and ambulatory measurements (devices implemented and place where conventional BP was recorded).

Results for the Maracaibo population stood out among the overall results. The highest prevalence of hypertension among IDACO cohorts was found in Maracaibo. This is consistent with findings of the CARMELA study (Cardiovascular Risk Factor Multiple Evaluation in Latin America), where the highest prevalence for men and the second highest for women were in Venezuela, compared with 7 other Latin American countries.³⁹ The Maracaibo cohort had the highest rate of sustained hypertension (47.3% among untreated subjects) compared with the next highest (26.7%) in the IDACO cohorts. Longitudinal studies have shown that subjects with sustained hypertension are at higher risk of cardiovascular mortality than subjects with masked or white coat hypertension.²⁹ The outlying results for Maracaibo can be at least partly attributed to lifestyle. The typical diet in Maracaibo is rich in carbohydrates, salt, and fats.^{40,41} Outdoor recreational activities are scarce, and high temperatures limit the hours in which residents can perform physical activities.⁴² A sedentary lifestyle is prevalent.^{42,43} However, we cannot rule out the possible influence of other factors, such as gene–environment interactions and high levels of violence-related stress, on hypertension rates.

This study had several strengths: the use of multiple cohorts from both developed and developing countries; the population-based design of data collection for all cohorts; the use of both conventional BP measurements and ambulatory BP monitoring; the availability of individual subject data allowing us to assess the relationship between risk factors and the hypertension prevalence rates; and the use of the HDI as a socioeconomic indicator. However, our study also had some limitations. Some cohorts had a small sample size and conventional and ambulatory BP measurements were not standardized among the cohorts although day and night periods were homogeneous.¹³ The conventional BP in our study was the average of 2 readings obtained at a single examination. Participants using antihypertensive drugs were classified as hypertensive. This might have caused an overestimation of our prevalence rates of ambulatory hypertension by the inclusion of white coat hypertensive subjects treated based on their conventional BP. Finally, our data were collected between 1985 and 2008. Hypertension prevalence rates might have changed during this time period.⁴⁴ Unfortunately, the IDACO database does not include follow-up BP measurements preventing us from assessing time trends in hypertension prevalence, treatment, and control rates. Overall, the study provides a large-scale, multinational view of hypertension, treatment, and control.

Perspectives

Hypertension affected almost half of our study population, which represented 12 countries and, therefore, is a major public health problem. Population-specific differences in hypertension rates were at least partly explained by differences in the ages of the participants and differences in socioeconomic conditions. Regional variation in rates of cardiovascular risk factors did not explain differences in hypertension rates among cohorts and were not related to variation in the HDI. However, exclusion of subjects with traditional risk factors from analysis reduced hypertension rates by 8% to 9%, implying that there are other important factors that need to be targeted to reduce hypertension rates at global scale. All cohorts had low rates of treatment and control, indicating that immediate and significant changes are needed in public health actions and medical education.^{37,38} Strategies for reducing rates of hypertension should continue to focus on preventable and modifiable risk factors but should also consider local socioeconomic factors as target for hypertension prevention.

Given that $\approx 23\%$ of the population was affected either by white coat or masked hypertension, cost-effectiveness studies are needed to assess whether implementing 24-hour ambulatory BP monitoring in the detection, diagnosis, and treatment of hypertension in resource-poor settings should be recommended. Without those studies at hand, it seems intuitive to consider that regions with limited resources should focus on identifying people with hypertension who still do not receive treatment and that the treatment provided is able to effectively control high BP. However, in populations where white coat hypertension reaches a third of those with untreated conventional hypertension (eg, Maracaibo) or masked hypertension reaches a third of the conventional normotensive subjects (eg, JingNing) that assumption might be challenged. If ambulatory BP measurement is deemed too costly, home BP monitoring might provide an appropriate and cheap alternative.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Novelty and Significance

What Is New?

- Data on the prevalence of ambulatory hypertension are scarce. We compared prevalence, treatment, and control rates of conventional and ambulatory hypertension among 10 population-based cohorts in 3 continents. We examined how between-cohort differences in risk factors influence hypertension rates. We are the first to assess the impact of socioeconomic factors on conventional and ambulatory hypertension.

What Is Relevant?

- Overall, the prevalence of hypertension was 49.6% for the conventional blood pressure and 48.7% for the ambulatory blood pressure. Less than half of individuals with hypertension received antihypertensive treatment, and of those, less than half had their blood pressure controlled.
- Hypertension risk factors explained $\approx 9\%$ of the total hypertension rates.
- Lower social and economic developments was associated with higher prevalence rates of both conventional and ambulatory hypertension.

