Marta Sofia Ferreira Pereira

PREVALENCE, AWARENESS, TREATMENT AND CONTROL OF HYPERTENSION:

Systematic review and original results from EPIPorto study

Porto, 2008

Marta Sofia Ferreira Pereira

PREVALENCE, AWARENESS, TREATMENT AND CONTROL OF HYPERTENSION:

Systematic review and original results from EPIPorto study

U.PORTO
FMUP FACULDADE DE MEDICINA
UNIVERSIDADE DO PORTO

Dissertação de candidatura ao grau de Mestre em Epidemiologia apresentada à

Faculdade de Medicina da Universidade do Porto

Porto, 2008

Investigação realizada no Serviço de Higiene e Epidemiologia da Faculdade de Medicina da Universidade do Porto, sob orientação da Professora Doutora Ana Azevedo.

Este trabalho foi efectuado no âmbito de um projecto financiado pela Fundação para a Ciência e a Tecnologia (POCTI/SAU-ESP/61492/2004). Durante a sua realização, a candidata usufruiu de uma bolsa de iniciação à investigação científica no âmbito das actividades da Unidade de Investigação e Desenvolvimento Cardiovascular do Porto (JNICT UI&D 51/94).

Ao abrigo do Art.º 8º do Decreto-Lei n.º 388/70 esta dissertação teve como base dois manuscritos, sendo que colaborei activamente no desenho, recolha, armazenamento e análise da informação, tendo sido responsável pela análise dos dados que reportam, bem como pela versão inicial dos manuscritos:

I. Decreasing gap in prevalence, awareness, treatment and control of hypertension between developing and developed countries. [submetido]

II. Awareness, treatment and control of hypertension in a Portuguese general population – distribution and determinants.

Agradecimentos

À Professora Doutora Ana Azevedo, pela orientação, pelo empenho e pelo rigor científico que a tornam num verdadeiro exemplo a seguir.

Ao Professor Doutor Henrique Barros, por me dar a conhecer o mundo da Epidemiologia e pela confiança que continua a depositar em mim.

Ao Professor Doutor Nuno Lunet, pelo empenho e dedicação no primeiro artigo desta dissertação.

A todos os colegas do Serviço de Higiene e Epidemiologia, pelo companheirismo, profissionalismo, e pela ajuda na recolha e tratamento dos dados.

A todos os colegas de mestrado, pelo carinho especial e por tudo o que partilhamos juntos.

À Professora Doutora Fátima Pina e à Dra. Débora Castiglione pela gentileza na construção dos mapas.

À Barbara e Joana, a companhia diária e ajuda incansável.

Ao Chapouto, pela paciência, amor e carinho.

Aos meus pais, o amor e apoio incondicional.

Ao meu avô, por ter sido um exemplo de vida.

Contents

1. Introduction

Hypertension (HT) is a silent killer because it is deadly and has no early significant symptoms. Approximately 7.1 million deaths per year may be attributable to HT[1]. It is a leading cause of cardiovascular morbidity and mortality and its prevention and appropriate treatment are the key components of the management of this condition[2, 3].

The emergence of chronic diseases epidemiology, and particularly of cardiovascular epidemiology, after World War II, was followed by the development of effective pharmacologic treatments in the 1950s, and their testing in randomized trials starting in the 1960s. Epidemiological research started in 1950 with the Framingham study[4] in the United States of America (USA) and later on, with the multinational Seven Countries Study[5]. The concept of multifactorial origin of coronary heart disease was proposed during the 60s. The fields of HT epidemiology, treatment, and control in populations began to take their modern forms.

Numerous observational studies have demonstrated a powerful association of high blood pressure (BP) with risk for CHD[6, 7]. The relationship between BP and risk of CVD events is continuous, consistent and independent of other risk factors[8]. This association exists for men and women, younger and older people, in all races[9]. Hypertension is also a major risk factor for heart failure[10], peripheral arterial disease[11], stroke[6] and kidney disease[12].

In Portugal the number of individuals in whom HT should be prevented to avoid one case of CHD, according to the Framingham risk prediction models, is 15 among men and 25 among women[13].

Definition and classification of hypertension

The level of BP is rarely the only risk factor for an outcome, but is almost always part of a multifaceted pattern of risk. Nonetheless, practitioners need precise criteria for the diagnosis of HT, even if arbitrary. To consider a BP of 138/88 as normal and not in need of treatment and one of 140/90 as abnormal and in need of treatment is obviously inappropriate, but medical practice requires decisional criteria to be used for workup and therapy.

The conceptual definition of HT incorporates the increased risk for cardiovascular diseases and is based on benefits, risks, costs, death, disability and quality of life.

Table 1. Definition of hypertension according to three different societies.

Guideline definition	2007 ESH/ESC		British Hypertension Society		JNC 7	
Blood Pressure (mm Hg)	**Systolic**	**Diastolic**	**Systolic**	**Diastolic**	**Systolic**	**Diastolic**
Optimal	<120	<80	<120	<80	-	-
Normal	120-129	80-84	<130	<85	<120	<80
High normal	130-139	85-89	130-139	85-89	-	-
Pre-hypertension	-	-	-	-	120-139	80-89
Hypertension						
Grade 1 (mild)	140-159	90-99	140-159	90-99	140-159	90-99
Grade 2 (moderate)	160-179	100-109	160-179	100-109	≥160	≥100
Grade 3 (severe)	≥180	≥110	≥180	≥110	-	-
Isolated systolic hypertension	≥140	<90	-	-	-	-
Grade 1	-	-	140-159	<90	-	-
Grade 2	-	-	≥160	<90	-	-

ESH/ESC – European Society of Hypertension/European Society of Cardiology
JNC – Joint National Committee

Guidelines for treatment of arterial HT were first published in 1977[14], and were regularly updated since then. National and international guidelines have been increasingly standardized and unified in fewer versions. However, there still exist different definitions according to scientific societies (Table 1). In Europe, the currently used definition (2007 Guidelines for the management of arterial HT by The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension and of the European Society of Cardiology (2007 ESH/ESC)) was retained from the previous version of the same document in 2003. The most recent USA recommendations came from The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). Inside Europe, some countries have their own guidelines, such as the guidelines from the British Hypertension Society.

The main difference between existing guidelines is the name of categories and not the cut-points. All definitions consider HT as systolic BP ≥140 and/or diastolic ≥90 mmHg, but the American guidelines abandoned the term “optimal” and included the term “pre-hypertension”. This new designation intended to disclose the recognition that early intervention by adoption of healthy lifestyles could reduce BP and decrease the rate of its progression to hypertensive levels in these individuals. This is based on the

fact that even below categorical HT, subjects with high-normal BP (130–139 mmHg systolic and/or 85–89 mmHg diastolic) are at increased risk for CHD compared with those with optimal values[9, 15, 16]. However, the most striking novelty in these recent guidelines is the focus on addressing total cardiovascular risk more than looking only to the BP level.

Factors influencing blood pressure level

Hypertension is involved in a complex web of causation, in which some factors are both its cause and consequence. Moreover, many of these risk factors interact with HT in the influence on cardiovascular risk. A number of important causal factors for HT have been identified, some of them modifiable but others not.

Age, a non-modifiable risk factor, is strongly associated with HT. The prevalence of HT increases with advancing age to the point where more than half of people 60-69 years of age and approximately three-fourths of those 70 years of age and older are affected[17].

Substantial evidence documented that body weight is directly associated with BP and that excess body fat predisposes to HT[18]. In a meta-analysis of randomized controlled trials, mean systolic and diastolic BP reductions associated with an average weight loss of 5.1 kg were 4.4 and 3.6 mmHg, respectively[19].

Some studies have shown a U- or J-shaped association of mortality with alcohol consumption, meaning that low and moderate drinking results in a reduced mortality compared with non-drinkers, while heavy drinkers have a rising death rate[20]. However this relationship has recently been challenged, based on a meta-analysis of available data, that suggested a linear relationship between alcohol consumption, BP levels and prevalence of HT in populations[21].

Dietary salt intake is a contributor to BP elevation and consequentially to the prevalence of HT[22, 23]. According to randomized controlled trials in hypertensive patients[24], reducing sodium intake by 4.7-5.8 g per day reduces BP by an average of 4-6 mmHg.

Lack of physical exercise is a strong predictor of cardiovascular mortality independent of BP and other risk factors[25] A recent meta-analysis concluded that dynamic aerobic endurance training reduces resting systolic and diastolic BP by 3.0/2.4 mmHg[26]. Even moderate levels of exercise lowered BP, and contribute also to reduce other risk factors for cardiovascular diseases[27].

The nicotine in cigarette smoke acutely raises BP, even in addicted smokers[28]. However cross-sectional data on smokers and non-smokers are not consistent. Some studies find smokers to have a higher BP[29], whereas others find to have lower BP[30]. Regardless of this putative effect, all smokers should be strongly advised to quit, because smoking is associated with multiple effects and contribute to major cardiovascular damage.

Multiple studies suggest that people exposed to repeated psychological stresses may develop HT more frequently than would otherwise similar people who are not stressed[31]. Exposure to major catastrophes, such as earthquakes and massive explosions, leads to higher levels of BP that may persist for months [32].

It has been clearly established that HT and diabetes[33] coexist more commonly than is predicted by chance. In patients with type 2 diabetes, almost all of whom are obese, HT is more common than among obese people without diabetes [32].

The prevalence of all the above-mentioned characteristics is high, so in order to prevent BP levels from rising, primary prevention measures should be introduced to reduce or minimize these causal factors in the population.

Prevalence of high blood pressure

Global assumptions are difficult due to heterogeneity between countries. According to a systematic review of studies reporting data from 1980 and 2004, the overall worldwide prevalence of HT was approximately 26% in adult population[34].

In the USA, the prevalence of HT has increased from 50 million in 1990 to 65 million in 2000[35]. Reported differences by gender and race are small. The increasing prevalence is primarily a consequence of trends for the population to become older and more obese of increasing survival of hypertensive patients as a result of improved lifestyles or more effective drug therapy.

Research from WHO MONICA Project found inverse trends in HT prevalence in a sample of 24 populations from different countries worldwide[36]. The global analysis found that age-adjusted prevalence of HT decreased, during a 10-year period, from the mid-1980s to mid-1990s. This decrease is explained by the introduction of new drugs and non-pharmacological measures for the prevention and management of HT. However this is not true for all countries. Finland, Poland, Russia, Germany, Italy are examples of countries with an increasing trend in HT prevalence. The highest prevalence was reported in Finland among men and in Russia among women, while

the lowest prevalence was found in Spain in both genders. It is very important to refer that the WHO MONICA Project sample mainly represents populations from developed countries.

Data from national surveys in six European countries[37], performed in the 1990s, using similar sampling and reporting techniques, estimated the prevalence of HT as 38% in Italy, 38% in Sweden, 42% in England, 47% in Spain, 49% in Finland and 55% in Germany. In Portugal, data suggest that 3,311,830 people have HT (42.1%)[38].

As a result of progressive urbanization and westernization of their lifestyle, developing countries are now undergoing an epidemiological transition. These changes are leading to a new epidemiological situation with a decline in infectious diseases and emergence of cardiovascular diseases. Ideal data on HT prevalence and incidence based on large population-based surveillance that use standardized and validated protocols are lacking for most developing countries. However, the reported HT prevalence was 27.2 in India[39], 40.6% in Syria[40], 23.9% among men and 13.7% among women in Vietnam[41] and 27.1% among men and 30.2% among women in Tanzania[42]. These values are lower compared with HT prevalence in developed world, but the global tendency is for these values to increase[43].

Differences in HT prevalence are not only present between countries, but also between racial or ethnic groups. The prevalence among U.S. Blacks is higher than in Whites and Mexican-Americans in both genders and all ages[35]. A systematic review including studies from 1995 to present confirms that in most studies HT was significantly higher in Blacks than Whites[44].

Although differences in prevalence between countries invite for immediate attempts of interpretation, several important questions remain. Survey data for HT are difficult to standardize, and mean differences in the range observed here might be artificial. However, the possibility that the pattern of bias would be completely regional seems remote.

Awareness of hypertension

Early detection and adequate treatment of arterial HT improve prognosis and may contribute to cost containment for health care providers. The first barrier is that nearly one-half of hypertensive persons are unaware of their condition [36, 45]. This could reflect insufficient contact with health care professionals to allow an accurate diagnosis and communication of the findings to the person. In developing countries, contact between the health care system and the community is limited. Mass screening could provide a useful approach to increase awareness of the diagnosis but would have to be repeated frequently for sustained effects. Such screening should, additionally, be closely linked to diagnostic and treatment opportunities. In most developed societies, adults come in contact with the health care community and can have their BP measured on a relatively frequent basis. Under this circumstance, the challenge is to ensure communication of the diagnosis in a way that the individual with HT can understand.

On the other hand, the initial step for optimal management of patients with arterial HT is the recognition and acceptance of updated recommendations by the physicians themselves. The translation from scientific data to improvement in patient care can be disturbed and interrupted in many ways. Compliance with guidelines by physicians is influenced by knowledge and acceptance of guidelines (guideline awareness) which may lead to changes in clinical practice. Some studies have evaluated the awareness of physicians in respect to arterial HT. The Hypertension Evaluation Project (HEP)[46] found that only about a quarter of participating physicians had sufficient guideline conforming knowledge about diagnosis and treatment of arterial HT. Data of Hyman and Pavlik[47] showed that a substantial proportion of physicians would not start antihypertensive treatment unless the BP exceeded values of 160/95 mmHg, which is in contrast to the recommendations of the guidelines. These results suggest that further improvements in population HT control will require changes in physician's behavior. Data support the hypothesis that the physician and his guideline awareness for the treatment process could be the origin of the unacceptable poor treatment results of patients with arterial HT, more than the poor patient compliance.

Worldwide patients' awareness of their HT varies from 25.2% to 75%[34], and in Portugal 46.1% were aware of their high BP[38].

Treatment and control of hypertension

After the right diagnosis and assessment, the next step should be the implementation of a correct treatment in order to achieve control. The primary goal of treatment is to achieve the maximum reduction in long-term total risk of cardiovascular morbidity and mortality. This requires, besides the appropriate treatment for raised BP *per se*, the treatment of all reversible risk factors identified, including smoking, dyslipidaemia, abdominal obesity and diabetes.

Epidemiological studies provide scientific evidence on the distribution and determinants of high BP, establish the role of high BP as a risk factor and quantify the potential value of treating and preventing HT in the general population. Clinical trials have established that BP reduction in people with HT reduces the risk of a variety of BP related endpoints[48-50]. It is estimated that antihypertensive therapy has been associated with reductions in 30-40% in stroke incidence, 20-25% in myocardial infarction and >50% in heart failure [51]. However, the proportion of treatment among hypertensives is very low. It ranges from 10.7% to 66% worldwide[34] and is 39.0% in Portugal.

The recent guidelines recommend rational combinations of antihypertensives and highlight the importance of lifestyle interventions[52, 53]. These should be implemented, whenever appropriated, in all patients, including subjects with high-normal BP and patients who require drug treatment. Weight reduction[54], adoption of a healthy diet[55] (rich in fruits, vegetables and low-fat daily products), sodium intake reduction[56], physical activity[57] and moderation of alcohol consumption[58] contribute to reducing BP. Adoption of these lifestyles may even decrease the number and doses of antihypertensive drugs and the overall cardiovascular risk. A large number of drugs are currently available for reducing BP. More than two-thirds of hypertensive individuals cannot be controlled with only one drug and will require two or more antihypertensive agents selected from different drug classes[59]. Lifestyle measures should never be abandoned with the initiation of drug treatment, especially in patients at high levels of risk.

The decision to start treatment should be based both on the level of systolic and diastolic BP and in the level of total cardiovascular risk. This is illustrated in Figure 1, taken from the 2007 ESH/ESC Guidelines[52].

According to these guidelines, it is recommended that BP be lowered at least to below 140/90 mmHg in all hypertensive patients. However, treatment should be more

aggressive in specific conditions, like in diabetics in whom the target BP is <130/80 mmHg.

Blood pressure (mmHg)					
Other risk factors OD or disease	Normal SBP 120–129 or DBP 80–84	High normal SBP 130–139 or DBP 85–89	Grade 1 HT SBP 140–159 or DBP 90–99	Grade 2 HT SBP 160–179 or DBP 100–109	Grade 3 HT SBP≥180 or DBP≥110
No other risk factors	No BP intervention	No BP intervention	Lifestyle changes for several months then drug treatment if BP uncontrolled	Lifestyle changes for several weeks then drug treatment if BP uncontrolled	Lifestyle changes + Immediate drug treatment
1–2 risk factors	Lifestyle changes	Lifestyle changes	Lifestyle changes for several weeks then drug treatment if BP uncontrolled	Lifestyle changes for several weeks then drug treatment if BP uncontrolled	Lifestyle changes + Immediate drug treatment
≥3 risk factors, MS or OD	Lifestyle changes	Lifestyle changes and consider drug treatment	Lifestyle changes + Drug treatment	Lifestyle changes + Drug treatment	Lifestyle changes + Immediate drug treatment
Diabetes	Lifestyle changes	Lifestyle changes + Drug treatment			
Established CV or renal disease	Lifestyle changes + Immediate drug treatment	Lifestyle changes + Immediate drug treatment	Lifestyle changes + Immediate drug treatment	Lifestyle changes + Immediate drug treatment	Lifestyle changes + Immediate drug treatment

Figure 1. Initiation of antihypertensive treatment (Table from Mancia, G. et al. ESH-ESC Practice Guidelines for the Management of Arterial Hypertension: ESH-ESC Task Force on the Management of Arterial Hypertension. J Hypertens 2007;25:1751-62).

Only a minority of hypertensive patients are effectively managed, suggesting that the guidelines are not being strictly followed, or the adherence to lifestyle changes and long-term compliance with multiple drugs are major problems. According to a recent systematic review that summarizes studies from 1980 through 2003[34], the percentage of hypertensives that are controlled varies from 0.9% in Korea, 5.0% in Spain, 9.3% in the UK, 16% in Canada, 31% in the USA to 38% in Barbados. In Portugal 11.2% had their BP controlled (<140/90 mmHg)[38].

The low proportion of awareness by hypertensive subjects, the poor guideline awareness by physicians and non-compliance by patients may contribute significantly to these disappointing results, and explain why HT remains a leading cause of death worldwide.

