Wolters Kluwer Health | Lippincott Williams & Wilkins

EUROPEAN SOCIETY OF CARDIOLOGY®

Original Scientific Paper

Prevalence, awareness, treatment and control of high blood pressure in a Swiss city general population: the CoLaus study

Nadia Danon-Hersch[a], Pedro Marques-Vidal[a,c], Pascal Bovet[a], Arnaud Chiolero[a], Fred Paccaud[a], Alain Pécoud[b], Daniel Hayoz[d], Vincent Mooser[f], Gérard Waeber[e] and Peter Vollenweider[e]

[a]Institute of Social and Preventive Medicine (IUMSP), [b]Medical Outpatient Clinic, University of Lausanne, [c]Centre for Cardiovascular and Metabolic Research (Cardiomet), [d]Department of Medicine, Vascular Medicine, [e]Department of Medicine, University Hospital (CHUV), Lausanne, Switzerland and [f]Medical Genetics, GlaxoSmithKline, Philadelphia, Pennsylvania, USA

Received 30 May 2008 **Accepted** 18 October 2008

Background **This study is aimed to assess the prevalence of awareness, treatment and control of high blood pressure (HBP) and associated factors in a Swiss city.**

Design **Population-based cross-sectional study of 6182 participants (52.5% women) aged 35–75 years living in Lausanne, Switzerland.**

Methods **HBP was defined as blood pressure $\geq$ 140/90 mmHg or current antihypertensive medication.**

Results **The overall prevalence of HBP was 36% (95% confidence interval: 35–38%). Among participants with HBP, 63% were aware of it. Among participants aware of HBP, 78% were treated, and among those treated, 48% were controlled (BP <140/90 mmHg). In multivariate analysis, HBP prevalence was associated with older age, male sex, low educational level, high alcohol intake, awareness of diabetes or dyslipidaemia, obesity and parental history of myocardial infarction. HBP awareness was associated with older age, female sex, awareness of diabetes or dyslipidaemia, obesity and parental history of myocardial infarction. HBP control was associated with younger age, higher educational level and no alcohol intake. Alone or in combination, sartans were the most often prescribed antihypertensive medication category (41%), followed by diuretics, β-blockers, angiotensin converting enzyme inhibitors and calcium channel blockers. Only 31% of participants treated for HBP were taking $\geq$ 2 antihypertensive medications.**

Conclusion **Although more than half of all participants with HBP were aware and more than three-quarters of them received a pharmacological treatment, less than half of those treated were adequately controlled.** ***Eur J Cardiovasc Prev Rehabil*** **16:66–72 © 2009 The European Society of Cardiology**

European Journal of Cardiovascular Prevention and Rehabilitation 2009, **16**:66–72

Keywords: awareness, control, cross-sectional study, epidemiology, high blood pressure, Switzerland, treatment

Introduction

High blood pressure (HBP) is one of the most frequent treatable cardiovascular risk factors [1]. Traditionally, awareness, treatment and control of hypertension have been shown to follow the 'rule of halves': half of the hypertensive participants are diagnosed, half of the diagnosed hypertensive participants are treated, and half of the treated hypertensive patients are controlled [2]. Recent studies have shown that overall detection and treatment rates have improved [3], whereas control has largely remained suboptimal [4]. Considerable differences in HBP control have been observed around the world: BP control among hypertensive patients, defined as BP less than 140/90 mmHg, was 29% in the United States in the 1990s, but less than 10% in several

Correspondence to Pedro Marques-Vidal, MD, PhD, Institute of Social and Preventive Medicine (IUMSP), Centre Hospitalier Universitaire Vaudois and University of Lausanne, Bugnon 17, Lausanne 1005, Switzerland
Tel: +41 21 314 72 65; fax: +41 21 314 73 73;
e-mail: Pedro-Manuel.Marques-Vidal@chuv.ch

1741-8267 © 2009 The European Society of Cardiology DOI: 10.1097/HJR.0b013e32831e9511

European countries [5]. The better BP control in the United States has been related to lower BP thresholds for starting treatment and to a more intensive treatment than elsewhere [6].

Several factors have been associated with low HBP awareness and/or control, namely increasing age [7], male sex [8], low education [9], nonwhite race [10], previous cardiovascular disease, living alone, decreased physical activity or depression. Overweight and diabetes have been related to higher HBP awareness and HBP treatment [11], but not to improved BP control. Despite recent guidelines stressing the need for more aggressive treatment among patients with a risk of coronary heart disease, many physicians set higher BP target levels than recommended [12].