Summary

Our study highlights the high prevalence rates of hypertension among all cohorts and the poor treatment and control rates, even when ambulatory blood pressure measurement is used to define hypertension. The impact of traditional risk factors and socioeconomic aspects on the hypertension prevalence rates underscores that strategies for reducing rates of hypertension should continue focusing on preventable and modifiable risk factors but should also consider local socioeconomic factors.

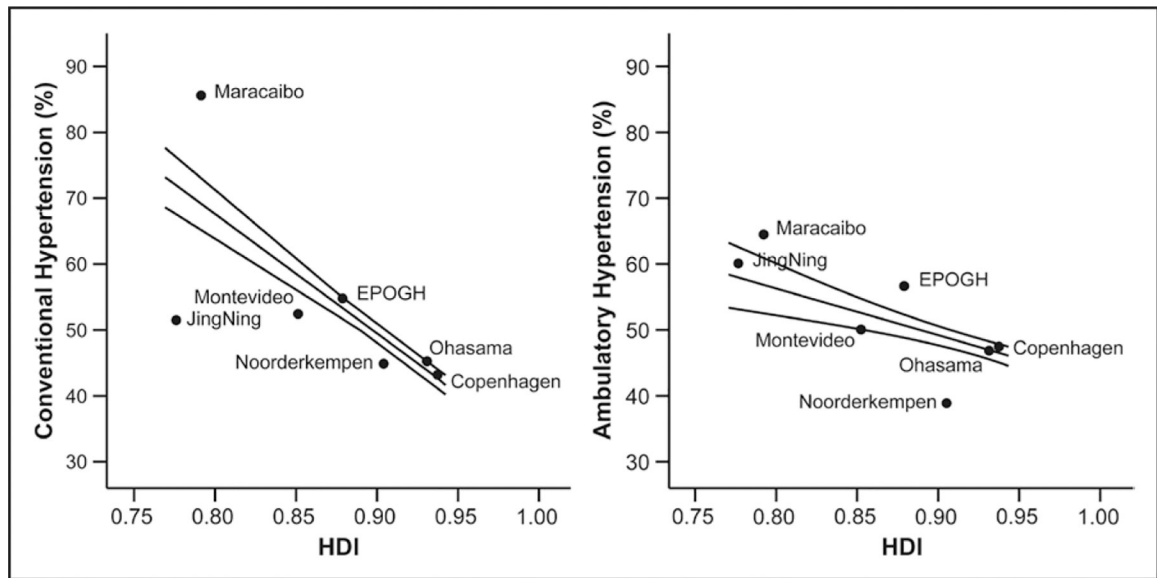


Figure. Meta-regression analysis relating the sex- and age-adjusted prevalence rates of conventional (**left**) and ambulatory (**right**) hypertension to the Human Development Index (HDI). EPOGH indicates European Project on Genes in Hypertension.

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Crude and Sex- and Age-Standardized Prevalence of Conventional and Ambulatory Hypertension by Cohort in 6546 Participants Aged 40 to 80 Years

Table 1.

Cohort	n	Conventional Hypertension			Ambulatory Hypertension		
		Cases	Crude Rate	Standardized Rate*	Cases	Crude Rate	Standardized Rate*
Copenhagen	2142	952	44.4 (42.3–46.5)	43.0 (41.9–44.6)	1045	48.8 (46.7–50.9)	47.3 (46.1–48.9)
Ohasama	1275	591	46.4 (43.6–49.1)	44.9 (42.1–48.0)	609	47.8 (45.0–50.5)	46.9 (44.2–50.1)
Noorderkempen	943	377	40.0 (36.9–43.1)	44.7 (41.6–48.3)	332	35.2 (32.2–38.3)	38.9 (35.8–42.5)
Montevideo	962	488	50.7 (47.6–53.9)	52.2 (49.1–55.6)	471	49.0 (45.8–52.1)	50.0 (46.8–53.4)
JingNing	189	94	49.7 (42.6–56.9)	51.2 (44.4–58.7)	111	58.7 (51.7–65.7)	59.7 (53.0–67.1)
EPOGH	491	252	51.3 (46.9–55.7)	54.5 (46.7–63.2)	259	52.7 (48.3–57.2)	56.4 (48.6–65.1)
Maracaibo	544	472	86.8 (83.9–89.6)	84.7 (80.4–89.4)	362	66.5 (62.6–70.5)	64.0 (58.6–70.0)
All	6546	3226	49.3 (48.1–50.5)	...	3189	48.7 (47.5–49.9)	...

Conventional hypertension was a conventional blood pressure of 140 mm Hg systolic or 90 mm Hg diastolic or use of antihypertensive drugs. Ambulatory hypertension was a 24-hour blood pressure 130 mm Hg systolic or 80 mm Hg diastolic or use of antihypertensive drugs. EPOGH indicates European Project on Genes in Hypertension.

* Rates were standardized to the distribution of sex and age in the whole study population (55.2% women, 53.9% between 40 and 60 years).