Specific features of Portugal

Current international guidelines recommend that they should be adapted at national level, depending on local cultural background, socioeconomic situations, and heath care organization. Sociedade Portuguesa de Hipertensão has issued its own guidelines[60]. Similarly to the European document, the authors emphasize the assessment of total absolute cardiovascular risk before prescription of individual treatment, modification of lifestyles before/with pharmacological treatment and the importance of follow-up of the patients. However, blood pressure categories are different from the 2007 ESH/ESC guidelines. The Portuguese guidelines recommend fewer categories, excluding "optimal blood pressure", "grade 3 hypertension" and "isolated systolic hypertension".

In Portugal, barriers that preclude an effective primary prevention, treatment and control of HT are mostly shared by other societies, starting from an insufficient attention to health education by health care professionals, lack of access to places to engage in physical activity, increasing habits of eating out, large amounts of sodium added to foods by the food industry and restaurants, higher costs of food products that are poor in sodium and calories and lack of exercise programs in adolescence. Overcoming the barriers will require a large program directed not only to high-risk populations, but also to communities, schools, worksites, and the food industry.

The “National program for prevention and control of cardiovascular diseases” [61], emphasizes the need to inform and educate the population, to explain in a way that each person understands the message, allowing people to choose to adapt and take more healthy and desirable options within their own lifestyle. For HT, the aims are to increase the proportion of hypertensives diagnosed and controlled, by introducing technical guidelines, based on international consensus adopted by the scientific community on diagnosis and treatment of HT for health professionals, a self-help manual for surveillance and control of BP, for the hypertensive patient and to develop studies on prevalence, awareness and control of HT.

With this work we will try to clarify and update missing information regarding HT and to explain its awareness, treatment and control, worldwide and in Portugal.

.

References

1. *World Health Report 2002: Reducing risks, promoting healthy life.* Geneva, Switzerland: 2002.

2. Rodgers A, Ezzati M, Vander Hoorn S, Lopez AD, Lin RB, Murray CJ. Distribution of major health risks: findings from the Global Burden of Disease study. *PLoS Med.* 2004;1:e27.

3. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL. Selected major risk factors and global and regional burden of disease. *Lancet.* 2002;360:1347-1360.

4. Dawber TR, Meadors GF, Moore FE, Jr. Epidemiological approaches to heart disease: the Framingham Study. *Am J Public Health Nations Health.* 1951;41:279-81.

5. Coronary heart disease in seven countries. I. The study program and objectives. *Circulation.* 1970;41:I1-8.

6. MacMahon S, Peto R, Cutler J, Collins R, Sorlie P, Neaton J, Abbott R, Godwin J, Dyer A, Stamler J. Blood pressure, stroke, and coronary heart disease. Part 1, Prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias. *Lancet.* 1990;335:765-74.

7. Lawes CM, Vander Hoorn S, Rodgers A. Global burden of blood-pressure-related disease, 2001. *Lancet.* 2008;371:1513-8.

8. Stokes J, 3rd. , Kannel WB, Wolf PA, D'Agostino RB, Cupples LA. Blood pressure as a risk factor for cardiovascular disease. The Framingham Study--30 years of follow-up. *Hypertension.* 1989;13:I13-8.

9. Vasan RS, Larson MG, Leip EP, Evans JC, O'Donnell CJ, Kannel WB, Levy D. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med.* 2001;345:1291-7.

10. Tocci G, Sciarretta S, Volpe M. Development of heart failure in recent hypertension trials. *J Hypertens.* 2008;26:1477-1486.

11. Jager A, Kostense PJ, Ruhe HG, Heine RJ, Nijpels G, Dekker JM, Bouter LM, Stehouwer CDA. Microalbuminuria and Peripheral Arterial Disease Are Independent Predictors of Cardiovascular and All-Cause Mortality, Especially Among Hypertensive Subjects : Five-year Follow-up of the Hoorn Study. *Arterioscler Thromb Vasc Biol.* 1999;19:617-624.

12. Klag MJ, Whelton PK, Randall BL, Neaton JD, Brancati FL, Ford CE, Shulman NB, Stamler J. Blood pressure and end-stage renal disease in men. *N Engl J Med.* 1996;334:13-8.

13. Frioes F, Azevedo A, Castro A, Alvelos M, Pimenta J, Vazquez B, Bettencourt P, Barros H. Impact of cardiovascular risk factors in an urban sample of Portuguese adults according to the Framingham risk prediction models. *Rev Port Cardiol.* 2003;22:511-20.

14. Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. A cooperative study. *JAMA.* 1977;237:255-61.

15. Rodgers A, MacMahon S. Blood pressure and the global burden of cardiovascular disease. *Clin Exp Hypertens.* 1999;21:543-52.

16. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet.* 2002;360:1903-13.

17. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. *Hypertension.* 1995;25:305-13.

18. Stamler J. Epidemiologic findings on body mass and blood pressure in adults. *Ann Epidemiol.* 1991;1:347-62.

19. Neter JE, Stam BE, Kok FJ, Grobbee DE, Geleijnse JM. Influence of weight reduction on blood pressure: a meta-analysis of randomized controlled trials. *Hypertension.* 2003;42:878-84.

20. Jackson R, Stewart A, Beaglehole R, Scragg R. Alcohol consumption and blood pressure. *Am J Epidemiol.* 1985;122:1037-44.

21. Fillmore KM, Stockwell T, Chikritzhs T, Bostrom A, Kerr W. Moderate alcohol use and reduced mortality risk: systematic error in prospective studies and new hypotheses. *Ann Epidemiol.* 2007;17:S16-23.

22. Adrogue HJ, Madias NE. Sodium and potassium in the pathogenesis of hypertension. *N Engl J Med.* 2007;356:1966-78.

23. Law MR. Epidemiologic evidence on salt and blood pressure. *Am J Hypertens.* 1997;10:42S-45S.

24. Dickinson HO, Mason JM, Nicolson DJ, Campbell F, Beyer FR, Cook JV, Williams B, Ford GA. Lifestyle interventions to reduce raised blood pressure: a systematic review of randomized controlled trials. *J Hypertens.* 2006;24:215-33.

25. Sandvik L, Erikssen J, Thaulow E, Erikssen G, Mundal R, Rodahl K. Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *N Engl J Med.* 1993;328:533-7.

26. Cornelissen VA, Fagard RH. Effects of endurance training on blood pressure, blood pressure-regulating mechanisms, and cardiovascular risk factors. *Hypertension.* 2005;46:667-75.

27. Fagard RH. Exercise characteristics and the blood pressure response to dynamic physical training. *Med Sci Sports Exerc.* 2001;33:S484-92; discussion S493-4.

28. Groppelli A, Giorgi DM, Omboni S, Parati G, Mancia G. Persistent blood pressure increase induced by heavy smoking. *J Hypertens.* 1992;10:495-9.

29. Poulsen PL, Ebbehoj E, Hansen KW, Mogensen CE. Effects of smoking on 24-h ambulatory blood pressure and autonomic function in normoalbuminuric insulin-dependent diabetes mellitus patients. *Am J Hypertens.* 1998;11:1093-9.

30. Bolinder G, de Faire U. Ambulatory 24-h blood pressure monitoring in healthy, middle-aged smokeless tobacco users, smokers, and nontobacco users. *Am J Hypertens.* 1998;11:1153-63.

31. Peters JL, Kubzansky L, McNeely E, Schwartz J, Spiro A, 3rd, Sparrow D, Wright RO, Nie H, Hu H. Stress as a potential modifier of the impact of lead levels on blood pressure: the normative aging study. *Environ Health Perspect.* 2007;115:1154-9.

32. Gerin W, Chaplin W, Schwartz JE, Holland J, Alter R, Wheeler R, Duong D, Pickering TG. Sustained blood pressure increase after an acute stressor: the effects of the 11 September 2001 attack on the New York City World Trade Center. *J Hypertens.* 2005;23:279-84.

33. Schutta MH. Diabetes and hypertension: epidemiology of the relationship and pathophysiology of factors associated with these comorbid conditions. *J Cardiometab Syndr.* 2007;2:124-30.

34. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J Hypertens.* 2004;22:11-9.

35. Fields LE, Burt VL, Cutler JA, Hughes J, Roccella EJ, Sorlie P. The burden of adult hypertension in the United States 1999 to 2000: a rising tide. *Hypertension.* 2004;44:398-404.

36. Antikainen RL, Moltchanov VA, Chukwuma C, Sr., Kuulasmaa KA, Marques-Vidal PM, Sans S, Wilhelmsen L, Tuomilehto JO. Trends in the prevalence, awareness, treatment and control of hypertension: the WHO MONICA Project. *Eur J Cardiovasc Prev Rehabil.* 2006;13:13-29.

37. Wolf-Maier K, Cooper RS, Banegas JR, Giampaoli S, Hense H-W, Joffres M, Kastarinen M, Poulter N, Primatesta P, Rodriguez-Artalejo F, Stegmayr B, Thamm M, Tuomilehto J, Vanuzzo D, Vescio F. Hypertension Prevalence and Blood Pressure Levels in 6 European Countries, Canada, and the United States. *JAMA.* 2003;289:2363-2369.

38. Macedo ME, Lima MJ, Silva AO, Alcantara P, Ramalhinho V, Carmona J. Prevalence, awareness, treatment and control of hypertension in Portugal: the PAP study. *J Hypertens.* 2005;23:1661-6.

39. Kaur P, Rao TV, Sankarasubbaiyan S, Narayanan AM, Ezhil R, Rao SR, Gupte MD. Prevalence and distribution of cardiovascular risk factors in an urban industrial population in south India: a cross-sectional study. *J Assoc Physicians India.* 2007;55:771-6.

40. Maziak W, Rastam S, Mzayek F, Ward KD, Eissenberg T, Keil U. Cardiovascular health among adults in Syria: a model from developing countries. *Ann Epidemiol.* 2007;17:713-20.

41. Hoang VM, Byass P, Dao LH, Nguyen TK, Wall S. Risk factors for chronic disease among rural Vietnamese adults and the association of these factors with sociodemographic variables: findings from the WHO STEPS survey in rural Vietnam, 2005. *Prev Chronic Dis.* 2007;4:A22.

42. Bovet P, Ross AG, Gervasoni JP, Mkamba M, Mtasiwa DM, Lengeler C, Whiting D, Paccaud F. Distribution of blood pressure, body mass index and smoking habits in the urban population of Dar es Salaam, Tanzania, and associations with socioeconomic status. *Int J Epidemiol.* 2002;31:240-7.

43. Mensah GA. Epidemiology of stroke and high blood pressure in Africa. *Heart.* 2008;94:697-705.

44. Kurian AK, Cardarelli KM. Racial and ethnic differences in cardiovascular disease risk factors: a systematic review. *Ethn Dis.* 2007;17:143-52.

45. Burt VL, Cutler JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Roccella EJ. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population. Data from the health examination surveys, 1960 to 1991. *Hypertension.* 1995;26:60-9.

46. Hagemeister J, Schneider CA, Barabas S, Schadt R, Wassmer G, Mager G, Pfaff H, Hopp HW. Hypertension guidelines and their limitations--the impact of physicians' compliance as evaluated by guideline awareness. *J Hypertens.* 2001;19:2079-86.

47. Hyman DJ, Pavlik VN. Self-reported hypertension treatment practices among primary care physicians: blood pressure thresholds, drug choices, and the role of guidelines and evidence-based medicine. *Arch Intern Med.* 2000;160:2281-6.

48. Kostis JB, Davis BR, Cutler J, Grimm RH, Jr., Berge KG, Cohen JD, Lacy CR, Perry HM, Jr., Blaufox MD, Wassertheil-Smoller S, Black HR, Schron E, Berkson DM, Curb JD, Smith WM, McDonald R, Applegate WB. Prevention of heart failure by antihypertensive drug treatment in older persons with isolated systolic hypertension. SHEP Cooperative Research Group. *JAMA.* 1997;278:212-6.

49. Psaty BM, Lumley T, Furberg CD, Schellenbaum G, Pahor M, Alderman MH, Weiss NS. Health Outcomes Associated With Various Antihypertensive Therapies Used as First-Line Agents: A Network Meta-analysis. *JAMA.* 2003;289:2534-2544.

50. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension. Final results of the Systolic Hypertension in the Elderly Program (SHEP). SHEP Cooperative Research Group. *JAMA.* 1991;265:3255-64.

51. Neal B, MacMahon S, Chapman N. Effects of ACE inhibitors, calcium antagonists, and other blood-pressure-lowering drugs: results of prospectively designed overviews of randomised trials. Blood Pressure Lowering Treatment Trialists' Collaboration. *Lancet.* 2000;356:1955-64.

52. Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, Grassi G, Heagerty AM, Kjeldsen SE, Laurent S, Narkiewicz K, Ruilope L, Rynkiewicz A, Schmieder RE, Boudier HA, Zanchetti A. 2007 ESH-ESC Practice Guidelines for the Management of Arterial Hypertension: ESH-ESC Task Force on the Management of Arterial Hypertension. *J Hypertens.* 2007;25:1751-62.

53. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., Jones DW, Materson BJ, Oparil S, Wright JT, Jr., Roccella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA.* 2003;289:2560-72.

54. He J, Whelton PK. Epidemiology and prevention of hypertension. *Med Clin North Am.* 1997;81:1077-1097.

55. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, Obarzanek E, Conlin PR, Miller ER, 3rd, Simons-Morton DG, Karanja N, Lin PH. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. *N Engl J Med.* 2001;344:3-10.

56. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, Obarzanek E, Conlin PR, Miller ER, Simons-Morton DG, Karanja N, Lin P-H, The D-SCRG. Effects on Blood Pressure of Reduced Dietary Sodium and the Dietary Approaches to Stop Hypertension (DASH) Diet. *N Engl J Med.* 2001;344:3-10.

57. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Ann Intern Med.* 2002;136:493-503.

58. Xin X, He J, Frontini MG, Ogden LG, Motsamai OI, Whelton PK. Effects of alcohol reduction on blood pressure: a meta-analysis of randomized controlled trials. *Hypertension.* 2001;38:1112-7.

59. Materson BJ, Reda DJ, Cushman WC, Massie BM, Freis ED, Kochar MS, Hamburger RJ, Fye C, Lakshman R, Gottdiener J, et al. Single-drug therapy for hypertension in men. A comparison of six antihypertensive agents with placebo. The Department of Veterans Affairs Cooperative Study Group on Antihypertensive Agents. *N Engl J Med.* 1993;328:914-21.

60. Polonia J, Ramalhinho V, Martins L, Saavedra J. [Portuguese Society of Cardiology recomendations, assessment and treatment of hypertension]. *Rev Port Cardiol.* 2006;25:649-60.

2. Aims

We intended to provide updated data on prevalence, awareness, treatment and control of hypertension, worldwide and in our community. The specific aims were:

1. To systematically review data from community-based studies published since 2001, in order to quantify differences in prevalence, awareness, treatment and control between genders and level of development of countries.

2. To estimate the prevalence, awareness, treatment and control of hypertension in a representative sample of urban adults from Porto, Portugal.

3. To identify the determinants of awareness, treatment and control of hypertension in a representative sample of urban adults from Porto, Portugal.

3. Papers

3.1. Decreasing gap in prevalence, awareness, treatment and control of hypertension between developing and developed countries

DECREASING GAP IN PREVALENCE, AWARENESS, TREATMENT AND CONTROL OF HYPERTENSION BETWEEN DEVELOPING AND DEVELOPED COUNTRIES

Marta Pereira[1], Nuno Lunet[1], Ana Azevedo[1], Henrique Barros[1]

[1]Department of Hygiene and Epidemiology, University of Porto Medical School; Cardiovascular R&D Unit; Public Health Institute of the University of Porto (ISPUP).

Abstract

Objective: This systematic review aimed to quantify differences in prevalence, awareness, treatment and control between world regions, in the last six years.

Methods: We searched Medline (*prevalence AND awareness AND treatment AND control AND (hypertension OR high blood pressure)*) for population-based surveys. Prevalence, awareness, treatment and control of hypertension were compared between men and women, and developing and developed countries, adjusting for age.

Results: We identified 248 articles, of which 204 did not fulfil inclusion criteria and were excluded. The remaining articles reported data from 35 countries. The median prevalence of hypertension ranged from 28% in women from developing countries to 41% in men from developed countries. Awareness and treatment were 1.7-fold higher in men from developing countries compared to women from developed countries. The proportion of control among all hypertensives doubled from 7% in men from developing to 14% in women from developed countries.

Conclusion: There were no significant differences between developed countries and developing countries, except in a higher prevalence in men. Developing countries are coming closer to developed countries regarding the prevalence, awareness, treatment and control of hypertension.

Introduction

Hypertension (HT) affects approximately one billion individuals [1] and is a major risk factor for coronary heart disease, heart failure, cerebrovascular disease and chronic renal failure [2-5]. The high incidence of these diseases and the high prevalence of HT in all populations make it the single most important cause of worldwide morbidity and mortality [6, 7].

The importance of HT as a global problem has been increasingly recognized and it is an essential feature of current epidemiological transition. Major changes in the health profile of many developing countries are taking place[8]. Life expectancy in these countries is increasing, and people are increasingly exposed to diseases of old age like hypertension and cardiovascular diseases (CVD)[9]. It is currently common knowledge that CVD play an important role in the profile of morbidity and mortality in these societies. The World Health Organization estimated that, in 1999, low and middle income countries contributed to 78% of CVD deaths and that by 2010 CVD are expected to be the leading cause of death in developing countries[10].

It has been convincingly demonstrated that adequate management of HT can effectively reduce the risk of stroke, myocardial infarction[11], chronic kidney disease[12] and heart failure[13]. Primary prevention of HT involves actions at the community level aiming to reduce obesity, alcohol and salt consumption and increase physical activity [14]. Effective control of HT in the community warrants an improvement in awareness (among both health professionals and the general population), assessment of overall absolute CVD risk and increase in the efficiency of the nonpharmacological and pharmacological interventions to reduce this global risk[15]. Until the last decade, the worldwide picture regarding awareness, treatment and control of HT was far from optimal[16].

To adequately contextualize the magnitude of HT as a public health issue, local data and perspectives are not enough. The prevalence of HT varies widely across countries, the ratio between regions with highest and lowest HT prevalence surpassing 20 in men and 11 in women [16]. Previous systematic reviews[16-18] have covered surveys with data collected until the early 2000's. During the last six years, many studies were published reporting data from specific cities, regions or national surveys. To have an up-to-date worldwide view, it is important to assemble more recent data and to quantify differences between world regions. The aim of this study was to systematically review data from community-based studies published since 2001, in order to quantify differences in prevalence, awareness, treatment and control between world regions.