In the Swiss population, mean systolic BP (SBP) and diastolic BP (DBP) levels were lower than in Finland and Germany in the 1990s [13] and further decreased between 1993 and 2000 [14]. Despite these relatively low BP levels, there is little recent evidence about HBP awareness and control. Thus, this cross-sectional study aimed at (i) estimating HBP prevalence, awareness, treatment and control in adults of a Swiss city; (ii) identifying the characteristics associated with these indicators and (iii) describing the prescribed antihypertensive medications.

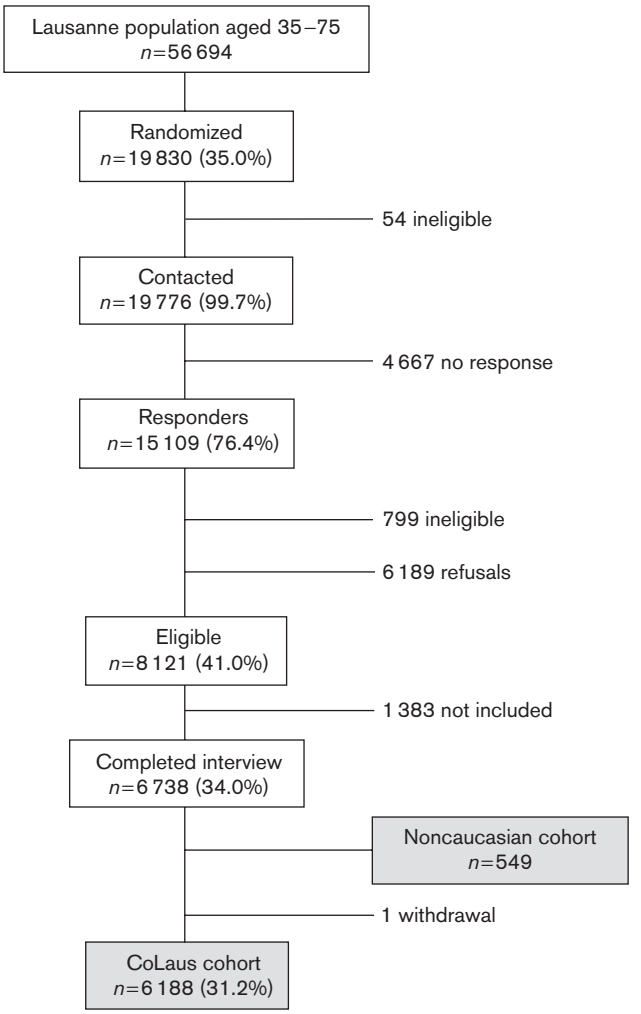
Methods

Recruitment process and inclusion criteria

The sampling procedure of the Cohorte Lausannoise (CoLaus) study has been described previously [15]. Briefly, the complete list of the Lausanne inhabitants aged 35–75 years ($n = 56\,694$) was provided by the population registry of the city. A simple, nonstratified random selection of the participants was made and a random sample of 35% of the overall population was drawn (Fig. 1). An invitation letter with a quick description of the study and a formulary in a prestamped envelope was sent to all randomized participants. Individuals interested in participating returned the formulary and were contacted telephonically within 14 days by one of the staff members who provided more information about the study and arranged for an appointment.

As the CoLaus study aimed at including only Caucasians to avoid population stratification and to increase genetic homogeneity for association studies, the following inclusion criteria were applied: (i) written informed consent; (ii) aged 35–75 years; (iii) willingness to take part in the examination and to have blood sample drawn and (iv) Caucasian origin. Caucasian origin was defined as having both parents and grandparents Caucasian.

Fig. 1



Sampling procedure of the Cohorte Lausannoise (CoLaus) study.

Assessment process

All participants were asked to attend the Outpatient Clinic at the Centre Hospitalier Universitaire Vaudois (CHUV) (Lausanne, Switzerland) in the morning after an overnight fast. Data were collected by trained field interviewers during a single visit lasting about 60 min. Signed informed consent was obtained from participants upon arrival at the study clinic. A first questionnaire mailed with the appointment letter and self-administered before the morning visit was then quickly reviewed and a second structured questionnaire was submitted by face-to-face interview before the clinical measurements.