Table 2. Treatment and Control Rates of Conventional and Ambulatory Hypertension by Cohort

Cohort	Conventional Hypertension				Ambulatory Hypertension			
	All HT	Treated and Controlled	Treated and Not Controlled	Not Treated	All HT	Treated and Controlled	Treated and Not Controlled	Not Treated
Copenhagen	952	105 (11.0)	214 (22.5)	633 (66.5)	1045	108 (10.3)	211 (20.2)	726 (69.5)
Ohasama	591	242 (40.9)	196 (33.2)	153 (25.9)	609	261 (42.8)	177 (29.1)	171 (28.1)
Noorderkempen	377	98 (26.0)	95 (25.2)	184 (48.8)	332	124 (37.4)	69 (20.8)	139 (41.9)
Montevideo	488	66 (13.5)	162 (33.2)	260 (53.3)	471	73 (15.5)	155 (32.9)	243 (51.6)
JingNing	94	9 (9.6)	34 (36.2)	51 (54.3)	111	8 (7.2)	35 (31.5)	68 (61.3)
EPOGH	252	61 (24.2)	99 (39.3)	92 (36.5)	259	63 (24.3)	97 (37.5)	99 (38.2)
Maracaibo	472	17 (3.6)	151 (32.0)	304 (64.4)	362	69 (19.1)	99 (27.3)	194 (53.6)
All	3226	598 (18.5)	951 (29.5)	1677 (52.0)	3189	706 (22.1)	843 (26.5)	1640 (51.4)

Values are n (percentage). Treatment and control rates were assessed among those with hypertension. Conventional hypertension was a conventional blood pressure 140 mm Hg systolic or 90 mm Hg diastolic or use of antihypertensive drugs. Ambulatory hypertension was a 24-hour systolic blood pressure 130 mm Hg systolic or 80 mm Hg diastolic or use of antihypertensive drugs. EPOGH indicates European Project on Genes in Hypertension; and HT, hypertension.

Table 3.

Prevalence of White Coat and Masked Hypertensions Among 4997 Untreated Participants

Cohort	Conventional Normotension		Conventional Hypertension		Conventional and Ambulatory Hypertension
	All	Masked HT	All	White Coat HT	Sustained HT
Copenhagen	1190	249 (20.9)	633	156 (24.6)	477 (26.2)
Ohasama	684	104 (15.2)	153	86 (56.2)	67 (8.0)
Noorderkempen	566	50 (8.8)	184	95 (51.6)	89 (11.9)
Montevideo	474	74 (15.6)	260	91 (35.0)	169 (23.0)
JingNing	95	29 (30.5)	51	12 (23.5)	39 (26.7)
EPOGH	239	39 (16.3)	92	32 (34.8)	60 (18.1)
Maracaibo	72	16 (22.2)	304	126 (41.4)	178 (47.3)
All	3320	561 (16.9)	1677	598 (35.7)	1079 (21.6)

Values are number of participants (percentage). This analysis included untreated participants only. White coat hypertension was conventional hypertension in the presence of a normal ambulatory blood pressure. Masked hypertension was ambulatory hypertension in participants with a normal conventional blood pressure. Sustained hypertension was hypertension on both conventional and ambulatory measurements. EPOGH indicates European Project on Genes in Hypertension; and HT, hypertension.

Table 4. Odds Ratios of Having Hypertension According to the Presence of Other Cardiovascular Risk Factors

Cardiovascular Risk Factors (0, 1)	Conventional Hypertension		Ambulatory Hypertension	
	Odds Ratio	PValue	Odds Ratio	PValue
Diabetes mellitus	1.95 (1.60–2.36)	<0.0001	2.19 (1.81–2.64)	<0.0001
Obesity	2.59 (2.23–3.01)	<0.0001	2.51 (2.18–2.90)	<0.0001
Dyslipidemia	1.44 (1.29–1.61)	<0.0001	1.34 (1.20–1.49)	<0.0001
Previous cardiovascular disease	3.50 (2.84–4.30)	<0.0001	3.11 (2.54–3.79)	<0.0001
Smoking	0.60 (0.54–0.68)	<0.0001	0.81 (0.72–0.90)	0.0002

Odds ratios (95% confidence interval) are obtained from univariate logistic regression analysis stratified for cohort. Conventional hypertension was a conventional blood pressure ≥ 140 mm Hg systolic or ≥ 90 mm Hg diastolic or use of antihypertensive drugs. Ambulatory hypertension was a 24-hour systolic blood pressure ≥ 130 mm Hg systolic or ≥ 80 mm Hg diastolic or use of antihypertensive drugs. Diabetes mellitus was the use of antidiabetic drugs, a fasting glucose ≥ 7.0 mmol/L, a random glucose ≥ 11.1 mmol/L, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records. Obesity was a body mass index ≥ 30 kg/m². Dyslipidemia was a total cholesterol ≥ 6.2 mmol/L.