Methods

A systematic literature review was carried out on Medline using the expression: *"prevalence AND awareness AND treatment AND control AND (hypertension OR high blood pressure)".* The search was restricted to studies published from March 2001 through August 2007. The selection criteria were set *a priori* and applied independently by two reviewers (MP and AA). Studies were included if they were population-based and reported gender-specific prevalence, awareness, treatment and control of hypertension, and the definition of hypertension. There was no restriction concerning the date of the survey. When the abstract provided all the required data, no language restriction was applied regarding the full text; if the full text was necessary, selection was restricted to articles published in English, French, Portuguese or Spanish.

For each study, we abstracted information about definition of hypertension, blood pressure measurement methods, country/region, date of data collection, upper and lower limits of the participants' age, sample size, prevalence of hypertension, proportion of awareness and treatment among the hypertensive participants and proportion of control among treated and hypertensive participants. The data for prevalence, awareness, treatment and control of HT were collected for men and women separately. In cases in which the age range of the participants was not reported, we considered: the upper/lower limit as the last specific limit reported plus/minus the range of the closest class, if the data were presented by age groups (for example, for classes <30 years, 30-39, 40-49, ≥50, we would consider the overall range as 20 to 59 years); the upper/lower limit as mean plus/minus two times the standard deviation, if only summary data, but not distribution by age classes, were reported. When there were estimates from more than one country in the same study, we considered country-specific estimates. When the study only presented separate results for different regions within one country, we considered region-specific estimates. There was one study that presented the results for different ethnic groups separately. In this case, we computed one estimate weighted by the percentage of the population of each ethnic group in those countries given by demographic data presented in census [19].

We defined hypertension as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg and/or self-reported current use of blood pressure-lowering medication[1]. The articles that only presented other definitions of hypertension were excluded. Awareness of hypertension was defined as a self-reported prior diagnosis of hypertension by a health-care professional among those with hypertension. Treatment of hypertension was defined as self-reported current use of

pharmacologic medication to manage high blood pressure among those with hypertension. Control of hypertension was defined as having an average systolic blood pressure <140 mmHg and an average diastolic blood pressure <90 mmHg, in the context of pharmacologic treatment and among those with hypertension.

Countries were classified by geographical world regions and as developed or developing according to the United Nations classification[20].

The estimates of prevalence, awareness, treatment and control of HT obtained in each study are presented individually (Appendix – Table A) and as median value for all studies, developing and developed countries, and each specific region. Additionally, age-adjusted mean levels were computed for each geographical region.

Mean prevalences were compared between men and women, and between developing and developed countries, using multiple linear regression models. Prevalence of HT, awareness, treatment and control were used as dependent variables and lower and upper age limits in each study, gender of the participants enrolled in the study, development status (developed or developing) of the country and an interaction term between gender and development status as independent variables. The coefficients presented reflect the differences in estimates of prevalence, awareness, treatment and control of HT (expressed as percentage) between men and women, according to development status, and between developing and developed countries, according to gender. Gender-specific estimates of prevalence, awareness, treatment and control of HT for each region were calculated using multiple linear regression models adjusting for age.

In all adjusted models, confidence intervals were calculated using robust estimates of the standard errors, to account for the dependence among the observations made in the same countries, considered to belong to the same conglomerate.

Results

We identified 248 publications and excluded 204 as described in Figure 1. In the remaining 44 articles [21-64], data were stratified by country and sex and, finally, we obtained 136 prevalence estimates, reporting data from 35 countries. The characteristics and results of individual studies are presented in Table A (Appendix). Table 1 shows the geographical distribution of the studies by region and country. Forty-four of these studies came from developed countries and 24 from developing countries.

Most studies (69%) covered one region within one country, 19% had national coverage and 12% reported summary estimates for one country based on samples from several regions despite lack of national representativeness. The device used to measure blood pressure was a random-zero or standard mercury sphygmomanometer in 67% of the studies, electronic in 24%, aneroid in 3% and in the remaining 6% the type of device was not specified. The recommendations of the Joint National Committee for the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) [65] and European Society of Cardiology – European Society of Hypertension Guidelines [14] regarding the number of blood pressure measurements in different visits were respected in only one study [34]. In most other studies (59%) two measurements were made in one visit, in 32% three measurements were made in one visit, in 4% two or three measurements were made depending on the difference between the first two measurements, and in one study only one measurement was made in one visit. One study did not present the protocol for blood pressure measurements [23].

We designed a world map (Figure 2) that illustrates the geographical distribution of prevalence, awareness, treatment and control of HT, by sex. The median prevalence of HT ranged from 28% in women from developing countries to 41% in men from developed countries. Awareness and treatment were 1.7-fold higher in men from developing countries in comparison to women from developed countries. The proportion of control among all hypertensives doubled from 7% in men from developing to 14% in women from developed countries (Table 2). As shown in Table 3, the prevalence of HT was significantly higher in men in developed countries, while in developing countries there was no significant difference by gender. Awareness, treatment and control were significantly lower in men, both in developed and developing countries. Differences between developed countries and developing countries were not as obvious. The only statistically significant difference was observed for prevalence among men, which was lower in developing countries. Although not

reaching statistical significance, there was a trend towards a higher proportion of awareness and control in developed countries in both sexes.

Data on prevalence by region and by sex are shown in Table 4. Among men, Northern Europe showed the highest prevalence (45.8%), while the lowest prevalence was observed in Australia / New Zealand (30.2%). North America presented the highest proportion of awareness, treatment and control of HT (66.1%, 46.3% and 24.9%, respectively), while Southern Asia presented the lowest awareness (35.3%), Southern Europe the lowest treatment (23.6%) and Northern and Central Asia the lowest control rate (5.7%). In women, the highest prevalence of HT was reported in Africa (40.3%) and the lowest in Australia / New Zealand (23.8%). South and Central America presented the highest awareness, treatment and control proportions of HT (73.6%, 62.5% and 33.2%, respectively), while Southern Asia presented the lowest awareness (46.4%), Northern Europe the lowest treatment (29.9%), and Northern Europe the lowest proportion of control (10.0%).

Discussion

In this study, we report a lower prevalence and higher awareness, treatment and control of hypertension among women and these results are consistent with previous data [16]. There were no significant differences between developed countries and developing countries, except for prevalence, which was 7.9% higher in men. Despite not reaching statistical significance, awareness of HT was 7% higher in both men and women from developed countries in comparison with developing countries.

The distribution of hypertension in populations is influenced by a number of factors, including genetic and environmental [66-68]. However, given the different methodologies between surveys, especially regarding age and gender of the population under study, number of measurements of blood pressure and time interval between measurements, the differences in reported estimates do not necessarily reflect true differences in susceptibility. In a careful systematic review, selection of studies with defined characteristics may reduce this variability and allow insight into real effects. The number of included studies varied according to geographical area, with the majority of studies presenting results from developed countries. Despite the lower representation of studies from developing countries, we found original data in the required format from all continents. The sample size in studies from developing countries was not smaller, in comparison to developed countries, arguing in favor of their precision. When there was more than one study from the same country, we included all studies because overall data from several studies is more likely to lead to a

more representative overview of the whole population. Still, to avoid overweighting those countries in the global estimates, we considered all studies from the same country to belong to one cluster, thus taking into account the dependence of observations.

The definition of HT as a dichotomous concept must be based in arbitrary cut-off BP values. The threshold for HT used in this systematic review is that currently recommended by the European and American guidelines at an office or clinic environment [14, 65]. A more comprehensive view could be reached by including all studies regardless of the definition used. This heterogeneity, however, would unbalance comparisons. A previous systematic review by Lawes et al [17] considered average blood pressure levels alternatively to prevalence of HT and found that Europe had the highest mean systolic blood pressure (SBP) levels and Asian populations had the lowest mean SBP levels. Given that we intended to review a wider perspective on HT, including not only prevalence but also data leading to levels of control, the dichotomous concept was the only acceptable option, in order to be able to translate the classification of subjects into decisions on interventions and their success.

The individual studies used different methodologies regarding blood pressure measurement and selection of subjects. To take into account one of the most important of these differences we adjusted for age by including the upper and lower age limits of the participants, when assessing differences by gender and development status of the countries. In another model, not shown, the year of data collection of the study was taken into account and no difference was found in the results. Additionally, we included an interaction term to account for the different effect of gender by development status of countries and vice-versa. This analysis revealed an interaction between gender and development status only on prevalence of HT. Assuming that differences in access to care by gender is less of an issue in developed than in developing countries[69, 70], we expected a higher rate of awareness and treatment in women than men in developed countries, reflecting higher health concerns in women[71, 72], while in developing countries the opposite trend would be compatible with easier access to care by men[73]. The fact that this anticipated pattern was not confirmed by the data may reflect a desirable attenuation of gender inequalities in developing countries. The results clearly show that, overall, women were more aware of their status and more likely to get pharmacological treatment. Original studies on the association between gender and HT have been contradictory. Several studies showed that female gender is a strong indicator of success in HT control [74, 75] and others reported no differences between genders [76], while in others men had better control of HT [77, 78]. Concerning results of

previous systematic reviews, the differences between genders on prevalence, awareness, treatment and control are consistent with our results, although none of them quantified differences by developing and developed countries[16, 17].

Until recently, HT was associated with wealth. This relation was reflected by a higher prevalence in developed countries[18] and a positive association between growth national product (GNP) per capita and prevalence of HT in developing countries, according to a review by Fuentes et al. [79] of population-based studies carried out from 1980 to 1998. Apparently, differences between developed and developing countries are decreasing. Kearney et al. [16], in a systematic review including studies from 1980 through 2003, suggested that the prevalence of HT had remained stable or decreased in developed countries and had increased in developing countries. We only found differences on the prevalence of HT by development status among men, and even this difference was not large despite statistically significant. Developed countries had higher levels of awareness, likely reflecting more difficult access to health care in developing countries. These differences may be underestimated, because the developing countries were represented by fewer studies, especially from the poorest countries. The worldwide low proportion of control among treated hypertensives suggests low compliance by patients and low aggressiveness in HT management by physicians, since the effectiveness of drug treatment is well documented[80] .

The limitations of this systematic review were the language restriction, the utilization of a single search engine and the option to include only papers that presented values of prevalence, awareness, treatment and control stratified by sex. Publication bias is not a major issue, because this is not an analytical study, and it is not likely that the success in publication depends on the prevalence found. We can assume that studies which included larger samples and more thorough methods get to be published in more highly ranked journals, but the possibility of accessing the full text of publications in other journals has largely increased. We could have introduced selection bias by including only the studies with estimates on prevalence, awareness, treatment and control, although it is not likely that prevalence would be systematically higher or lower in studies reporting only this parameter. Given the gender differences reported in this review, overall data for men and women together are not appropriate and should not be presented even in original studies. The studies that only included participants aged over 60 were excluded because estimates in this age range could not be used to represent population-based prevalences. We restricted the studies by the publication date and not by date of survey, because some studies did not present the date of survey. We assume these dates are directly related with each other, although

there is certainly heterogeneity and in all studies there is a gap of many months or years between data collection and publication.

The overall trends show that developing countries are coming closer to developed countries regarding the incidence and prevalence of chronic diseases, namely CVD and their risk factors. The prevalence of HT in developed countries has been decreasing. Given the low level of control among hypertensives in all countries and the high cost of lifelong effective treatment, it is currently a major challenge that we understand the reasons for the observed trends. This knowledge should be able to support interventions to stop and reverse current trends in developing countries.

Acknowledgments

The authors gratefully acknowledge the contribution of Prof. Fátima Pina and Dra Débora Castiglione in designing the maps in Figure 2.

Sources of funding

This study was funded by a grant from Fundação para a Ciência e a Tecnologia (POCI/SAU-ESP/61492/2004).

References

1. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., Jones DW, Materson BJ, Oparil S, Wright JT, Jr., Roccella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA.* 2003;289:2560-72.

2. D'Agostino RB, Sr., Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, Kannel WB. General cardiovascular risk profile for use in primary care: the Framingham Heart Study. *Circulation.* 2008;117:743-53.

3. Klag MJ, Whelton PK, Randall BL, Neaton JD, Brancati FL, Ford CE, Shulman NB, Stamler J. Blood pressure and end-stage renal disease in men. *N Engl J Med.* 1996;334:13-8.

4. Jager A, Kostense PJ, Ruhe HG, Heine RJ, Nijpels G, Dekker JM, Bouter LM, Stehouwer CDA. Microalbuminuria and Peripheral Arterial Disease Are Independent Predictors of Cardiovascular and All-Cause Mortality, Especially Among Hypertensive Subjects : Five-year Follow-up of the Hoorn Study. *Arterioscler Thromb Vasc Biol.* 1999;19:617-624.

5. Stokes J, 3rd. , Kannel WB, Wolf PA, D'Agostino RB, Cupples LA. Blood pressure as a risk factor for cardiovascular disease. The Framingham Study--30 years of follow-up. *Hypertension.* 1989;13:I13-8.

6. Rodgers A, Ezzati M, Vander Hoorn S, Lopez AD, Lin RB, Murray CJ. Distribution of major health risks: findings from the Global Burden of Disease study. *PLoS Med.* 2004;1:e27.

7. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ. Selected major risk factors and global and regional burden of disease. *Lancet.* 2002;360:1347-60.

8. Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet.* 2007;370:1929-38.

9. Manton KG. The global impact of noncommunicable diseases: estimates and projections. *World Health Stat Q.* 1988;41:255-66.

10. World Health Organization. *World Health Report-Health Systems: Improving Performance* . Geneve: WHO; 2000.

11. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL. Selected major risk factors and global and regional burden of disease. *Lancet.* 2002;360:1347-1360.

12. Toto RD. Treatment of hypertension in chronic kidney disease. *Semin Nephrol.* 2005;25:435-9.

13. Yusuf S, Thom T, Abbott RD. Changes in hypertension treatment and in congestive heart failure mortality in the United States. *Hypertension.* 1989;13:I74-9.

14. Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, Grassi G, Heagerty AM, Kjeldsen SE, Laurent S, Narkiewicz K, Ruilope L, Rynkiewicz A, Schmieder RE, Boudier HA, Zanchetti A. 2007 ESH-ESC Practice Guidelines for the Management of Arterial Hypertension: ESH-ESC Task Force on the Management of Arterial Hypertension. *J Hypertens.* 2007;25:1751-62.

15. Hypertension control. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser.* 1996;862:1-83.

16. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J Hypertens.* 2004;22:11-9.

17. Lawes CM, Vander Hoorn S, Law MR, Elliott P, MacMahon S, Rodgers A. Blood pressure and the global burden of disease 2000. Part 1: estimates of blood pressure levels. *J Hypertens.* 2006;24:413-22.

18. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet.* 2005;365:217-23.

19. Joop G, Nicolaas H, Sprangers A. Demografie van de allochtonen in Nederland. *Centraal Bureau voor de Statistiek.* 2005;

20. Department of Economic and Social Affairs-Statistics Division. *Indicators for Monitoring the Millennium Development Goals.* New York: United Nations; 2003.

21. Antikainen RL, Moltchanov VA, Chukwuma C, Sr., Kuulasmaa KA, Marques-Vidal PM, Sans S, Wilhelmsen L, Tuomilehto JO. Trends in the prevalence, awareness, treatment and control of hypertension: the WHO MONICA Project. *Eur J Cardiovasc Prev Rehabil.* 2006;13:13-29.

22. Centers for Disease Control. Racial/ethnic disparities in prevalence, treatment, and control of hypertension--United States, 1999-2002. *MMWR Morb Mortal Wkly Rep.* 2005;54:7-9.

23. Dickson B, Blackledge J, Hajjar I. The impact of lifestyle behavior on hypertension awareness, treatment, and control in a southeastern population. *Am J Med Sci.* 2006;332:211-215.

24. Howard G, Prineas R, Moy C, Cushman M, Kellum M, Temple E, Graham A, Howard V. Racial and geographic differences in awareness, treatment, and control of hypertension: the Reasons for Geographic and Racial Differences in Stroke study. *Stroke.* 2006;37:1171-1178.

25. Hennis A, Wu SY, Nemesure B, Leske MC. Hypertension prevalence, control and survivorship in an Afro-Caribbean population. *J Hypertens.* 2002;20:2363-9.

26. Inamo J, Malfatti S, Lang T, Atallah A, Inamo A, Larabi L, de Gaudemaris R. Arterial hypertension in the French Caribbean regions: gender related differences. *Arch Mal Coeur Vaiss.* 2005;98:845-9.

27. Fasce E, Campos I, Ibanez P, Flores M, Zarate H, Roman O, Fasce F. Trends in prevalence, awareness, treatment and control of hypertension in urban communities in Chile. *J Hypertens.* 2007;25:1807-11.

28. Atallah A, Inamo J, Larabi L, Chatellier G, Rozet JE, Machuron C, de Gaudemaris R, Lang T. Reducing the burden of arterial hypertension: what can be expected from an improved access to health care? Results from a study in 2420 unemployed subjects in the Caribbean. *J Hum Hypertens.* 2007;21:316-22.

29. Ordunez-Garcia P, Munoz JL, Pedraza D, Espinosa-Brito A, Silva LC, Cooper RS. Success in control of hypertension in a low-resource setting: the Cuban experience. *J Hypertens.* 2006;24:845-9.

30. Agyemang C, Bruijnzeels MA, Owusu-Dabo E. Factors associated with hypertension awareness, treatment, and control in Ghana, West Africa. *J Hum Hypertens.* 2006;20:67-71.

31. Ben Romdhane H, Skhiri H, Bougatef S, Ennigrou S, Gharbi D, Chahed MK, Achour N. Hypertension prevalence, awareness, treatment and control: results from a community based survey. *Tunis Med.* 2005;83 Suppl 5:41-6.

32. Danon-Hersch N, Chiolero A, Shamlaye C, Paccaud F, Bovet P. Decreasing association between body mass index and blood pressure over time. *Epidemiology.* 2007;18:493-500.

33. Wang Z, Wu Y, Zhao L, Li Y, Yang J, Zhou B. Trends in prevalence, awareness, treatment and control of hypertension in the middle-aged population of China, 1992-1998. *Hypertens Res.* 2004;27:703-9.

34. Li W, Jiang X, Ma H, Yu TS, Ma L, Puente JG, Tang Y, He X, Ma S, Jin S, Kong L, Chen C, Liu L. Awareness, treatment and control of hypertension in patients attending hospital clinics in China. *J Hypertens.* 2003;21:1191-7.

35. Gu D, Reynolds K, Wu X, Chen J, Duan X, Muntner P, Huang G, Reynolds RF, Su S, Whelton PK, He J. Prevalence, awareness, treatment, and control of hypertension in china. *Hypertension.* 2002;40:920-7.