Questionnaire data

The first questionnaire recorded the information on demographic data, socio-economic and marital status and several lifestyle factors. Alcohol consumption was calculated and classified across three categories: none, moderate (≤ 2 units of alcoholic beverages per

day on average) and high (> 3 units per day on average). The second questionnaire focused on personal and family history of disease and cardiovascular risk factors and treatment. All medicines including the self-prescribed drugs were collected together with the main reported indications.

Clinical data

Body weight and height were measured with precision medical instruments (Seca Schweiz, Reinach, Basel, Switzerland) on participants standing without shoes in light indoor clothes. Body mass index (BMI, kg/m^2) was calculated and obesity was defined for a BMI ≥ 30 kg/m^2.

BP and heart rate were measured thrice on the left arm after at least 10 min rest in the seated position using a clinically validated automated oscillometric device (Omron HEM-907, Matsusaka, Japan) with a standard cuff, or a large cuff if arm circumference was ≥ 33 cm. The average of the last two BP readings was used. HBP was defined as mean SBP ≥ 140 mmHg or mean DBP ≥ 90 mmHg or antihypertensive medication. HBP was further classified into three categories: grade 1 (SBP ≥ 140 and < 160 mmHg and DBP ≥ 90 and < 100 mmHg); grade 2 (SBP ≥ 160 and < 180 mmHg and DBP ≥ 100 and < 110 mmHg) and grade 3 (SBP ≥ 180 mmHg and DBP ≥ 110 mmHg) [16]. As BP is generally overestimated when measured in a single visit, this study refers to HBP rather than hypertension.

HBP awareness was defined as a positive answer to the question 'Have you ever been told by a doctor that you have high blood pressure (hypertension)?' Awareness of diabetes and dyslipidaemia were assessed with similar questions. Parental history of myocardial infarction (MI) (at least one first-degree parent presenting with MI before age 60 years) was also assessed. Antihypertensive medication was defined as a positive answer to the question 'Are you taking a medication/drug to treat hypertension?' and was further checked by systematically recording all over-the-counter and prescribed drugs/medications taken by the participant (self-reported). Five classes of antihypertensive medications were defined: diuretics, β-blockers, calcium channel blockers, angiotensin converting enzyme inhibitors, angiotensin II receptor blockers (ARBs or sartans) and other antihypertensive drugs.

Biological data

Venous blood samples (50 ml) were drawn in the fasting state and tubes were centrifuged at 1500 rpm for 10 min at 4°C within 2 h of admission. Most biological assays were performed by the CHUV Clinical Laboratory on fresh blood samples. All measurements were conducted in a Modular P apparatus (Roche Diagnostics, Switzerland). The following analytical procedures (with maximum interbatch and intrabatch coefficients of variation) were used: total cholesterol by cholesterol oxidase-phenol 4-aminoantipyrine peroxidase (1.6–1.7%); HDL-cholesterol by cholesterol oxidase-phenol 4-aminoantipyrine peroxidase + polyethylene glycol + cyclodextrin (3.6–0.9%); triglycerides by glycerol phosphate oxidase-phenol 4-aminoantipyrine peroxidase (2.9–1.5%) and glucose by glucose dehydrogenase (2.1–1.0%).

Statistical analysis

Statistical analyses were performed using Stata 9.2 (Stata Corp, College Station, USA). Results were expressed as means ± standard deviations or as percentages and 95% confidence intervals (CIs). Bivariate comparisons were performed using the Student's t-test or χ^2 test for continuous and discrete variables, respectively. Multivariate analysis was performed using logistic regression and results were expressed as odds ratio and 95% CI.

Results

Characteristics of the sample

Participation rate was 41%. Of the initial 6188 participants, six were excluded because of missing data for BP. The main characteristics of the remaining 6182 participants are summarized in Table 1. Compared to women, men were slightly younger, had higher BP, BMI, triglycerides and glucose levels, and a higher educational level. In contrast, women had higher total and HDL-cholesterol levels.