Table 5. Prevalence Rates of Conventional Hypertension After Exclusion of Subjects With Risk Factors

Cohort	All Participants	Participants Free of						All Risk Factors
		Smoking	Diabetes Mellitus	Obesity	Cholesterol	6.2 mmol/L	History of CVD	
Copenhagen	952/2142 (44.4)	633/1208 (52.4)	901/2069 (43.5)	732/1812 (40.4)	439/1128 (38.9)	865/2013 (43.0)	186/489 (38.0)	
Ohasama	591/1275 (46.4)	476/1042 (45.7)	472/1052 (44.9)	568/1243 (45.7)	535/1175 (45.5)	534/1209 (44.2)	314/760 (41.3)	
Noorderkempen	377/943 (40.0)	293/678 (43.2)	348/906 (38.4)	282/791 (35.7)	226/608 (37.2)	298/835 (35.7)	98/321 (30.5)	
Montevideo	488/962 (50.7)	412/769 (53.6)	441/887 (49.7)	321/717 (44.8)	292/604 (48.3)	432/881 (49.0)	137/321 (42.7)	
JingNing	94/189 (49.7)	69/128 (53.9)	94/189 (49.7)	91/185 (49.2)	82/170 (48.2)	87/181 (48.1)	52/103 (50.5)	
EPOGH	252/491 (51.3)	196/373 (52.5)	226/453 (49.9)	163/353 (46.2)	171/341 (50.1)	196/407 (48.2)	59/144 (41.0)	
Maracaibo	472/544 (86.8)	405/457 (88.6)	348/410 (84.9)	342/394 (86.8)	378/436 (86.7)	408/480 (85.0)	157/184 (85.3)	
All	3226/6546 (49.3)	2484/4655 (53.4)	2830/5966 (47.4)	2499/5495 (45.5)	2123/4462 (47.6)	2820/6006 (45.7)	1003/2322 (43.2)	

Values are the number of hypertensive participants and the total number of participants not having the corresponding risk factor. The number between brackets is the percentage hypertensive subjects. Diabetes mellitus was the use of antidiabetic drugs, a fasting glucose ≥ 7.0 mmol/L, a random glucose ≥ 11.1 mmol/L, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records. Obesity was a body mass index ≥ 30 kg/m². CVD indicates cardiovascular disease; and EPOGH, European Project on Genes in Hypertension.

Table 6. Prevalence Rates of Ambulatory Hypertension After Exclusion of Subjects With Risk Factors

Cohort	All Participants	Participants Free of						All Risk Factors
		Smoking	Diabetes Mellitus	Obesity	Cholesterol	6.2 mmol/L	History of CVD	
Copenhagen	1045/2142 (48.8)	629/1208 (52.1)	992/2069 (47.9)	812/1812 (44.8)	501/1128 (44.4)	953/2013 (47.3)	201/489 (41.1)	
Ohasama	609/1275 (47.8)	487/1042 (46.7)	487/1052 (46.3)	588/1243 (47.3)	550/1175 (46.8)	552/1209 (45.7)	325/760 (42.8)	
Noorderkempen	332/943 (35.2)	252/678 (37.2)	303/906 (33.4)	238/791 (30.1)	194/608 (31.9)	258/835 (30.9)	74/321 (23.1)	
Montevideo	471/962 (49.0)	390/769 (50.7)	422/887 (47.6)	316/717 (44.1)	298/604 (49.3)	424/881 (48.1)	140/321 (43.6)	
JingNing	111/189 (58.7)	77/128 (60.2)	111/189 (58.7)	107/185 (57.8)	96/170 (56.5)	103/181 (56.9)	56/103 (54.4)	
EPOGH	259/491 (52.7)	200/373 (53.6)	229/453 (50.6)	169/353 (47.9)	176/341 (51.6)	202/407 (49.6)	59/144 (41.0)	
Maracaibo	362/544 (66.5)	309/457 (67.6)	253/410 (61.7)	253/394 (64.2)	286/436 (65.6)	308/480 (64.2)	108/184 (58.7)	
All	3189/6546 (48.7)	2344/4655 (50.4)	2797/5966 (46.9)	2483/5495 (45.2)	2101/4462 (47.1)	2800/6006 (46.6)	963/2322 (41.5)	

Values are the number of hypertensive participants and the total number of participants not having the corresponding risk factor. The number between brackets is the percentage hypertensive subjects. Diabetes mellitus was the use of antidiabetic drugs, a fasting glucose ≥ 7.0 mmol/L, a random glucose ≥ 11.1 mmol/L, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records. Obesity was a body mass index ≥ 30 kg/m². CVD indicates cardiovascular disease; and EPOGH, European Project on Genes in Hypertension.