36. Asai Y, Ishikawa S, Kayaba K, Goto T, Nago N, Kario K, Kajii E. Prevalence, awareness, treatment, and control of hypertension in Japanese rural communities. *Nippon Koshu Eisei Zasshi.* 2001;48:827-36.

37. Pan WH, Chang HY, Yeh WT, Hsiao SY, Hung YT. Prevalence, awareness, treatment and control of hypertension in Taiwan: results of Nutrition and Health Survey in Taiwan (NAHSIT) 1993-1996. *J Hum Hypertens.* 2001;15:793-8.

38. Jo I, Ahn Y, Lee J, Shin KR, Lee HK, Shin C. Prevalence, awareness, treatment, control and risk factors of hypertension in Korea: the Ansan study. *J Hypertens.* 2001;19:1523-32.

39. Choi KM, Park HS, Han JH, Lee JS, Lee J, Ryu OH, Lee KW, Cho KH, Yoon D, Baik SH, Choi DS, Kim SM. Prevalence of prehypertension and hypertension in a Korean population: Korean National Health and Nutrition Survey 2001. *J Hypertens.* 2006;24:1515-21.

40. Howteerakul N, Suwannapong N, Sittilerd R, Rawdaree P. Health risk behaviours, awareness, treatment and control of hypertension among rural community people in Thailand. *Asia Pac J Public Health.* 2006;18:3-9.

41. Altun B, Arici M, Nergizoglu G, Derici U, Karatan O, Turgan C, Sindel S, Erbay B, Hasanoglu E, Caglar S. Prevalence, awareness, treatment and control of hypertension in Turkey (the PatenT study) in 2003. *J Hypertens.* 2005;23:1817-23.

42. Hazarika NC, Narain K, Biswas D, Kalita HC, Mahanta J. Hypertension in the native rural population of Assam. *Natl Med J India.* 2004;17:300-4.

43. Lim TO, Morad Z. Prevalence, awareness, treatment and control of hypertension in the Malaysian adult population: results from the national health and morbidity survey 1996. *Singapore Med J.* 2004;45:20-7.

44. Zachariah MG, Thankappan KR, Alex SC, Sarma PS, Vasan RS. Prevalence, correlates, awareness, treatment, and control of hypertension in a middle-aged urban population in Kerala. *Indian Heart J.* 2003;55:245-51.

45. Deepa R, Shanthirani CS, Pradeepa R, Mohan V. Is the 'rule of halves' in hypertension still valid?--Evidence from the Chennai Urban Population Study. *J Assoc Physicians India.* 2003;51:153-7.

46. Tugay Aytekin N, Pala K, Irgil E, Akis N, Aytekin H. Distribution of blood pressures in Gemlik District, north-west Turkey. *Health Soc Care Community.* 2002;10:394-401.

47. Mohan V, Deepa M, Farooq S, Datta M, Deepa R. Prevalence, awareness and control of hypertension in Chennai--The Chennai Urban Rural Epidemiology Study (CURES-52). *J Assoc Physicians India.* 2007;55:326-32.

48. Chaturvedi S, Pant M, Yadav G. Hypertension in Delhi: prevalence, awareness, treatment and control. *Trop Doct.* 2007;37:142-5.

49. Efstratopoulos AD, Voyaki SM, Baltas AA, Vratsistas FA, Kirlas DE, Kontoyannis JT, Sakellariou JG, Triantaphyllou GB, Alokrios GA, Lianas DN, Vasilakis EA, Fotiadis KN, Kastritsea EE. Prevalence, awareness, treatment and control of hypertension in Hellas, Greece: the Hypertension Study in General Practice in Hellas (HYPERTENSHELL) national study. *Am J Hypertens.* 2006;19:53-60.

50. Macedo ME, Lima MJ, Silva AO, Alcantara P, Ramalhinho V, Carmona J. Prevalence, awareness, treatment and control of hypertension in Portugal: the PAP study. *J Hypertens.* 2005;23:1661-6.

51. Psaltopoulou T, Orfanos P, Naska A, Lenas D, Trichopoulos D, Trichopoulou A. Prevalence, awareness, treatment and control of hypertension in a general population sample of 26,913 adults in the Greek EPIC study. *Int J Epidemiol.* 2004;33:1345-52.

52. Sarafidis PA, Lasaridis A, Gousopoulos S, Zebekakis P, Nikolaidis P, Tziolas I, Papoulidou F. Prevalence, awareness, treatment and control of hypertension in employees of factories of Northern Greece: the Naoussa study. *J Hum Hypertens.* 2004;18:623-9.

53. Panagiotakos DB, Pitsavos CH, Chrysohoou C, Skoumas J, Papadimitriou L, Stefanadis C, Toutouzas PK. Status and management of hypertension in Greece: role of the adoption of a Mediterranean diet: the Attica study. *J Hypertens.* 2003;21:1483-9.

54. Menotti A, Lanti M, Zanchetti A, Puddu PE, Cirillo M, Mancini M, Vagnarelli OT. Impact of the Gubbio population study on community control of blood pressure and hypertension. Gubbio Study Research Group. *J Hypertens.* 2001;19:843-50.

55. Perez-Fernandez R, Marino AF, Cadarso-Suarez C, Botana MA, Tome MA, Solache I, Rego-Iraeta A, Mato AJ. Prevalence, awareness, treatment and control of hypertension in Galicia (Spain) and association with related diseases. *J Hum Hypertens.* 2007;21:366-73.

56. Primatesta P, Brookes M, Poulter NR. Improved hypertension management and control: results from the health survey for England 1998. *Hypertension.* 2001;38:827-32.

57. Primatesta P, Poulter NR. Improvement in hypertension management in England: results from the Health Survey for England 2003. *J Hypertens.* 2006;24:1187-92.

58. Meisinger C, Heier M, Volzke H, Lowel H, Mitusch R, Hense HW, Ludemann J. Regional disparities of hypertension prevalence and management within Germany. *J Hypertens.* 2006;24:293-9.

59. Lang T, de Gaudemaris R, Chatellier G, Hamici L, Diene E. Prevalence and therapeutic control of hypertension in 30,000 subjects in the workplace. *Hypertension.* 2001;38:449-54.

60. Agyemang C, Bindraban N, Mairuhu G, Montfrans G, Koopmans R, Stronks K. Prevalence, awareness, treatment, and control of hypertension among Black Surinamese, South Asian Surinamese and White Dutch in Amsterdam, The Netherlands: the SUNSET study. *J Hypertens.* 2005;23:1971-7.

61. Scheltens T, Bots ML, Numans ME, Grobbee DE, Hoes AW. Awareness, treatment and control of hypertension: the 'rule of halves' in an era of risk-based treatment of hypertension. *J Hum Hypertens.* 2007;21:99-106.

62. Agyemang C, Ujcic-Voortman J, Uitenbroek D, Foets M, Droomers M. Prevalence and management of hypertension among Turkish, Moroccan and native Dutch ethnic groups in Amsterdam, the Netherlands: The Amsterdam Health Monitor Survey. *J Hypertens.* 2006;24:2169-76.

63. Zdrojewski T, Szpakowski P, Bandosz P, Pajak A, Wiecek A, Krupa-Wojciechowska B, Wyrzykowski B. Arterial hypertension in Poland in 2002. *J Hum Hypertens.* 2004;18:557-62.

64. Cifkova R, Skodova Z, Lanska V, Adamkova V, Novozamska E, Jozifova M, Plaskova M, Hejl Z, Petrzilkova Z, Galovcova M, Palous D. Prevalence, awareness, treatment, and control of hypertension in the Czech Republic. Results of two nationwide cross-sectional surveys in 1997/1998 and 2000/2001, Czech Post-MONICA Study. *J Hum Hypertens.* 2004;18:571-9.

65. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., Jones DW, Materson BJ, Oparil S, Wright JT, Jr., Roccella EJ, the National High Blood Pressure Education Program Coordinating C. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension.* 2003;42:1206-1252.

66. Colhoun HM, Hemingway H, Poulter NR. Socio-economic status and blood pressure: an overview analysis. *J Hum Hypertens.* 1998;12:91-110.

67. Kunes J, Zicha J. Developmental windows and environment as important factors in the expression of genetic information: a cardiovascular physiologist's view. *Clin Sci (Lond).* 2006;111:295-305.

68. Marteau JB, Zaiou M, Siest G, Visvikis-Siest S. Genetic determinants of blood pressure regulation. *J Hypertens.* 2005;23:2127-43.

69. Okojie CE. Gender inequalities of health in the Third World. *Soc Sci Med.* 1994;39:1237-47.

70. Craft N. Women's health is a global issue. *BMJ.* 1997;315:1154-7.

71. Koopmans GT, Lamers LM. Gender and health care utilization: the role of mental distress and help-seeking propensity. *Soc Sci Med.* 2007;64:1216-30.

72. Green CA, Pope CR. Gender, psychosocial factors and the use of medical services: a longitudinal analysis. *Soc Sci Med.* 1999;48:1363-72.

73. Baghdadi G. Gender and medicines: an international public health perspective. *J Womens Health (Larchmt).* 2005;14:82-6.

74. Stockwell DH, Madhavan S, Cohen H, Gibson G, Alderman MH. The determinants of hypertension awareness, treatment, and control in an insured population. *Am J Public Health.* 1994;84:1768-1774.

75. Alexander M, Tekawa I, Hunkeler E, Fireman B, Rowell R, Selby JV, Massie BM, Cooper W. Evaluating Hypertension Control in a Managed Care Setting. *Arch Intern Med.* 1999;159:2673-2677.

76. Knight EL, Bohn RL, Wang PS, Glynn RJ, Mogun H, Avorn J. Predictors of Uncontrolled Hypertension in Ambulatory Patients. *Hypertension.* 2001;38:809-814.

77. Hicks LS, Fairchild DG, Horng MS, Orav EJ, Bates DW, Ayanian JZ. Determinants of JNC VI Guideline Adherence, Intensity of Drug Therapy, and Blood Pressure Control by Race and Ethnicity. *Hypertension.* 2004;44:429-434.

78. Majernick TG, Zacker C, Madden NA, Belletti DA, Arcona S. Correlates of hypertension control in a primary care setting. *Am J Hypertens.* 2004;17:915-920.

79. Fuentes R, Ilmaniemi N, Laurikainen E, Tuomilehto J, Nissinen A. Hypertension in developing economies: a review of population-based studies carried out from 1980 to 1998. *J Hypertens.* 2000;18:521-9.

80. Neal B, MacMahon S, Chapman N. Effects of ACE inhibitors, calcium antagonists, and other blood-pressure-lowering drugs: results of prospectively designed overviews of randomised trials. Blood Pressure Lowering Treatment Trialists' Collaboration. *Lancet.* 2000;356:1955-64.

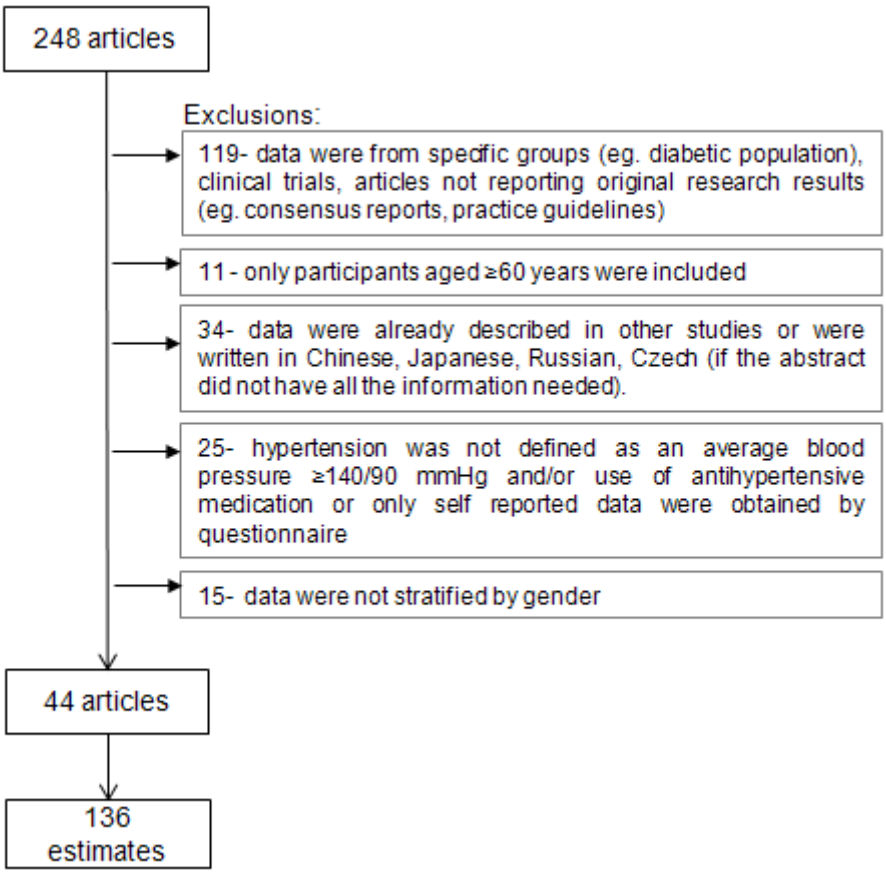

Figure 1. Systematic review flowchart, including the number and motive of articles exclusion.

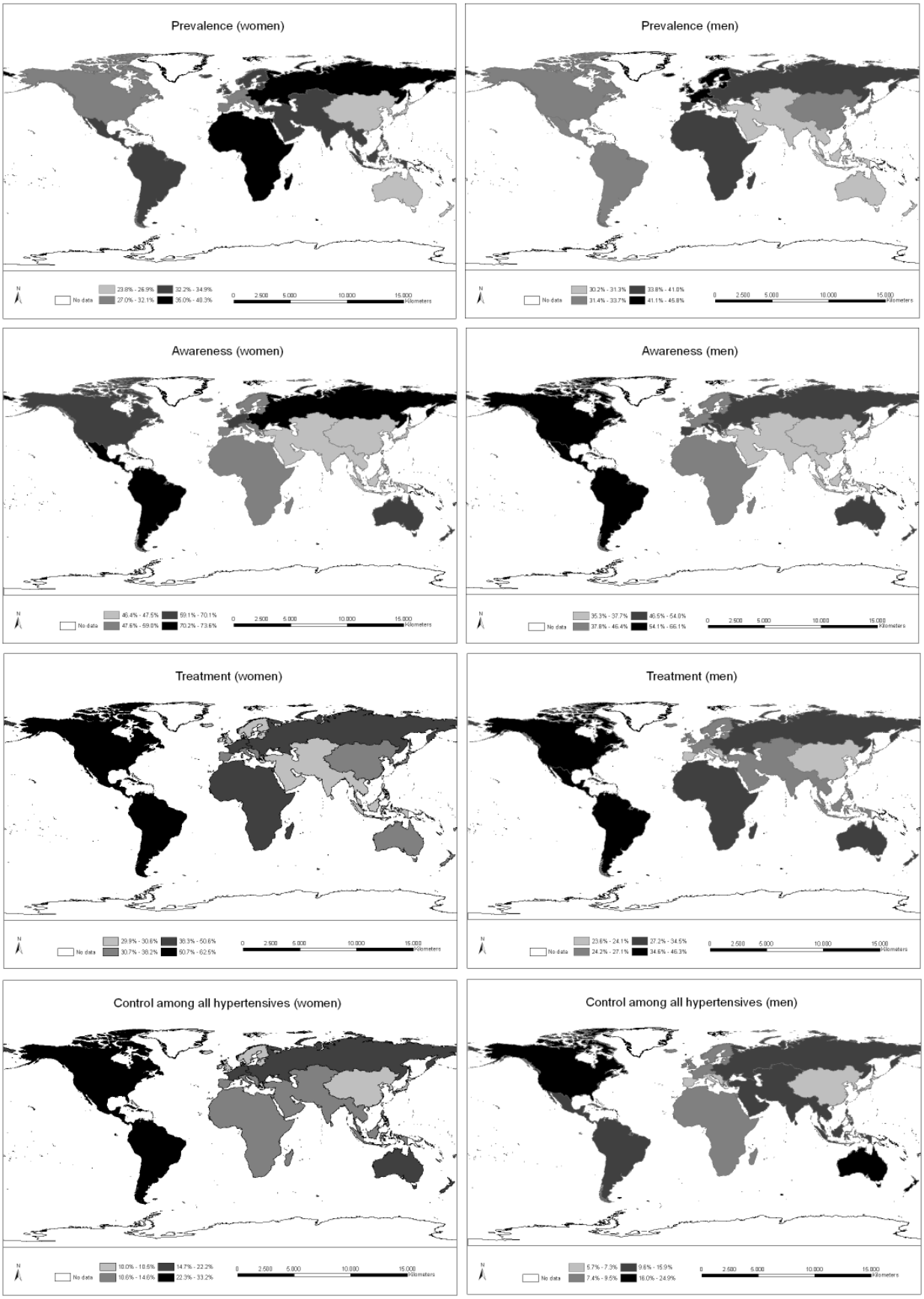

Figure 2. Geographical distribution of prevalence, awareness, treatment and control of hypertension, by sex. Data are expressed as median level of each region.

Table 1. Geographic origin of the studies.

Regions	Number of Studies	Country (nr of studies)
North America	5	Canada (1), USA (4)
Central, South America and Caribbean	5	Barbados (1), Antilles (1), Chile (1), Guadeloupe (1), Cuba (1)
Africa	3	Ghana (1), Tunisia (1), Seychelles (1)
Eastern Asia	8	China (5), Japan (1), Korea (2)
South-Eastern, South-Central and Western Asia	9	India (5), Malaysia (1), Thailand (1), Turkey (2)
Southern Europe	10	Greece (4), Italy (3), Portugal (1), Spain (2)
Northern Europe	10	Denmark (1), Finland (3), Sweden (2), United Kingdom/England (4)
Western Europe	11	Belgium (1), France (1), Germany (5), Switzerland (1), Netherlands (3)
Central and Eastern Europe	5	Czech Republic (1), Poland (2), Russia (2)
Australia/ New Zealand	2	Australia (1), New Zealand (1)

Table 2. Median (interquartile range) prevalence, awareness, treatment and control of hypertension in different world regions.