Table 1 Distribution of selected variables in the participants

	Men (n=2937)	Women (n=3245)	P value
Age (years)	52.6 ± 10.8	53.5 ± 10.7	0.001
Body mass index (kg/m^2)	26.6 ± 4.0	25.1 ± 4.8	<0.001
Systolic BP (mmHg)	132 ± 17	125 ± 18	<0.001
Diastolic BP (mmHg)	81 ± 11	78 ± 11	<0.001
Education (%)			
Basic	499 (17)	779 (24)	
Apprenticeship	1116 (38)	1168 (36)	<0.001
High school/college	676 (23)	811 (25)	
University	646 (22)	487 (15)	
Alcohol drinking (%)			
None	470 (16)	1201 (37)	
Moderate	1703 (58)	1882 (58)	<0.001
High	764 (26)	162 (5)	
Obesity (%)	499 (17)	454 (14)	0.004
Biological data			
Total cholesterol (mmol/l)	5.56 ± 1.04	5.61 ± 1.03	0.05
HDL-cholesterol (mmol/l)	1.44 ± 0.36	1.81 ± 0.43	<0.001
Triglycerides (mmol/l)	1.65 ± 1.53	1.16 ± 0.66	<0.001[a]
Glucose (mmol/l)	5.78 ± 1.23	5.34 ± 1.02	<0.001
Awareness of diabetes (%)	206 (7)	97 (3)	<0.001
Awareness of dyslipidaemia (%)	793 (27)	649 (20)	<0.001
Parental history of MI (%)	156 (5.3)	202 (6.2)	0.13

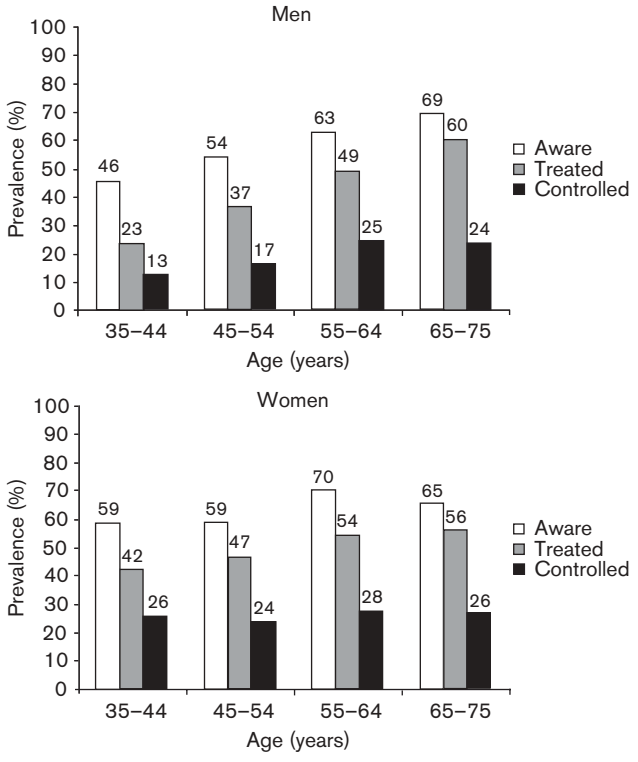
Results are expressed as mean ± SD or number of participants and percentage. Statistical analysis by χ^2 test or Student's t-test. [a]Test performed on log-transformed data. BP, blood pressure; MI, myocardial infarction.

High blood pressure prevalence, awareness, treatment and control

Prevalence of HBP was 31% (95% CI: 29–32%) in women and 43% (95% CI: 41–44%) in men and increased with age from 18% (95% CI: 15–21%) in the 35–44 year age group to 75% (95% CI: 71–79%) in the 65–75 year age group in men; the corresponding figures being 10% (95% CI: 8–12%) and 59% (95% CI: 55–63%) in women.

The distribution of BP categories is summarized in Table 2. Almost two-thirds of participants with HBP were aware of their status. Among those aware, more than three-quarters were treated. Less than half of those treated had BP controlled (BP $< 140/90$ mmHg). Among treated participants, 76% (95% CI: 72–79%) of men and 80% (95% CI: 76–84%) of women had BP less than 160/95 mmHg. Women with HBP had higher rates of awareness, treatment and control than men, but these differences decreased with age (interaction term sex × age group: $P < 0.05$ for awareness, NS for control). In contrast, treatment rates among aware participants with HBP increased linearly with age, as shown in Fig. 2 (χ^2 test for linear trend, $P < 0.001$). The majority of participants with HBP had grade I HBP (Table 2).

Fig. 2



Prevalence (%) of awareness, treatment and control in men and women aged 35–75 years with high blood pressure (defined as blood pressure ≥ 140/90 mmHg or antihypertensive medication) from Lausanne, Switzerland.

Table 2 Prevalence (%) of high blood pressure awareness, treatment and control

Blood pressure status	Men ($n=2937$)	Women ($n=3245$)	All ($n=6182$)
<140/90 mmHg			
No HBP	57 (56–59)	69 (68–71)	64 (62–65)
Treated hypertension	9 (8–10)	8 (7–9)	8 (8–9)
140–159/90–99 mmHg			
Not aware	14 (13–15)	8 (7–9)	11 (10–12)
Aware but not treated	4 (3–5)	3 (2–3)	3 (3–4)
Treated	7 (6–8)	6 (5–6)	6 (6–7)
160–179/100–109 mmHg			
Not aware	2 (2–3)	2 (2–3)	2 (2–3)
Aware but not treated	2 (1–2)	1 (1–2)	1 (1–2)
Treated	3 (2–3)	2 (1–2)	2 (2–2)
≥ 180/110 mmHg			
Not aware	1 (0–1)	0 (0–0)	0 (0–1)
Aware but not treated	1 (0–1)	0 (0–0)	0 (0–1)
Treated	1 (0–1)	1 (0–1)	1 (1–1)
Prevalence of HBP (%)	43 (41–44)	31 (29–32)	36 (35–38)
Percentage aware among HBP	60 (58–63)	65 (62–68)	63 (61–65)
Percentage treated among aware	76 (73–79)	80 (77–83)	78 (76–80)
Percentage controlled among treated	45 (41–49)	50 (46–55)	48 (45–51)
Percentage treated among HBP	46 (43–49)	52 (49–55)	49 (47–51)
Percentage controlled among HBP	21 (19–23)	26 (24–29)	23 (21–25)

HBP is defined as BP ≥ 140/90 mmHg or antihypertensive medication. Control is defined as BP <140/90 mmHg in a person with antihypertensive medication. Results are expressed as percentage and (95% confidence interval) of all participants, unless otherwise specified. BP, blood pressure; HBP, high blood pressure.

Factors related to high blood pressure prevalence, awareness and control

The factors significantly and independently related to prevalence, awareness and control of HBP were assessed separately for each sex using logistic regression analysis. The results are summarized in Table 3. As a relatively small proportion (22%) of aware participants with HBP were untreated, we did not analyse the factors related to HBP treatment.

Prevalence of HBP was significantly and positively associated with age, alcohol intake, awareness of diabetes, awareness of dyslipidaemia and obesity, and negatively associated with female sex and educational level.

Awareness of HBP was significantly and positively associated with age, female sex, awareness of diabetes, awareness of dyslipidaemia and obesity, whereas no association was found with education. Stratified analyses according to education level, directly standardized for age and sex to the population of Lausanne aged 35–75 years, yielded similar results (data not shown). The amount of alcohol consumption was negatively associated and parental history of MI was positively associated with HBP awareness after adjusting for age, but this relationship became nonsignificant after multivariate adjustment.

Finally, control of HBP was positively associated with educational level and negatively with age and alcohol drinking. No association was found with awareness of diabetes, awareness of dyslipidaemia and obesity or parental history of MI.