	Sex	**Hypertension (%)** median (P25-P75)	**Awareness (%)** median (P25-P75)	**Treatment (%)** median (P25-P75)	**Control (%) *** median (P25-P75)	**Control (%) †** median (P25-P75)
All countries	men	38 (29-45)	45 (34-56)	25 (20-35)	31 (21-39)	8 (5-12)
	women	31 (23-37)	60 (47-72)	36 (28-51)	36 (25-46)	14 (8-22)
Developing	men	30 (24-38)	36 (28-50)	23 (20-36)	27 (19-38)	7 (4-13)
	women	28 (21-36)	48 (39-72)	33 (28-55)	30 (22-43)	11 (7-23)
Developed	men	41 (33-46)	50 (38-58)	26 (20-34)	32 (23-41)	8 (5-12)
	women	32 (26-39)	62 (53-72)	39 (28-51)	39 (29-48)	14 (10-22)

P25 denotes 25 percentile;

P75 denotes 75 percentile;

* proportion of control among the treated;

† proportion of control among the hypertensive.

Table 3. Effect of gender and level of development of countries on prevalence, awareness, treatment and control of hypertension, adjusting for age and taking into account the interaction between gender and level of development of countries.

	Men vs. Women *		**Developing vs. Developed †**	
	Developing countries	Developed countries	Men	Women
	β (95% CI) ‡	**β (95% CI) ‡**	**β (95% CI) ‡**	**β (95% CI) ‡**
Hypertension	1.7 (-1.5 to 4.9)	7.9 (5.3 to 10.4)	-6.5 (-11.3 to -1.8)	-0.4 (-5.0 to 4.3)
Awareness	-12.0 (-18.3 to -5.8)	-12.5 (-15.9 to -9.0)	-6.7 (-14.7 to 1.3)	-7.1 (-16.9 to 2.6)
Treatment	-11.3 (-16.3 to -6.2)	-11.4 (-14.1 to -8.7)	0.7 (-5.6 to 6.9)	0.5 (-8.4 to 9.4)
Control	-4.4 (-8.6 to -0.3)	-5.2 (-9.9 to -0.5)	-3.7 (-10.5 to 3.1)	-4.4 (-12.5 to 3.7)

* Women as reference;

† Developed countries as reference;

‡ linear regression model including prevalence, awareness, treatment and control of HT as dependent variables, and lower and higher age limits in each study, the development status of each country (developed or developing), the gender of the participants and an interaction term between gender and development status as independent variables;

β denotes the regression coefficient;

CI denotes confidence interval.

Table 4. Mean prevalence, awareness, treatment and control of hypertension, by region and sex, estimated by linear regression, adjusting for age.

		Prevalence (95% CI)				
		Hypertension	**Awareness**	**Treatment**	**Control ***	**Control †**
North America	Men	33.7 (30.7 to 36.6)	66.1 (58.3 to 73.9)	46.3 (40.3 to 52.3)	50.1 (39.5 to 60.8)	24.9 (18.0 to 31.8)
	women	30.6 (25.7 to 35.4)	70.1 (65.3 to 75.0)	53.3 (42.4 to 64.1)	55.9 (46.0 to 65.8)	31.0 (21.0 to 41.0)
Central, South America and Caribbean	Men	33.1 (25.4 to 40.8)	61.1 (46.6 to 75.6)	38.4 (28.3 to 48.6)	37.9 (24.8 to 50.9)	15.9 (7.6 to 24.2)
	women	33.5 (25.2 to 41.8)	73.6 (56.1 to 91.0)	62.5 (48.8 to 76.2)	50.4 (37.5 to 63.3)	33.2 (18.6 to 47.8)
Africa	men	40.5 (31.5 to 49.6)	39.4 (20.1 to 58.6)	34.5 (15.6 to 53.4)	21.3 (17.0 to 25.6)	8.6 (1.9 to 15.2)
	women	40.3 (38.7 to 42.0)	55.8 (35.7 to 76.0)	49.0 (24.9 to 73.2)	24.7 (9.6 to 39.8)	14.6 (0 to 30.2)
Eastern Asia	men	33.6 (31.3 to 36.0)	37.7 (24.9 to 50.6)	24.1 (10.0 to 38.2)	25.3 (19.7 to 31.0)	5.7 (2.0 to 9.4)
	women	26.9 (25.0 to 28.8)	47.5 (36.8 to 58.2)	34.7 (23.9 to 45.5)	30.4 (23.2 to 37.5)	10.5 (7.6 to 13.4)
South-Eastern, South-Central and Western Asia	men	31.3 (25.1 to 37.6)	35.3 (32.0 to 38.6)	27.1 (24.4 to 29.7)	31.8 (29.6 to 34.0)	10.6 (6.4 to 14.9)
	women	32.6 (27.9 to 37.2)	46.4 (34.4 to 58.5)	30.6 (28.1 to 33.0)	30.3 (24.7 to 35.8)	11.8 (8.7 to 15.0)
Southern Europe	men	37.3 (28.5 to 46.0)	47.3 (43.0 to 51.5)	23.6 (20.4 to 26.7)	31.4 (20.5 to 42.2)	7.3 (3.4 to 11.1)
	women	32.1 (24.4 to 39.8)	59.0 (49.7 to 68.3)	38.1 (32.7 to 43.5)	29.5 (21.0 to 38.0)	12.2 (7.0 to 17.3)
Northern Europe	men	45.8 (37.7 to 53.9)	40.7 (33.0 to 48.4)	24.7 (19.8 to 29.6)	29.0 (19.5 to 38.4)	8.0 (3.7 to 12.3)

	women	34.9 (27.5 to 42.3)	52.1 (47.2 to 57.0)	29.9 (22.6 to 37.2)	31.9 (24.4 to 39.4)	10.0 (5.4 to 14.6)
Western Europe	men	42.4 (37.4 to 47.4)	46.4 (40.6 to 52.2)	27.1 (24.8 to 29.4)	29.7 (20.3 to 39.1)	9.5 (5.1 to 13.9)
	women	29.3 (24.2 to 34.5)	63.0 (59.1 to 66.9)	42.7 (38.7 to 46.8)	44.5 (36.3 to 52.7)	22.2 (16.6 to 27.7)
Central and Eastern Europe	men	41,2 (34.1 to 48.2)	53.7 (44.6 to 62.8)	34.5 (26.4 to 42.5)	29.1 (23.3 to 35.0)	10.1 (4.3 to 15.9)
	women	38.4 (27.2 to 49.7)	70.8 (67.8 to 73.9)	50.6 (43.1 to 58.0)	34.4 (21.3 to 47.5)	17.9 (9.7 to 26.1)
Australia/ New Zealand	men	30.2 (20.3 to 40.0)	54.0 (44.6 to 63.4)	33.2 (28.6 to 37.8)	50.9 (45.3 to 56.4)	16.7 (14.5 to 18.9)
	women	23.8 (18.4 to 29.2)	67.1 (60.4 to 73.8)	38.2 (30.2 to 46.2)	52.7 (44.3 to 61.0)	19.6 (16.8 to 22.3)

CI denotes confidence interval;

* proportion of control among treated hypertensives;

† proportion of control among hypertensives.

Table A (Appendix). Studies' characteristics, and prevalence, awareness, treatment and control of hypertension in individual studies.

Region	Country	Year of data collection	Study population	Device	Preparation	Nr measurements/ Nr visits	Age range	Sample size	Sex	Prevalence (%)	Awareness † (%)	Treatment † (%)	Control ‡ (%)	Control † (%)
North America	Canada [21]	1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	268	Women	26.0	69.0	34.0	40.0	13.6
								259	Men	31.0	57.0	34.0	33.0	11.2
	USA [21]	1989-1990	regional sample	random-zero or standard mercury	5 min	2/1	35-64	567	Women	21.0	61.0	34.0	52.0	17.7
								450	Men	30.0	56.0	17.0	44.0	7.5
	USA [22]	1999-2002	national sample	-	-	3/1	≥20	5000	Women	29.0	69.3	56.1	63.3	35.5
								5000	Men	27.8	59.4	45.2	60.8	27.5
	USA [23]	2006*	regional sample	-	-	-	40-75>	472	Women	59.0	77.0	75.0	52.0	39.0
								220	Men	57.0	85.0	80.0	47.5	38.0
	USA [24]	2003	national sample	aneroid	5 min	2/1	45-85>	4654	Women	51.5	92.9	83.0	65.4	54.3
								6952	Men	52.2	98.6	79.3	66.1	52.3
Central, South America and Caribbean	Barbados [25]	1988	national sample	random zero	5 min	2/1	40-84	2472	Women	59.6	70.0	60.8	33.2	20.2
								1835	Men	49.8	50.4	42.6	37.0	15.8
	Antilles [26]	2001-2002	multi-site sample	electronic	5 min	3/1	<30- 50>	2979	Women	18.9	82.1	74.8	61.3	45.8
								3134	Men	19.5	47.6	34.4	38.6	13.3
	Chile [27]	2004	multi-site sample	standard mercury	30 min	2/1	15-75>	4765	Women	23.0	75.2	66.5	56.8	37.8
								3707	Men	20.0	53.8	50.2	40.2	20.2
	Guadeloupe [28]	2001-2003	regional sample	electronic	5 min	3/1	18-69	1332	Women	30.3	40.2	41.6	37.5	15.6
								1088	Men	38.2	67.6	19.5	17.3	3.4

	Cuba [29]	2001- 2002	regional sample	standard mercury	-	3/1	15-74	918	Women	17.8	85.8	71.6	68.0	48.7
								749	Men	22.8	69.2	48.1	59.6	28.9
Africa	Ghana [30]	2004	multi-site sample	electronic	5 min	2/1	16-50>	644	Women	28.0	40.3	32.6	22.2	7.2
								787	Men	31.0	27.0	23.0	21.7	5.0
	Tunisia [31]	2000-2001	regional sample	-	-	2/1	40-69	1091	Women	48.2	48.3	36.0	12.0	4.3
								746	Men	38.7	30.2	21.9	16.8	3.7
	Republic of Seychelles [32]	2004	national sample	standard mercury	30 min	3/1	25-64	687	Women	36.0	75.0	72.0	41.6	30.0
								568	Men	44.0	55.0	49.0	24.5	12.0
Eastern Asia	China [21]	1993	regional sample	random-zero or standard mercury	5 min	2/1	35-64	643	Women	36.0	63.0	31.0	21.0	6.5
								480	Men	38.0	49.0	19.0	14.0	2.7
	China [33]	1992-1994	multi-site sample	standard mercury	5 min	3/1	35-59	9906	Women	21.5	39.8	31.4	19.5	4.1
								8840	Men	24.1	34.9	23.3	19.6	2.7
	China [34]	1999	multi-site sample	-	-	2/2	≥35	5063	Women	42.2	78.0	70.0	38.0	26.6
								4640	Men	51.2	77.0	69.0	28.0	19.3
	China [35]	2000-2001	national sample	standard mercury	5 min	3/1	35-74	3927	Women	25.8	50.8	33.8	31.0	10.5
								3777	Men	28.6	39.5	23.5	26.1	6.1
	Japan [36]	1992-1995	multi-site sample	electronic	5 min	1/1	55§	6887	Women	33.0	46.0	38.0	34.2	13.0
								4415	Men	37.0	39.0	27.0	37.0	10.0
	China (Taiwan) [37]	1993-1996	multi-site sample	standard mercury	5 min	2/1¶	≥19	2460	Women	19.0	39.0	28.0	18.0	5.0
								2434	Men	26.0	22.0	13.0	18.0	2.0
	Korea [38]	2000	regional sample	standard mercury	5 min	3/1	18-92	1948	Women	24.5	33.5	28.4	27.9	7.9
								2278	Men	41.5	20.1	14.7	20.9	3.1

	Korea [39]	2001	national sample	standard mercury	5 min	2/1	20-60>	3454	Women	23.7	33.5	27.0	51.8	14.0
								2620	Men	31.5	25.9	18.6	41.4	7.7
South-Eastern, South-Central and Western Asia	Thailand [40]	2006*	regional sample	standard mercury	15 min	2/1	35-60	308	Women	18.8	79.3	31.0	44.4	13.8
								219	Men	16.4	41.7	22.2	37.5	8.3
	Turkey [41]	2003	national sample	random zero	30 min	2/1[¶]	18-80	2891	Women	36.1	47.9	20.7	22.2	8.0
								2019	Men	27.5	27.9	37.0	38.6	8.2
	India [42]	2004*	regional sample	standard mercury	15 min	3/1	≥30	1739	Women	33.4	20.7	20.5	20.2	4.1
								1441	Men	33.2	22.8	22.4	15.9	3.6
	Malaysia [43]	1996	national sample	electronic	-	2/1	≥30	11388	Women	33.9	37.0	25.0	25.0	6.0
								10003	Men	31.9	29.0	21.0	28.0	6.0
	India [44]	1999-2000	regional sample	standard mercury	5 min	2/1**	40-60	151	Women	52.3	44.3	35.4	25.0	8.9
								163	Men	56.3	33.7	22.8	38.1	8.7
	India [45]	2003*	regional sample	standard mercury	10 min	2/1	≥20	705	Women	19.9	41.4	22.1	41.9	9.3
								557	Men	23.9	34.7	15.8	38.1	6.0
	Turkey [46]	1999	regional sample	standard mercury	5 min	2/1	≥30	1040	Women	36.7	52.1	45.8	24.6	11.3
								952	Men	29.7	33.9	26.9	23.7	6.4
	India [47]	2007*	regional sample	standard mercury	5 min	2/1	20-65>	1254	Women	17.2	26.2	16.8	44.2	28.4
								1096	Men	23.2	36.9	28	47	35.7
	India [48]	2007*	regional sample	standard mercury	2 min	3/1	20-59	589	Women	29.0	60.8	49.7	28.2	14
								624	Men	26.1	45.4	35.6	18.8	6.7
Southern Europe	Greece [49]	2002-2004	regional sample	standard mercury	5 min	3/1	≥17	5924	Women	33.6	55.4	30.9	32.4	10.0
								5616	Men	28.5	44.6	19.7	33.3	6.6

	Italy [21]	1993-1994	regional sample	random-zero or standard mercury	5 min	2/1	35-64	666	Women	31.0	43.0	31.0	14.0	4.3
								651	Men	41.0	38.0	24.0	45.0	10.8
	Italy [21]	1994	regional sample	random-zero or standard mercury	5 min	2/1	35-64	689	Women	41.0	48.0	25.0	31.0	7.8
								685	Men	54.0	45.0	13.0	13.0	1.7
	Spain [21]	1994-1996	regional sample	random-zero or standard mercury	5 min	2/1	35-64	1211	Women	20.0	83.0	49.0	48.0	23.5
								1398	Men	19.0	62.0	31.0	67.0	20.8
	Portugal[50]	2003	national sample	electronic	5 min	3/1	18-90	2737	Women	38.9	56.1	48.1	32.1	15.4
								2286	Men	49.5	36.0	30.6	23.4	7.2
	Greece [51]	2001	regional sample	standard mercury	5 min	2/1	20-86	15883	Women	43.8	60.2	51.4	27.3	14.0
								11030	Men	45.2	46.4	37.6	27.0	10.2
	Greece [52]	1998	regional sample	standard mercury	5 min	3/1	15-73	892	Women	28.7	25.4	14.8	21.1	3.1
								1045	Men	32.1	13.4	9.6	15.6	1.5
	Greece [53]	2001-2002	regional sample	aneroid	30 min	3/1	35-75	1154	Women	24.0	81.9	60.5	30.3	22.8
								1128	Men	38.0	79.4	35.3	37.7	10.7
	Italy [54]	1983-1985	regional sample	standard mercury	5 min	3/1	30-79	1972	Women	46.0	70.0	47.0	22.0	12.0
								1576	Men	41.0	64.0	41.0	24.0	11.0
	Spain [55]	2004	regional sample	standard mercury	5 min	2/1	18-104	1548	Women	20.7	61.3	47.6	37.5	18.8
								1336	Men	31.1	42.4	27.9	34.9	10.6
Northern Europe	Denmark [21]	1991-1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	611	Women	23.0	55.0	26.0	39.0	10.1
								607	Men	34.0	33.0	19.0	13.0	2.5
	Finland [21]	1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	610	Women	49.0	65.0	26.0	31.0	8.1
								568	Men	56.0	58.0	24.0	23.0	5.5

	Finland [21]	1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	595	Women	46.0	60.0	23.0	25.0	5.8
								508	Men	58.0	57.0	26.0	20.0	5.2
	Finland [21]	1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	627	Women	43.0	51.0	21.0	28.0	5.9
								569	Men	60.0	43.0	15.0	32.0	4.8
	Sweden [21]	1994-1996	regional sample	random-zero or standard mercury	5 min	2/1	35-64	749	Women	33.0	38.0	25.0	12.0	3.0
								644	Men	46.0	33.0	19.0	18.0	3.4
	Sweden [21]	1994	regional sample	random-zero or standard mercury	5 min	2/1	35-64	596	Women	28.0	56.0	25	30.0	7.5
								568	Men	39.0	38.0	18.0	28.0	5.0
	UK [21]	1991-1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	797	Women	32.0	36.0	17.0	39.0	6.6
								812	Men	45.0	30.0	13.0	31.0	4.0
	UK [21]	1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	727	Women	31.0	51.0	28.0	42.0	11.8
								678	Men	44.0	34.0	20.0	40.0	8.0
	England [56]	1998	national sample	electronic	5 min	3/1	≥16	6307	Women	33.3	52.5	38.0	28.2	10.7
								5222	Men	41.5	25.7	25.7	31.1	8.0
	England [57]	2003	national sample	electronic	5 min	3/1	≥16	4555	Women	30.1	63.9	52.4	43.9	23.0
								4279	Men	33.1	59.7	43.1	47.8	20.6
Western Europe	Germany (SHIP) [58]	1997-2001	regional sample	electronic	5 min	3/1[II]	25-74	1921	Women	38.5	71.3	50.9	40.9	20.8
								1823	Men	60.1	57.6	34.6	24.3	8.4
	Germany (KORA) [58]	1997-2001	regional sample	electronic	5 min	3/1[II]	25-74	2151	Women	28.6	73.6	51.3	48.1	24.7
								2073	Men	41.4	55.0	28.2	36.2	10.2
	Belgium [21]	1990-1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	517	Women	22.0	78.0	54.0	63.0	34.0
								487	Men	35.0	44.0	24.0	49.0	11.8