Table 3 Factors related to high-blood pressure prevalence, awareness and control

	Prevalence				Awareness				Control			
	Age-adjusted	*P*	Multivariate	*P*	Age-adjusted	*P*	Multivariate	*P*	Age-adjusted	*P*	Multivariate	*P*
Age (per 10-year increase)	2.4 (2.3–2.5)	***	2.3 (2.2–2.5)	***	1.3 (1.2–1.4)	***	1.2 (1.1–1.3)	***	0.9 (0.7–1.0)	*	0.9 (0.8–1.0)	*
Woman	0.5 (0.4–0.5)	***	0.5 (0.5–0.6)	***	1.2 (1.0–1.4)		1.3 (1.0–1.6)	*	1.2 (1.0–1.5)		1.2 (0.9–1.5)	
Education												
Basic	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
Apprenticeship	1.0 (0.8–1.1)		1.0 (0.9–1.2)		1.1 (0.8–1.3)		1.2 (0.9–1.5)		1.2 (0.9–1.6)		1.3 (0.9–1.7)	
High school/ college	0.7 (0.6–0.9)	***	0.8 (0.7–1.0)		0.9 (0.7–1.2)		1.1 (0.8–1.4)		1.0 (0.7–1.5)		1.1 (0.7–1.5)	
University	0.6 (0.5–0.7)	***	0.6 (0.5–0.8)	***	0.9 (0.7–1.2)		1.2 (0.9–1.6)		1.8 (1.2–2.8)	**	2.0 (1.3–3.2)	**
Alcohol intake												
None	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
Moderate	0.9 (0.7–1.0)	*	0.9 (0.8–1.0)		0.8 (0.6–0.9)	*	0.9 (0.7–1.1)		1.1 (0.8–1.4)		1.0 (0.8–1.4)	
High	1.9 (1.6–2.3)	***	1.5 (1.3–1.9)	***	0.7 (0.6–0.9)	*	0.8 (0.6–1.1)		0.6 (0.4–0.8)	**	0.6 (0.4–0.8)	**
Diabetes	3.1 (2.4–4.1)	***	1.8 (1.3–2.4)	***	4.7 (3.1–7.2)	***	3.6 (2.3–5.5)	***	1.1 (0.8–1.6)		1.2 (0.9–1.7)	
Dyslipidaemia	1.8 (1.5–2.0)	***	1.4 (1.2–1.6)	***	2.4 (2.0–2.9)	***	2.2 (1.8–2.7)	***	1.1 (0.9–1.4)		1.1 (0.9–1.5)	
Obese (BMI $\geq$ 30)	4.0 (3.4–4.7)	***	3.4 (2.9–4.0)	***	2.0 (1.6–2.4)	***	1.6 (1.3–2.0)	***	0.9 (0.7–1.1)		0.8 (0.6–1.1)	
Parental history of MI	1.3 (1.0–1.6)		1.2 (1.0–1.6)		1.6 (1.1–2.4)	*	1.4 (1.0–2.1)		1.1 (0.7–1.8)		1.1 (0.6–1.8)	

Results are expressed as odds ratio and 95% confidence interval. Multivariate OR was adjusted for age, sex, nationality, education, alcohol intake, awareness of diabetes, awareness of dyslipidaemia, obesity and parental history of MI. *$P<0.05$; **$P<0.01$ and ***$P<0.001$. MI, myocardial infarction; ref., reference group.

Table 4 Distribution of antihypertensive medications among persons treated for hypertension

	Men ($n=575$)	Women ($n=519$)	All ($n=1094$)
Angiotensin II receptor blockers	242 (42) (38–46)	213 (41) (37–45)	455 (41) (38–44)
Diuretics	207 (36) (32–40)	208 (40) (36–44)	415 (38) (35–41)
β-blockers	184 (32) (28–36)	156 (30) (26–34)	340 (31) (28–34)
ACE inhibitors	178 (31) (27–35)	130 (25) (21–29)	308 (28) (25–31)
Calcium channel blockers	127 (22) (19–26)	99 (19) (16–23)	226 (21) (19–24)
Other	3 (0.5) (0.1–1.3)	3 (0.6) (0.1–1.7)	6 (0.6) (0.3–1.3)

Results are expressed as number (percentage) and 95% confidence interval of participants taking the drug. As some participants may take more than one antihypertensive medication, the sum of percentages exceeds 100%. ACE, angiotensin converting enzyme.

Antihypertensive drug treatment

The distribution of the main antihypertensive medications is summarized in Table 4. Alone or in combination, ARBs were the most commonly prescribed antihypertensive medication, followed by diuretics, β-blockers, angiotensin converting enzyme inhibitors and calcium channel blockers, although no significant differences were found between the prescription rates for ARBs and diuretics. Overall, 69% of all participants treated for HBP were taking one antihypertensive drug, 25% two drugs and 6% three or more drugs.

Discussion

Since the MONItoring of trends and determinants in CArdiovascular disease (MONICA) study in the 1980s [17], there has been little information regarding HBP management in Switzerland. Our data provide information on the current prevalence, awareness, treatment and control of HBP in a large population-based sample.

In our study, overall HBP prevalence was 36%, consistent with the self-reported prevalence observed in the 2002 telephone-based Swiss Health Survey [18]. HBP prevalence was higher in our study than in the United State, but lower than in several other European countries [5]. Comparison with the MONICA population-based survey [17] in 1992/1993, and with another population-based study [14] in the same region suggests a decrease in mean SBP and DBP. This is consistent with the secular decrease in BP levels observed in several European populations [19] and is unlikely to be explained by the increasing use of antihypertensive medication. The reasons of the decreasing HBP prevalence still need to be unravelled. Finally, and consistently with the literature [20], HBP prevalence was positively related with age and alcohol consumption, and negatively with educational level.