	Germany [21]	1994-1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	872	Women	34.0	59.0	31.0	32.0	9.9
								819	Men	46.0	52.0	21.0	12.0	2.5
	Germany [21]	1994-1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	669	Women	38.0	54.0	27.0	40.0	10.8
								658	Men	47.0	43.0	18.0	20.0	3.6
	Germany [21]	1991-1992	regional sample	random-zero or standard mercury	5 min	2/1	35-64	432	Women	32.0	62.0	48.0	43.0	20.6
								394	Men	40.0	49.0	28.0	16.0	4.5
	Switzerland [21]	1992-1993	regional sample	random-zero or standard mercury	5 min	2/1	35-64	770	Women	23.0	68.0	37.0	60.0	22.2
								733	Men	37.0	53.0	22.0	27.0	5.9
	France [59]	1997-1998	national sample	electronic	5 min	3/1	<30-50>	12267	Women	14.7	52.3	41.0	52.2	21.4
								17359	Men	27.3	33.4	21.7	34.1	7.4
	Netherlands [60]	2001-2003	regional sample	electronic	5min	2/1	35-60	808	Women	26.4	71.8	30.9	45.4	49.8
								575	Men	41.4	54.7	33.1	41.7	23.8
	Netherlands [61]	2000-2004	regional sample	electronic		2/1	20-60>	2729	Women	17.0	47.0	29.0	50.7	14.2
								2221	Men	31.2	24.8	14.0	32.3	4.5
	Netherlands [62]	2004	regional sample	electronic	5 min	2/1	18-65>	696	Women	34.3	53.1	52.5	16.4	8.6
								608	Men	47.6	36.2	28.2	29.9	8.4
Central and Eastern Europe	Poland[21]	1993	regional sample	random-zero or standard mercury	5 min	2/1	35-64	763	Women	35.0	64.0	40	24.0	9.6
								751	Men	44.0	51.0	20.0	29.0	5.8
	Russia [21]	1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	598	Women	46.0	81.0	52.0	52.0	27.0
								586	Men	48.0	55.0	38.0	37.0	14.1
	Russia [21]	1994-1995	regional sample	random-zero or standard mercury	5 min	2/1	35-64	656	Women	54.0	65.0	41.0	32.0	13.1
								623	Men	45.0	42.0	20.0	21.0	4.2

	Poland [63]	2002	national sample	electronic	-	3/1	18-93	1525	Women	29.0	73.0	59.0	21.5	14.0
								1526	Men	29.0	60.0	50.0	21.2	10.0
	Czech Republic [64]	2000-2001	multi-site sample	standard mercury	5 min	3/1	25-64	1693	Women	31.1	73.4	60.7	41.9	25.4
								1627	Men	42.3	63.0	44.3	37.0	16.4
Australia/ New Zealand	Australia[21]	1994	regional sample	random-zero or standard mercury	5 min	2/1	35-64	688	Women	29.0	66.0	41.0	47.0	19.3
								637	Men	38.0	51.0	33.0	47.0	15.5
	New Zealand [21]	1993-1994	regional sample	random-zero or standard mercury	5 min	2/1	35-64	727	Women	23.0	73.0	32.0	57.0	18.2
								745	Men	26.0	62.0	29.0	53.0	15.4

* Year of publication of the study, as year of survey was not reported;

†Proportion of treatment and control among the hypertensives;

‡Proportion of control among treated;

§Median age, as age range not described;

‖ Mean of the second and third measurements;

¶ If the difference between the first two measurement results was higher than 10 mmHg, a third measurement was made;

** If the difference between the first two measurement results was higher than 4 mmHg, a third measurement was made.

3.2. Awareness, treatment and control of hypertension in a Portuguese general population – distribution and determinants

AWARENESS, TREATMENT AND CONTROL OF HYPERTENSION IN A PORTUGUESE GENERAL POPULATION – DISTRIBUTION AND DETERMINANTS

Abstract

Introduction: We studied the determinants of awareness, treatment and control of hypertension (HT) in a representative sample of urban adults of Porto, Portugal.

Methods: Cross-sectional evaluation of 2310 community participants aged ≥18 years, randomly selected from the urban population of Porto. The mean (standard deviation) age was 53 (15) years for women and 54 (16) years for men and 61.5% were women. Participants attended an interview and clinical examination at our department, including blood pressure (BP) measurements, from 1999 to 2003. Hypertension was defined as blood pressure ≥140/90mmHg, considering 2 measurements on one day, and/or being medicated with antihypertensive drugs. The proportions of awareness, treatment and control were estimated among all hypertensives.

Results: The prevalence (95% confidence interval (CI)) of HT was 42.7% (40.0-45.3) in women and 46.7% (43.0-50.3) in men. Among the 707 women and 477 men with HT, the prevalence of awareness, drug treatment and control was, respectively, 58.9% (54.2-61.7), 51.2% (47.4-55.0) and 11.8% (9.3-14.2) among women and, 41.3% (36.6-46.0), 34.6% (30.1-39.1) and 7.9% (5.3-10.5) among men. In multivariate analysis, awareness of HT was positively associated with age in both genders, with diabetes among women, and with body mass index (BMI) among men. Among women, users of private practices as the main source of health care were less likely to be aware of HT. Single, widower and divorced men were less likely to be aware of their HT, in comparison with married/civil union men. In both genders, treatment was positively associated with age and diabetes and inversely with physical activity. BMI was positively associated with treatment only among men. Ethanol intake was associated with a lower likelihood of BP control in both genders. In men, control of HT was observed more often among diabetics and decreased with BMI.

Conclusion: We found a relatively low proportion of awareness, treatment and control of HT in both genders, particularly among men. The identified factors provide important information for improving BP prevention and control in this population. The concurrent presence of additional cardiovascular risk factors was in general not associated with a higher probability of treatment and control, although the proportional contribution of patients and the health care system to this situation could not be assessed.

Introduction

Hypertension (HT) is quantitatively the largest risk factor for cardiovascular diseases (CVD)[1]. The risks of elevated blood pressure (BP) have been determined from large-scale epidemiologic surveys, showing a strong, continuous and etiologically significant positive association with CVD[2, 3]. In Portugal, cerebrovascular disease, the outcome that is most strongly associated with HT, is the main cause of death and disability[4].

High BP has evolved to epidemic proportions, requiring population-based strategies for effective control and prevention. The effects of blood-pressure-lowering regimens on major cardiovascular events are well established, based on randomized controlled trials, and higher reductions in BP levels produce higher reductions in risk of major cardiovascular events[5]. However, naturally low BP levels may offer a degree of protection not provided by similarly low BP resulting from antihypertensive therapy [6-8].

In Portugal, a national population-based study conducted in 2003 showed that 3,311,830 (42.1%) people had HT, 46.1% of these were aware of their high BP, 39.0% were taking antihypertensive medication, and 11.2% had their blood pressure controlled (<140/90 mmHg)[9]. It is important to understand which factors explain these estimates, in order to identify barriers to prevention that must be overcome.

The aim of this study was to identify the determinants of awareness, treatment and control of HT in a representative sample of urban adults from Porto, Portugal.

Methods

In a population-based cohort of 2485 subjects aged ≥ 18 years and with baseline information collected between 1999 and 2003, recruitment was made using random digit dialing to select households in the city of Porto and subsequent simple randomization of a person aged or exceeding 18 years in each household. Selection was stratified in two age categories, with oversampling of subjects aged ≥ 40 years. In this process refusals were not replaced in the same household and the proportion of participation was 70% [10]. The investigation conforms to the principles in the Declaration of Helsinki. The local ethics committee approved the study and participants provided written informed consent.

Participants were invited to visit our department for an interview and clinical examination. The Mini-Mental State Examination was used for the rapid evaluation of cognitive impairment in individuals aged over 64 years. Those participants who scored <24 were considered unable to provide reliable information and were excluded in the analysis of the determinants obtained by questionnaire (tobacco smoking, ethanol

intake, physical activity, family history of cardiovascular disease, marital status and main setting for health care).

Blood pressure (BP) was measured on a single occasion by non-physician trained interviewers, following the recommendations of the American Heart Association [11]. Participants were instructed to take their medication and not to take alcohol, tea/coffee, smoke or practise exercise in the 30 minutes preceding the measurement. Two measurements of blood pressure separated by at least 5 minutes were taken with a mercury sphygmomanometer after 10-minute rest, with no tight clothes, on the right upper arm and at the heart level. The mean was considered and when the difference was larger than 5 mmHg for systolic or diastolic BP a third measurement was taken and the mean of the 2 closest values was registered. Systolic BP was identified by phase I Korotkoff sound and diastolic BP by phase V.

Arterial hypertension was defined as systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg and/or current antihypertensive drug therapy [12]. Awareness of HT was defined as ever having been diagnosed with HT by a health professional. Antihypertensive medication was considered after review of all the medicines taken chronically in the previous year by the participant. Control was defined as the proportion with systolic BP <140 mmHg and diastolic BP < 90 mmHg, among all hypertensive subjects. The proportions of awareness, treatment and control are expressed among all hypertensives.

Education was recorded as completed years of schooling and divided into three categories; ≤4, 5–11 and ≥12 years. Anthropometric measurements were obtained after a 12-hour overnight fast, with the participant wearing light clothing and no footwear. Body weight was measured to the nearest 0.1 kg using a digital scale, and height was measured to the nearest centimetre in the standing position using a wall stadiometer. Body mass index was calculated as weight (kg) divided by squared height (m^2). The World Health Organization reported the following categories for BMI[13]: obese (≥30 kg/m^2), overweight (25.0–29.9 kg/m^2), normal (18.5–24.9 kg/m^2) and underweight (<18.5 kg/m^2). The small number of underweight participants in this study made accurate inferences about this group impossible. Therefore, this category was joined in normal weight. The waist circumference was measured midway between the lower limit of the rib cage and the iliac crest and was classified according to the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (ATPIII)[14].

An overnight fasting serum sample was obtained to assess concentrations of total cholesterol, low-density lipoprotein (LDL)-cholesterol, high-density lipoprotein (HDL)-cholesterol, triglycerides, creatinine clearance and glucose. Participants were

classified according to tertiles of total cholesterol/HDL and triglycerides. Participants on anti-diabetic therapy and/or with fasting plasma glucose concentrations ≥126 mg/mL and/or diagnosed with diabetes by a health professional were considered to have diabetes[15]. We estimated creatinine clearance using the Cockcroft–Gault formula[16] and we categorized it as moderate-severe renal failure if < 60 ml/min, mild renal failure if 60-89 ml/min and normal if ≥ 90 ml/min[17].

Data concerning alcohol consumption, type of alcoholic beverage (wine, beer, and spirits) and lifetime alcohol consumption (exposure time, type of alcoholic beverage, frequency, and amount consumed) were assessed using a questionnaire. A photographic album was used to help the definition of the average portion size. The quantity of ethanol (grams (g) /week) was estimated by the multiplication of the quantity and frequency intake of each drink by their alcohol content.

Physical activity was evaluated using a questionnaire exploring all professional, domestic and leisure-time activities, detailing the intensity, duration and frequency for each activity. Total activity was quantified as metabolic equivalent per day (metabolic equivalent (MET)/day) and the subjects were classified according to tertiles.

Family history of CVD included events of stroke, sudden death and myocardial infarction in parents and siblings. We considered the event that occurred at the youngest age if more than one was documented. Marital status was grouped into married/civil union and single, widow(er) or divorced/separated. Family history of CVD, smoking habits, marital status and main setting for health care were self-reported.

Data are described using counts and proportions. Tertiles were identified separately for each sex in all variables. Unconditional logistic regression was used to estimate odds ratios (OR) for the association of independent variables and awareness, treatment and control of HT. A multivariate analysis using logistic regression was conducted to study the independent role of these factors. All variables that were associated with the outcome in univariate analysis were included in the model at first, except for smoking because the associations with ex-smoking status were interpreted as non-causal. Then, we removed the variables that had no significant association with the outcome and no confounding role on the effect of other predictors, one at a time, until the final model. Results are reported as OR and 95% confidence intervals (CI). All analyses were weighted according to the known age structure of the population of Porto, obtained from census data in 2001, to account for the sampling procedure.

Results

Among the 2485 participants in the study, 175 were excluded from this analysis due to lack of information on BP. The characteristics of the remaining 2310 participants are presented in table 1. The mean (standard deviation) age was 53 (15) years for women and 54 (16) years for men and 61.5% were women. Overall, this population has low levels of education, a high prevalence of overweight/obesity and very low physical activity levels. Ethanol intake was high among men (median 226g/week) and low among women (15g/week), with 504 (38.2%) women reporting no alcohol intake at all.

The prevalence (95% confidence interval) of hypertension was 42.7% (40.0-45.3) in women and 46.7% (43.0-50.3) in men. Among the 1184 subjects with HT (707 women and 477 men), the prevalence of awareness, drug treatment and control was, respectively, 58.9% (54.2-61.7), 51.2% (47.4-55.0) and 11.8% (9.3-14.2) among women and, 41.3% (36.6-46.0), 34.6% (30.1-39.1) and 7.9% (5.3-10.5) among men. Among treated hypertensives, 23.0% (18.6-27.5) of women and 22.8% (16.1-29.5) of men fulfilled criteria for control.

The OR (95% confidence interval) for the association between gender and awareness, treatment and control of HT, taking women as reference and adjusting for age, were 0.58 (0.45-0.74), 0.58 (0.45-0.75) and 0.64 (0.42-0.98), respectively.

In univariate analysis, awareness of HT was associated with increasing age, BMI and waist circumference in both genders. It was associated with higher educational level, diabetes and using public services as the main source of health care only among women and being married or living under civil union only among men (table 2).

In crude analysis, drug treatment for HT was positively associated with age, BMI, waist circumference, renal dysfunction and diabetes, and inversely with physical activity (table 3). The association between marital status and treatment took opposite directions in women and men, with single, widow or divorced women and married/civil union men being more likely to be treated.

In both genders, increasing BMI and ethanol intake were associated with a lower likelihood of achieving BP control (table 4). Physical activity was associated with a lower prevalence of control of HT among women, while education and diabetes were associated with a higher prevalence of control of HT among men.

In multivariate analysis (table 5), awareness of HT was positively associated with age in both genders, with diabetes among women, and with body mass index (BMI) among men. Among women, users of private practices as the main source of health care were less likely to be aware of HT. Single, widower and divorced men were less likely to be aware of their HT, in comparison with married/civil union men. In both

genders, treatment was positively associated with age and diabetes and inversely with physical activity. BMI was positively associated with treatment only among men. Ethanol intake was associated with a lower likelihood of BP control in both genders. In men, control of HT was observed more often among diabetics and decreased with BMI.

Discussion

In this study, we report an overall high prevalence of HT and low prevalence of awareness, treatment and control of HT. Age was an important non-modifiable factor strongly associated with awareness and treatment of HT in both genders, but we also found several modifiable factors like alcohol consumption, suggesting that a more effective control of HT could be achieved through lifestyle modifications, assuming this association is causal.

Data from the EPIPorto cohort are consistent with data already published in our country[9], with high prevalence and low proportion of control, and fit into the overall context of Southern Europe[18]. The low proportion of people aware, treated and controlled emphasizes the importance of developing strategies for primary prevention, correct diagnosis and the urgency to increase the efficiency of existing treatments. According to similar surveys in the 1990s, control has been achieved in 29% of hypertensives in United States, 17% in Canada, but in fewer than 10% in five European countries (England, Germany, Italy, Spain, and Sweden)[19]. More recently, some improvement has been observed in the United States, with a control rate around 34%[20].

Data showing the association between gender and HT control have been contradictory. Several studies described that females are more successful in the control of hypertension[21, 22], others showed no difference by gender[23] and others announce that BP control is more easily achieved in men [24, 25]. In our study, we found that women had higher levels of awareness, treatment and control than men.

In multivariate analysis, older age was independently and positively associated with awareness and treatment of HT and these results are consistent with other studies [26-28]. We did not find any significant association between age and control of HT. However, it is documented that older groups are less likely to have their BP controlled [29] despite their higher awareness and treatment rates. In fact, it is well established that higher awareness and treatment does not necessarily translate into better BP control. This could be due to higher noncompliance in the older groups, namely due to difficulties in affording antihypertensive medications and following instructions on medication[30].

We used education as a marker of socioeconomic status. Awareness and treatment of HT decreased with education among women and HT control increased with education among men, but these associations were explained by confounding by other factors. However, even the crude associations were weak and not observed in all groups, suggesting that higher levels of education do not translate into more health conscious behaviors in this population.

The worldwide tendency is that populations are growing older and more obese. With weight gain, BP usually increases, and the increasing prevalence of overweight is likely responsible for the significant increase in BP in all ages, including children and adolescents[31]. Overweight and obese men were more likely to be aware of their HT and treated, but less likely to be controlled. This could be explained by patient's non-compliance and/or by inappropriate management by physicians, because more aggressive treatment is recommended when the patient is obese [26, 28, 32]. The hemodynamic profile of obese subjects justifies the specific recommendations, because it is characterized by high cardiac output, high plasma and total blood volume, and inappropriately normal to total peripheral resistance[33]. Waist circumference was not an independent risk factor for the outcomes, mainly because this variable was partly explained by BMI.

The increasingly recognized importance of global absolute cardiovascular risk led to strong recommendations for more aggressive treatment on hypertensive subjects with multiple risk factors[34]. In contrast with the San Marino cohort, in which an association between hypertension awareness, treatment and control and metabolic abnormalities was reported[35], we did not observe increasing awareness, treatment and control with total cholesterol/HDL or triglycerides. Possibly, this is related with the cross-sectional nature of this study and the fact that we did not take lipid-lowering therapy into account, because in principle subjects under better health care are more likely to be aware and treated for both HT and dyslipidemia. Thus, a putative association may have been changed by interventions on lipids.

Diabetic women were more likely than non-diabetics to be aware of their HT and treated, but this did not lead to improvement in control, even when defining control as BP<140/90mmHg which by itself is not according to the lower thresholds recommended for diabetics[36]. Given the overall more health-conscious attitude and behavior of women, it might be speculated that insufficient treatment is an important factor in this group. On the other hand, men with diabetes were more likely to have treated and controlled HT, despite no improvement in awareness. This suggests, in line with the observed effect of marital status, that men are more passive in their own care

and depend on third parties, including spouses and health care workers, for the control of their risk.

Hypertensive patients with renal dysfunction constitute a subgroup at particularly high risk and for whom more intensive treatment and follow up is recommended. The fact that we did not observe a significant association with awareness, treatment and control likely reflects two mechanisms. On one hand, there could be reverse causation in that patients with inadequately managed and uncontrolled HT have renal dysfunction as a consequence. On the other hand, mild renal dysfunction may have been overlooked in many patients, given the frequently almost normal serum creatinine levels observed when the creatinine clearance is already meaningfully decreased.

In several epidemiological studies, BP levels among current smokers were the same as, or lower than, in non-smokers[37]. Male ex-smokers were more likely to be treated and controlled compared with non-smokers. This fact could be explained by a possible clinical event or recommendation that led to lifestyle changes, so the individuals stopped smoking and took special care to hypertension, in order to diminish the global risk for cardiovascular disease.

The relationship between ethanol intake and BP is multifactorial and contradictory[38]. We found a strong inverse association between alcohol intake and BP control, in both men and women. This association was already described in other populations, namely because alcohol attenuates the effects of antihypertensive drug therapy [39]. It is noteworthy that this effect was also found in women, for quantitatively very low intakes.

According to a recent meta-analysis of randomized controlled trials, aerobic training reduces resting and daytime ambulatory BP[40] and even moderate levels of exercise lower BP[41]. We report an inverse association between physical activity and BP treatment in men and women. This likely results from confounding by the severity of HT and reverse causation by the consequences of HT, that is, patients with more severe HT may have already had complications such as major cardiovascular events and the disability that results from these events precludes the practice of physical activity. We included this variable in the final model because it has an important confounding effect on the other variables.

We anticipated that family history of CVD would be strongly associated with HT awareness, because a family history of CVD should draw attention upon cardiovascular risk factors. However, this association was not confirmed after adjustment for the other variables in the model.

The differential effect of marital status by gender is related with sociological characteristics of this population, particularly in older birth cohorts. Apparently, men are less in control of their own health status, which is according to empirical impressions we have on this issue.

In attempting to separate differences attributable to subjects' characteristics and to their health care, we compared users of public and private systems as the main source for health care. The only effect was observed for a lower prevalence of awareness of HT among female users of private health care. The main explanation for this finding is probably related with the fact that most of these cases of HT were on average milder than those managed in public care. People are in general more likely to be aware of more severe than milder HT.

This study has four main limitations. First, the cross-sectional design did not allow us to exclude reverse causation as the main explanation for some of the associations reported. Second, since both awareness and treatment and several of the studied factors were defined relying on self-reported information, there could have been information bias and, moreover, it was most likely differential. Third, we were only able to considerer the pharmacological treatment in the treatment concept. This is reductive because lifestyle changes are a fundamental part for BP control and should be considered as part of treatment. Lastly, the statistical power to test hypotheses regarding determinants of control of HT was low, given the small absolute number of hypertensive subjects with controlled BP.

The low proportion of awareness, treatment and control of HT emphasizes the importance of developing strategies for primary and secondary prevention, of the correct diagnosis and the urgency to increase the efficiency of existing treatments. The identified factors provide important information for improving BP prevention and control among this population, through identification and lifestyle modification of persons with HT.

Acknowledgments

This study was funded by a grant from Fundação para a Ciência e a Tecnologia (POCI/SAU-ESP/61492/2004).

References

1. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL. Selected major risk factors and global and regional burden of disease. *Lancet.* 2002;360:1347-1360.

2. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet.* 2002;360:1903-13.

3. Lawes CM, Rodgers A, Bennett DA, Parag V, Suh I, Ueshima H, MacMahon S. Blood pressure and cardiovascular disease in the Asia Pacific region. *J Hypertens.* 2003;21:707-16.

4. World Health Organization. *The world health report 2004 - changing history.* Geneve: WHO; 2004.

5. Turnbull F. Effects of different blood-pressure-lowering regimens on major cardiovascular events: results of prospectively-designed overviews of randomised trials. *Lancet.* 2003;362:1527-35.

6. Andersson OK, Almgren T, Persson B, Samuelsson O, Hedner T, Wilhelmsen L. Survival in treated hypertension: follow up study after two decades. *BMJ.* 1998;317:167-71.

7. Thurmer HL, Lund-Larsen PG, Tverdal A. Is blood pressure treatment as effective in a population setting as in controlled trials? Results from a prospective study. *J Hypertens.* 1994;12:481-90.

8. Clausen J, Jensen G. Blood pressure and mortality: an epidemiological survey with 10 years follow-up. *J Hum Hypertens.* 1992;6:53-9.

9. Macedo ME, Lima MJ, Silva AO, Alcantara P, Ramalhinho V, Carmona J. Prevalence, awareness, treatment and control of hypertension in Portugal: the PAP study. *J Hypertens.* 2005;23:1661-6.

10. Ramos E, Lopes C, Barros H. Investigating the effect of nonparticipation using a population-based case-control study on myocardial infarction. *Ann Epidemiol.* 2004;14:437-441.

11. Perloff D, Grim C, Flack J, Frohlich ED, Hill M, McDonald M, Morgenstern BZ. Human blood pressure determination by sphygmomanometry. *Circulation.* 1993;88:2460-70.

12. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., Jones DW, Materson BJ, Oparil S, Wright JT, Jr., Roccella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA.* 2003;289:2560-72.

13. Expert Panel on the Identification, Evaluation, and Treatment of Overweight in Adults, Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults: executive summary. *Am J Clin Nutr.* 1998;68:899-917.

14. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA.* 2001;285:2486-97.

15. World Health Organization. *Diabetes mellitus: report of a WHO study group. Technical report Series 727.* Geneva: WHO; 1985.

16. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron.* 1976;16:31-41.

17. Levey AS, Eckardt KU, Tsukamoto Y, Levin A, Coresh J, Rossert J, De Zeeuw D, Hostetter TH, Lameire N, Eknoyan G. Definition and classification of chronic kidney disease: a position statement from Kidney Disease: Improving Global Outcomes (KDIGO). *Kidney Int.* 2005;67:2089-100.

18. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J Hypertens.* 2004;22:11-9.

19. Wolf-Maier K, Cooper RS, Banegas JR, Giampaoli S, Hense H-W, Joffres M, Kastarinen M, Poulter N, Primatesta P, Rodriguez-Artalejo F, Stegmayr B, Thamm M, Tuomilehto J, Vanuzzo D, Vescio F. Hypertension Prevalence and Blood Pressure Levels in 6 European Countries, Canada, and the United States. *JAMA.* 2003;289:2363-2369.

20. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., Jones DW, Materson BJ, Oparil S, Wright JT, Jr., Roccella EJ, the National High Blood Pressure Education Program Coordinating C. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension.* 2003;42:1206-1252.

21. Stockwell DH, Madhavan S, Cohen H, Gibson G, Alderman MH. The determinants of hypertension awareness, treatment, and control in an insured population. *Am J Public Health.* 1994;84:1768-1774.

22. Alexander M, Tekawa I, Hunkeler E, Fireman B, Rowell R, Selby JV, Massie BM, Cooper W. Evaluating Hypertension Control in a Managed Care Setting. *Arch Intern Med.* 1999;159:2673-2677.

23. Knight EL, Bohn RL, Wang PS, Glynn RJ, Mogun H, Avorn J. Predictors of Uncontrolled Hypertension in Ambulatory Patients. *Hypertension.* 2001;38:809-814.

24. Hicks LS, Fairchild DG, Horng MS, Orav EJ, Bates DW, Ayanian JZ. Determinants of JNC VI Guideline Adherence, Intensity of Drug Therapy, and Blood Pressure Control by Race and Ethnicity. *Hypertension.* 2004;44:429-434.

25. Majernick TG, Zacker C, Madden NA, Belletti DA, Arcona S. Correlates of hypertension control in a primary care setting. *Am J Hypertens.* 2004;17:915-920.

26. Wang Y, Wang QJ. The prevalence of prehypertension and hypertension among US adults according to the new joint national committee guidelines: new challenges of the old problem. *Arch Intern Med.* 2004;164:2126-34.

27. Agyemang C, Bruijnzeels MA, Owusu-Dabo E. Factors associated with hypertension awareness, treatment, and control in Ghana, West Africa. *J Hum Hypertens.* 2006;20:67-71.

28. Muntner P, Gu D, Wu X, Duan X, Wenqi G, Whelton PK, He J. Factors associated with hypertension awareness, treatment, and control in a representative sample of the chinese population. *Hypertension.* 2004;43:578-85.

29. Hyman DJ, Pavlik VN. Characteristics of Patients with Uncontrolled Hypertension in the United States. *N Engl J Med.* 2001;345:479-486.

30. Yiannakopoulou E, Papadopulos JS, Cokkinos DV, Mountokalakis TD. Adherence to antihypertensive treatment: a critical factor for blood pressure control. *Eur J Cardiovasc Prev Rehabil.* 2005;12:243-9.

31. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. *JAMA.* 2004;291:2107-13.

32. Chen R, Tunstall-Pedoe H, Morrison C, Connaghan J, A'Brook R. Trends and social factors in blood pressure control in Scottish MONICA surveys 1986-1995: the rule of halves revisited. *J Hum Hypertens.* 2003;17:751-9.

33. Wofford MR, Smith G, Minor DS. The treatment of hypertension in obese patients. *Curr Hypertens Rep.* 2008;10:143-50.

34. Mancia G, De Backer G, Dominiczak A, Cifkova R, Fagard R, Germano G, Grassi G, Heagerty AM, Kjeldsen SE, Laurent S, Narkiewicz K, Ruilope L, Rynkiewicz A, Schmieder RE, Boudier HA, Zanchetti A. 2007 ESH-ESC Practice Guidelines for the Management of Arterial Hypertension: ESH-ESC Task Force on the Management of Arterial Hypertension. *J Hypertens.* 2007;25:1751-62.

35. Mancia G, Parati G, Borghi C, Ghironzi G, Andriani E, Marinelli L, Valentini M, Tessari F, Ambrosioni E. Hypertension prevalence, awareness, control and association with metabolic abnormalities in the San Marino population: the SMOOTH study. *J Hypertens.* 2006;24:837-43.

36. Standards of medical care in diabetes--2008. *Diabetes Care.* 2008;31 Suppl 1:S12-54.

37. Seltzer CC. Effect of smoking on blood pressure. *Am Heart J.* 1974;87:558-64.

38. Klatsky AL. Alcohol and cardiovascular disease--more than one paradox to consider. Alcohol and hypertension: does it matter? Yes. *J Cardiovasc Risk.* 2003;10:21-4.

39. Puddey IB, Beilin LJ, Vandongen R. Regular alcohol use raises blood pressure in treated hypertensive subjects. A randomised controlled trial. *Lancet.* 1987;1:647-51.

40. Cornelissen VA, Fagard RH. Effects of endurance training on blood pressure, blood pressure-regulating mechanisms, and cardiovascular risk factors. *Hypertension.* 2005;46:667-75.

41. Fagard RH. Exercise characteristics and the blood pressure response to dynamic physical training. *Med Sci Sports Exerc.* 2001;33:S484-92; discussion S493-4.

Table 1. Characteristics of the participants.

Characteristic			Women (N=1421; 61.5%) n (%)	Men (N=889; 38.5%) n (%)
Age (years)	≤ 45		434 (30.5)	271 (30.5)
	46-60		523 (36.8)	293 (33.0)
	≥ 61		464 (32.6)	325 (36.6)
Education (years)	≤ 4		624 (43.9)	290 (32.7)
	5-11		367 (25.8)	314 (35.4)
	≥12		430 (30.3)	282 (31.8)
BMI (Kg/m^2)	<25		515 (36.8)	323 (36.8)
	25-29.9		522 (37.3)	415 (47.3)
	≥30		363 (25.9)	139 (15.9)
Waist circumference (cm)	Women	Men		
	<88	<102	835 (58.8)	729 (82.0)
	≥88	≥102	568 (40.5)	149 (17.0)
Total cholesterol/HLD	Women	Men		
1st third	≤3.1	≤3.8	400 (30.3)	279 (33.8)
2nd third	3.1-4.1	3.8-4.9	451 (34.2)	268 (32.4)
3rd third	>4.1	>4.9	469 (35.5)	279 (33.8)
Triglycerides (mg/dL)	Women	Men		
1st third	≤85	≤77	449 (33.7)	280 (33.1)
2nd third	85-136	77-115	434 (32.6)	279 (32.9)
3rd third	>136	>115	448 (33.7)	288 (34.0)
Creatinine clearance (mL/min)	≥90		231 (18.0)	285 (35.1)
	60-89		686 (53.5)	377 (46.4)
	<60		366 (28.5)	150 (18.5)
Diabetes	No		1319 (93.0)	814 (91.6)
	Yes		100 (7.0)	75 (8.4)
Tobacco*	never smoker		1002 (72.5)	244 (27.9)
	ex-smoker		143 (10.3)	325 (37.2)
	current smoker		237 (17.2)	305 (34.9)
Ethanol* (g/week)	Women	Men		
	<15.0	<226.0	660 (50.0)	408 (50.0)
	≥15.0	≥226.0	661 (50.0)	408 (50.0)
Physical activity* (MET/day)	Women	Men		
1st third	≤33.5	≤33.0	461 (33.4)	284 (32.7)
2nd third	33.5-36.6	33.0-37.7	451 (32.7)	284 (32.7)
3rd third	>36.6	>37.7	467 (33.9)	301 (32.6)
Family history of cardiovascular disease*	No		457 (43.0)	334 (51.2)
	Yes, age <55		118 (11.1)	55 (8.4)
	Yes, age 55-65		162 (15.3)	80 (12.2)
	Yes, age >65		301 (28.3)	157 (24.0)
	Does not know		24 (2.3)	27 (4.1)
Marital status	Married/civil union		851 (59.9)	712 (80.2)
	All others		570 (40.1)	176 (19.8)
Main setting for health care	Public		979 (70.4)	555 (64.0)
	Private		235 (16.9)	138 (15.9)
	Other/none		177 (12.7)	174 (20.1)

*Participants who scored <24 in the Mini-Mental State Examination were classified as unable to provide reliable information in this variables and were excluded for this analysis.

Table 2. Crude odds ratios (OR) for factors associated with awareness of hypertension, among women and men.

Awareness of HT			Women		Men	
Determinants			**Awareness of HT n (%)**	**Crude OR (95% CI)**	**Awareness of HT n (%)**	**Crude OR (95% CI)**
Age (years)		≤ 45	20 (33.9)	1	20 (24.7)	1
		46-60	150 (56.8)	3.37 (1.81-6.25)	66 (46.5)	2.95 (1.55-5.62)
		≥ 61	250 (65.3)	4.81 (2.62-8.82)	127 (50.4)	3.45 (1.88-6.33)
Education (years)		≤ 4	283 (65.1)	1	90 (46.9)	1
		5-11	80 (50.6)	0.51 (0.35-0.75)	71 (41.5)	0.67 (0.43-1.04)
		≥12	57 (50.4)	0.46 (0.30-0.70)	52 (46.8)	0.79 (0.47-1.03)
BMI (Kg/m^2)		<25	68 (48.6)	1	39 (31.5)	1
		25-29.9	177 (62.3)	2.02 (1.32-3.07)	119 (48.6)	2.29 (1.42-3.70)
		≥30	169 (61.7)	2.03 (1.33-3.08)	53 (52.0)	2.62 (1.47-4.69)
Waist circumference (cm)	Women	Men				
	<88	<102	155 (53.6)	1	150 (42.0)	1
	≥88	≥102	258 (63.4)	1.67 (1.22-2.29)	62 (53.0)	1.91 (1.22-2.98)
Total cholesterol/HDL	Women	Men				
1st third	≤3.1	≤3.8	73 (56.6)	1	60 (42.2)	1
2nd third	3.1-4.1	3.8-4.9	132 (58.7)	1.30 (0.83-2.04)	62 (44.0)	1.20 (0.72-2.00)
3rd third	>4.1	>4.9	174 (60.6)	1.41 (0.92-2.18)	79 (49.7)	1.72 (1.06-2.80)
Triglycerides (mg/dL)	Women	Men				
1st third	≤85	≤77	75 (57.2)	1	52 (41.9)	1
2nd third	85-136	77-115	116 (53.0)	0.88 (0.56-1.37)	72 (46.4)	1.35 (0.81-2.25)
3rd third	>136	>115	192 (64.0)	1.45 (0.94-2.23)	82 (46.9)	1.43 (0.86-2.35)
Creatinine clearance (mL/min)		≥90	46 (54.1)	1	58 (43.3)	1
		60-90	185 (61.1)	1.31 (0.79-2.17)	89 (46.1)	1.40 (0.86-2.26)
		<60	143 (59.6)	1.34 (0.80-2.24)	52 (46.8)	1.53 (0.90-2.61)

Diabetes	No		354 (57.3)	1	182 (44.2)	1
	Yes		64 (74.4)	2.33 (1.40-3.88)	31 (49.2)	1.35 (0.78-2.34)
Tobacco	never smoker		338 (59.2)	1	51 (41.1)	1
	ex-smoker		28 (53.8)	0.78 (0.43-1.41)	110 (50.9)	1.79 (1.11-2.89)
	current smoker		31 (62.0)	1.01 (0.54-1.88)	45 (36.3)	0.83 (0.47-1.45)
Ethanol (g/week)	Women	Men				
	<15.0	<226.0	166 (56.7)	1	87 (45.3)	1
	≥15.0	≥226.0	222 (61.3)	1.31 (0.95-1.81)	110 (43.1)	0.93 (0.62-1.40)
Physical activity (MET/day)	Women	Men				
1st third	≤33.5	≤33.0	157 (59.5)	1	79 (46.8)	1
2nd third	33.5-36.6	33.0-37.7	155 (63.3)	1.20 (0.83-1.73)	71 (47.0)	1.04 (0.66-1.66)
3rd third	>36.6	>37.7	84 (51.2)	0.70 (0.47-1.05)	54 (38.0)	0.64 (0.39-1.04)
Family history of cardiovascular disease	No		83 (50.6)	1	66 (41.5)	1
	Yes, age <55		37 (64.9)	1.65 (0.86-3.16)	18 (56.2)	1.47 (0.64-3.35)
	Yes, age 55-65		57 (59.4)	1.41 (0.84-2.38)	25 (53.2)	1.89 (0.92-3.88)
	Yes, age >65		115 (62.5)	1.75 (1.14-2.70)	42 (44.7)	1.34 (0.78-2.31)
	Don't know		12 (70.6)	2.52 (0.85-7.50)	6 (42.8)	1.27 (0.42-3.88)
Marital status	Married/civil union		247 (57.7)	1	189 (47.2)	1
	All others		173 (62.2)	1.18 (0.86-1.62)	24 (32.0)	0.29 (0.17-0.51)
Main setting for health care	Public		338 (63.9)	1	144 (45.3)	1
	Private		39 (43.8)	0.42 (0.27-0.68)	35 (50.7)	1.14 (0.65-2.02)
	Other/none		37 (49.3)	0.52 (0.32-0.86)	32 (39.5)	0.76 (0.44-1.29)

Table 3. Crude odds ratios (OR) for factors associated with treatment of hypertension, among women and men.

Treatment of HT			Women		Men	
Determinants			**Treatment of HT n (%)**	**Crude OR (95% CI)**	**Treatment of HT n (%)**	**Crude OR (95% CI)**
Age (years)		≤ 45	16 (27.1)	1	9 (11.1)	1
		46-60	117 (44.3)	2.14 (1.11-4.13)	53 (37.1)	4.88 (2.13-11.19)
		≥ 61	236 (61.5)	4.30 (2.26-8.18)	123 (48.6)	7.84 (3.54-17.38)
Education (years)		≤ 4	239 (54.8)	1	76 (39.4)	1
		5-11	78 (49.4)	0.77 (0.53-1.12)	63 (36.8)	0.76 (0.49-1.18)
		≥12	52 (46.0)	0.64 (0.41-0.98)	46 (41.4)	0.81 (0.49-1.35)
BMI (Kg/m^2)		<25	58 (41.1)	1	34 (27.4)	1
		25-29.9	149 (52.5)	1.59 (1.05-2.43)	101 (40.9)	1.71 (1.03-2.83)
		≥30	155 (56.6)	1.94 (1.27-2.96)	49 (48.0)	1.94 (1.07-3.50)
Waist circumference (cm)	Women	Men				
	<88	<102	130 (44.8)	1	126 (35.1)	1
	≥88	≥102	230 (56.5)	1.64 (1.21-2.24)	58 (49.6)	1.79 (1.14-2.80)
Total cholesterol/HDL	Women	Men				
1st third	≤3.1	≤3.8	67 (51.9)	1	57 (39.9)	1
2nd third	3.1-4.1	3.8-4.9	120 (53.1)	1.12 (0.72-1.74)	56 (39.4)	1.12 (0.68-1.86)
3rd third	>4.1	>4.9	142 (49.5)	1.00 (0.65-1.53)	63 (39.6)	1.20 (0.74-1.96)
Triglycerides (mg/dL)	Women	Men				
1st third	≤85	≤77	68 (51.9)	1	45 (36.0)	1
2nd third	85-136	77-115	96 (43.6)	0.67 (0.43-1.05)	75 (48.4)	1.81 (1.08-3.02)
3rd third	>136	>115	168 (56.0)	1.18 (0.77-1.80)	61 (34.7)	0.95 (0.57-1.58)
Creatinine clearance (mL/min)		≥90	34 (40.0)	1	34 (25.4)	1
		60-90	161 (53.1)	1.68 (1.01-2.79)	84 (43.1)	2.81 (1.67-4.72)
		>60	129 (53.5)	1.76 (1.05-2.95)	55 (49.6)	3.84 (2.17-6.79)

Diabetes	No		310 (50.1)	1	148 (35.8)	1
	Yes		57 (66.3)	2.04 (1.26-3.28)	37 (58.7)	2.88 (1.65-5.04)
Tobacco	never smoker		309 (54.1)	1	42 (33.9)	1
	ex-smoker		19 (36.5)	0.49 (0.27-0.89)	101 (46.8)	2.15 (1.32-3.48)
	current smoker		25 (50.0)	0.85 (0.46-1.54)	35 (28.2)	0.79 (0.44-1.41)
Ethanol (g/week)	Women	Men				
	<15.0	<226.0	157 (53.6)	1	84 (43.8)	1
	≥15.0	≥226.0	186 (51.4)	0.93 (0.68-1.28)	88 (34.5)	0.74 (0.49-1.11)
Physical activity (MET/day)	Women	Men				
1st third	≤33.5	≤33.0	165 (62.5)	1	82 (48.5)	1
2nd third	33.5-36.6	33.0-37.7	126 (51.4)	0.64 (0.45-0.92)	59 (39.1)	0.64 (0.40-1.03)
3rd third	>36.6	>37.7	61 (37.2)	0.34 (0.22-0.51)	35 (24.6)	0.28 (0.17-0.48)
Family history of cardiovascular disease	No		79 (47.9)	1	53 (33.3)	1
	Yes, age <55		34 (59.6)	1.43 (0.76-2.70)	15 (46.9)	1.88 (0.81-4.34)
	Yes, age 55-65		52 (54.2)	1.27 (0.76-2.14)	23 (48.9)	1.89 (0.92-3.86)
	Yes, age >65		97 (52.7)	1.24 (0.81-1.90)	41 (48.6)	1.75 (1.01-3.03)
	Don't know		12 (70.6)	2.66 (0.90-7.93)	8 (57.1)	3.31 (1.08-10.13)
Marital status	Married/civil union		209 (48.8)	1	160 (39.8)	1
	All others		160 (57.4)	1.40 (1.03-1.91)	25 (33.3)	0.49 (0.28-0.86)
Main setting for health care	Public		284 (53.7)	1	124 (39.0)	1
	Private		46 (51.7)	0.94 (0.59-1.50)	31 (44.9)	1.33 (0.75-2.36)
	Other/none		33 (44.0)	0.72 (0.44-1.18)	28 (34.6)	0.96 (0.55-1.67)

Table 4. Crude odds ratios (OR) for factors associated with control of hypertension, among women and men.

Control of HT			Women		Men	
Determinants			**Control of HT n (%)**	**Crude OR (95% CI)**	**Control of HT n (%)**	**Crude OR (95% CI)**
Age (years)		≤ 45	7 (12.1)	1	5 (6.2)	1
		46-60	37 (14.0)	1.06 (0.43-2.62)	14 (9.8)	1.64 (0.53-5.05)
		≥ 61	38 (9.9)	0.72 (0.29-1.76)	20 (7.9)	1.30 (0.44-3.82)
Education (years)		≤ 4	42 (9.6)	1	14 (7.3)	1
		5-11	21 (13.3)	0.88 (0.37-2.09)	11 (6.43)	1.47 (0.83-2.61)
		≥12	19 (17.0)	1.64 (0.72-3.75)	14 (12.6)	1.91 (1.05-3.51)
BMI (Kg/m^2)		<25	22 (15.6)	1	15 (12.1)	1
		25-29.9	33 (11.7)	0.63 (0.34-1.14)	18 (7.3)	0.51 (0.23-1.12)
		≥30	26 (9.5)	0.52 (0.28-0.97)	6 (5.9)	0.36 (0.13-0.99)
Waist circumference (cm)	Women	Men				
	<88	<102	37 (12.8)	1	30 (8.4)	1
	≥88	≥102	45 (11.8)	0.81 (0.50-1.30)	9 (7.7)	0.84 (0.38-1.87)
Total cholesterol/HLD	Women	Men				
1st third	≤3.1	≤3.8	10 (7.8)	1	10 (7.0)	1
2nd third	3.1-4.1	3.8-4.9	34 (15.0)	1.67 (0.77-3.63)	15 (10.6)	1.75 (0.74-4.18)
3rd third	>4.1	>4.9	27 (9.4)	1.05 (0.47-2.33)	13 (8.2)	1.65 (0.67-4.07)
Triglycerides (mg/dL)	Women	Men				
1st third	≤85	≤77	18 (13.8)	1	11 (8.8)	1
2nd third	85-136	77-115	23 (10.4)	0.62 (0.32-1.23)	15 (9.7)	1.12 (0.46-2.70)
3rd third	>136	>115	32 (10.7)	0.68 (0.36-1.30)	12 (6.8)	0.76 (0.30-1.92)
Creatinine clearance (mL/min)		≥90	6 (7.1)	1	9 (6.7)	1
		60-90	34 (11.2)	1.97 (0.79-4.91)	17 (8.7)	1.52 (0.60-3.84)
		>60	34 (14.1)	2.35 (0.95-5.83)	11 (9.9)	1.67 (0.62-4.46)

Diabetes	no		73 (11.8)	1	29 (7.0)	1
	yes		9 (10.5)	0.86 (0.41-1.79)	10 (15.9)	2.46 (1.11-5.46)
Tobacco	never smoker		64 (11.2)	1	6 (4.8)	1
	ex-smoker		9 (17.3)	1.72 (0.77-3.80)	23 (10.6)	3.01 (1.17-7.74)
	current smoker		6 (12.2)	1.21 (0.47-3.08)	10 (8.1)	2.24 (0.75-6.74)
Ethanol (g/week)	Women	Men				
	<15.0	<226.0	52 (17.8)	1	23 (12.0)	1
	≥15.0	≥226.0	24 (6.6)	0.31 (0.19-0.52)	14 (5.5)	0.42 (0.20-0.86)
Physical activity (MET/day)	Women	Men				
1st third	≤33.5	≤33.0	40 (15.2)	1	15 (8.9)	1
2nd third	33.5-36.6	33.0-37.7	27 (11.0)	0.68 (0.40-1.16)	15 (9.9)	0.97 (0.44-2.13)
3rd third	>36.6	>37.7	12 (7.4)	0.39 (0.20-0.78)	9 (6.3)	0.69 (0.27-1.78)
Family history of cardiovascular disease	No		17 (10.3)	1	8 (5.0)	1
	Yes, age <55		6 (10.5)	0.81 (0.30-2.21)	7 (21.9)	5.56 (1.65-18.80)
	Yes, age 55-65		12 (12.6)	1.15 (0.51-2.61)	4 (8.5)	1.44 (0.39-5.30)
	Yes, age >65		28 (15.2)	1.37 (0.70-2.66)	8 (8.5)	1.69 (0.58-4.93)
	Don't know		1 (5.9)	0.48 (0.06-3.84)	2 (14.3)	3.21 (0.59-17.43)
Marital status	Married/civil union		48 (11.2)	1	31 (7.7)	1
	All others		34 (12.2)	1.13 (0.70-1.83)	8 (10.7)	0.83 (0.36-1.94)
Main setting for health care	Public		55 (10.4)	1	25 (7.9)	1
	Private		16 (18.2)	2.11 (1.12-3.96)	9 (13.0)	2.21 (0.90-5.42)
	Other/none		9 (12.0)	1.76 (0.79-3.89)	5 (6.2)	0.82 (0.30-2.26)

Table 5. Adjusted odds ratios (OR) for factors associated with treatment, awareness and control of hypertension, among women and men

Determinants		Women	Men
		Adjusted* OR (95% CI)	Adjusted* OR (95% CI)
Awareness			
Age (years)	≤ 45	1	1
	46-60	3.03 (1.61-5.67)	2.41 (1.22-4.75)
	≥ 61	3.93 (2.12-7.27)	3.07 (1.64-5.74)
BMI (kg/m^2)	<25	-	1
	25-29.9	-	2.42 (1.52-3.84)
	≥30	-	2.74 (1.56-4.83)
Diabetes	No	1	-
	Yes	2.24 (1.26-3.95)	-
Marital status	Married/civil union	-	1
	All others	-	0.45 (0.25-0.81)
Main setting for health care	Public	1	-
	Private	0.52 (0.32-0.86)	-
	Other/none	0.60 (0.37-0.99)	-
Treatment			
Age (years)	≤ 45	1	1
	46-60	2.05 (1.06-3.97)	4.39 (1.86-10.4)
	≥ 61	3.51 (1.80-6.84)	5.79 (2.46-13.64)
BMI (Kg/m^2)	<25	-	1
	25-29.9	-	1.84 (1.01-3.35)
	≥30	-	2.20 (1.13-4.28)
Diabetes	no	1	1
	yes	1.79 (1.08-2.97)	1.81 (1.03-3.18)
Physical activity (MET/day)	Women Men		
1^{st} third	≤33.5 ≤33.0	1	1
2^{nd} third	33.5-36.6 33.0-37.7	0.67 (0.46-0.97)	0.70 (0.43-1.14)
3^{rd} third	>36.6 >37.7	0.48 (0.31-0.75)	0.41 (0.23-0.74)
Control			
BMI (Kg/m^2)	<25	-	1
	25-29.9	-	0.37 (0.17-0.81)
	≥30	-	0.33 (0.11-0.97)
Diabetes	no	-	1
	yes	-	3.30 (1.46-7.47)
Ethanol (g/week)	Women Men		
	<15.0 <226.0	1	1
	≥15.0 ≥226.0	0.31 (0.19-0.52)	0.43 (0.21-0.89)

*Adjusted for all variables in the model

4. Conclusions

- In the systematic review, we report a lower prevalence and higher awareness, treatment and control of hypertension among women than men. There were no significant differences between developed countries and developing countries, except for prevalence, which was 7.9% higher in men. Despite not reaching statistical significance, awareness of hypertension was 7% higher in both men and women from developed countries in comparison with developing countries. Developing countries are coming closer to developed countries regarding the prevalence, awareness, treatment and control of hypertension.

- The prevalence (95% confidence interval) of hypertension was 42.7% (40.0-45.3) in women and 46.7% (43.0-50.3) in men. Among the 707 women and 477 men with hypertension, the prevalence of awareness, drug treatment and control was, respectively, 58.9% (54.2-61.7), 51.2% (47.4-55.0) and 11.8% (9.3-14.2) among women and, 41.3% (36.6-46.0), 34.6% (30.1-39.1) and 7.9% (5.3-10.5) among men.

- Awareness of hypertension was positively associated with age in both genders, with diabetes among women, and with BMI among men. Among women, users of private practices as the main source of health care were less likely to be aware of hypertension. Single, widower and divorced men were less likely to be aware of their hypertension, in comparison with married/civil union men. In both genders, treatment was positively associated with age and diabetes and inversely with physical activity. BMI was positively associated with treatment only among men. Ethanol intake was associated with a lower likelihood of blood pressure control in both genders. In men, control of hypertension was observed more often among diabetics and decreased with BMI. The concurrent presence of additional cardiovascular risk factors was in general not associated with a higher probability of treatment and control.

5. Abstract

Hypertension is quantitatively the largest risk factor for cardiovascular diseases, which have recently become the main cause of death also in developing countries. The main subject of this thesis was the prevalence, awareness, treatment and control of hypertension. For that, we aimed first to obtain current worldwide estimates regarding distribution and differences between genders and developing and developed countries; second, to estimate their proportions and determinants in Portugal, using a community sample.

We did an updated systematic review searching in Medline (*prevalence AND awareness AND treatment AND control AND (hypertension OR high blood pressure)*) for population-based surveys, from 2001. The Portuguese estimates and determinants of hypertension were obtained using a cross-sectional evaluation of 2310 community participants aged ≥18 years and randomly selected from the urban population of Porto, between 1999 and 2003.

We identified 248 articles in the systematic review, of which 204 did not fulfil inclusion criteria and were excluded. The remaining articles reported data from 35 countries. The median prevalence of hypertension ranged from 28% in women from developing countries to 41% in men from developed countries. Awareness and treatment were 1.7-fold higher in men from developing countries compared to women from developed countries. The proportion of control among all hypertensives doubled from 7% in men from developing to 14% in women from developed countries.

In the Portuguese sample, the prevalence (95% confidence interval) of HT was 42.7% (40.0-45.3) in women and 46.7% (43.0-50.3) in men. Among the 707 women and 477 men with HT, the prevalence of awareness, drug treatment and control was, respectively, 58.9% (54.2-61.7), 51.2% (47.4-55.0) and 11.8% (9.3-14.2) among women and, 41.3% (36.6-46.0), 34.6% (30.1-39.1) and 7.9% (5.3-10.5) among men. In multivariate analysis, awareness of HT was positively associated with age in both genders, with diabetes among women, and with body mass index (BMI) among men. Among women, users of private practices as the main source of health care were less likely to be aware of HT. Single, widower and divorced men were less likely to be aware of their HT, in comparison with married/civil union men. In both genders, treatment was positively associated with age and diabetes and inversely with physical activity. BMI was positively associated with treatment only among men. Ethanol intake was associated with a lower likelihood of BP control in both genders. In men, control of HT was observed more often among diabetics and decreased with BMI.

6. Resumo

A hipertensão arterial é quantitativamente o principal factor de risco cardiovascular. As doenças cardiovasculares são a mais frequente causa de morte mesmo nos países em desenvolvimento. O objecto principal desta tese foi a prevalência, conhecimento, tratamento e controlo da hipertensão arterial. Para tal, propusemo-nos obter estimativas globais, analisar as diferenças entre sexo e nível de desenvolvimento dos países, e estimar a sua proporção e determinantes, utilizando uma amostra comunitária Portuguesa.

Efectuámos uma revisão sistemática na *Medline* (*prevalence AND awareness AND treatment AND control AND (hypertension OR high blood pressure)*) com o objectivo de identificar estudos de base populational desde o ano de 2001. As estimativas portuguesas e os seus determinantes foram obtidas utilizando um estudo transversal comunitário em que avaliámos 2310 participantes com idade ≥18 anos, seleccionados aleatoriamente da população da cidade do Porto, entre 1999 e 2003.

Foram identificados 248 artigos na revisão sistemática, dos quais 204 foram excluídos por não preencherem os critérios de inclusão. Os restantes artigos apresentavam dados de 35 países. A prevalência de hipertensão variou entre 28% nas mulheres residentes nos países em desenvolvimentos e 41% nos homens dos países desenvolvidos. O conhecimento e tratamento da hipertensão foram 1,7 vezes superiores nos homens dos países em desenvolvimento, comparando com as mulheres dos países desenvolvidos. A proporção de controlados, entre todos os hipertensos, duplicou de 7% nos homens dos países em desenvolvimento para 14% nas mulheres dos países desenvolvidos.

Na amostra portuguesa, a prevalência (intervalo de confiança a 95%) de hipertensão foi 42,7% (40,0-45,3) nas mulheres e 46,7% (43,0-50,3) nos homens. Em 707 mulheres e 477 homens hipertensos, a prevalência de conhecimento, tratamento farmacológico e controlo da hipertensão foi, respectivamente, 58,9% (54,2-61,7), 51,2% (47,4-55,0) e 11,8% (9,3-14,2) nas mulheres e 46,7% (43,0-50,3), 41,3% (36,6-46,0), 34,6% (30,1-39,1) e 7,9% (5,3-10,5) nos homens. Na análise multivariada, o conhecimento estava associado positivamente à idade em ambos os sexos, à diabetes nas mulheres e ao índice de massa corporal (IMC) nos homens. Nas mulheres, a utilização de serviços privados como principal fornecedor de cuidados de saúde estava associado a menor probabilidade estar consciente da sua hipertensão. Os homens solteiros, viúvos ou divorciados tinham menor probabilidade de conhecer a sua hipertensão, em comparação com os casados/união de facto. O tratamento estava

positivamente associado à idade e diabetes e inversamente à actividade física em ambos os sexos. O IMC estava positivamente associado ao tratamento apenas nos homens. A ingestão de etanol estava associada a menor probabilidade de controlo da hipertensão em ambos os sexos. Nos homens, o controlo da hipertensão foi observado mais frequentemente nos diabéticos e diminuía com o IMC.