About two-thirds of participants with HBP were aware of their condition. As the diagnosis was based on a single visit, although BP is known to substantially decrease over measurements made on subsequent visits, HBP prevalence is likely to be overestimated, and awareness and control levels might be underestimated. Although this problem of false-positive cases of HBP based on BP measurement on a single visit is well known [21], most studies report awareness and control in this way [5,7,22] and we can therefore compare our results with these studies. Our findings indicate that HBP screening rates are high in this Swiss city and no longer follow the 'rule of halves' [2]. Women with HBP were more frequently aware than men, a finding consistent with the literature [11]. Likewise, the high HBP

awareness rates among participants who also had other cardiovascular risk factors might reflect more frequent visits, hence more frequent occasions for BP measurement and/or advice for adherence to treatment by health care providers.

More than three-quarters of aware participants with HBP received antihypertensive drug treatment. This rate is as high or higher than in many other Western countries [2,23], and higher than in developing countries [22]. Overall, our results indicate that antihypertensive treatment coverage is high in Lausanne. The presence of participants with HBP of grade 2 or grade 3 among those aware but untreated, however, suggests that there is still room for further improvement.

BP control among all (unaware, untreated and treated) participants with HBP (23%) was lower than reported for Cuba (40%) [24] or the United States (29% at age 35–64 years) [5], but higher than the 5–11% found in developing countries [22,25]. Actually, less than half of the treated participants achieved normal BP levels. Lower BP control in Switzerland may relate to less intensive treatment [6], particularly among older participants [26], perhaps by fear of side effects such as orthostatic hypotension. Although current guidelines promote the prescription of (low dose) polytherapy, only 31% of those treated for HBP were taking ≥ 2 antihypertensive medications. Other possible factors for low BP control include inadequate pharmacological prescription [27] or low adherence to medication [28]. Lower HBP control among participants with high alcohol consumption, as found in other studies [29], is consistent with both a hypertensive effect of alcohol and lower adherence to treatment [30]. The positive association between length of education and HBP control is consistent with published literature [31].

International guidelines indicate that lower BP targets should be set for participants treated for HBP with several cardiovascular risk factors [32]. In this study, the presence of diabetes, dyslipidaemia, obesity or parental history of MI was not associated with improved BP control. Those findings might reflect the medical practitioners' difficulty in handling increasingly complex guidelines: a recent study among German primary care physicians [33] reported a low frequency of individualized treatment with regard to comorbidities. Alternatively, it is more difficult to control BP in patients with several comorbidities.

ARBs were the most frequently prescribed antihypertensive medications, although not significantly different from diuretics. This may reflect a trend for early adoption of the latest medications by doctors and/or intense commercial promotion for ARBs. The cross-sectional design of our study, however, does not allow drawing any conclusion on the efficacy and/or adequacy of the medication use patterns.

This study has some limitations. First, BP was assessed in a single visit and prevalence of HBP is therefore probably overestimated [21], similarly to all epidemiological studies [5,7,22] that have assessed BP on a single visit. Second, the participation rate was rather low (41%), which might limit the generalization of our findings. However, low participation is typical of surveys in Western countries and is comparable with the MONICA surveys conducted in Switzerland and in other countries [34]. The magnitude of the nonparticipation bias is not proportional to the percentage of nonparticipants [35] and a study on representativeness observed that people with risky behaviours participated in the same proportions as people without risk factors [36]. Third, only participants of Caucasian origin were included in this study, and inference should be done accordingly. Fourth, dosage of antihypertensive medications or compliance to treatment was not recorded, which limits the description of medication patterns. In particular, it is not possible to distinguish between low-dose polytherapy and high-dose monotherapy. Finally, no information was collected regarding nonpharmacological treatment of HBP.

Overall, our data indicate that some relatively simple measures could be applied to improve BP control in this sample. Taking into account the presence of other cardiovascular disease risk factors could be facilitated by assessing total cardiovascular disease risk using the SCORE [37] or the Framingham [38] risk equations. Other measures such as implementing nonpharmacological treatment and compliance of the patients could also be used.

In conclusion, the prevalence of HBP was lower in this Swiss city population than in several other Western European countries. Awareness and treatment rates were high but failed to result in adequate BP control in more than half of the individuals treated for HBP. The presence of other cardiovascular risk factors was associated with higher HBP awareness but not with better BP control. Further studies are needed to identify specific reasons for less than optimal BP control among treated participants.

Acknowledgements

Part of this study was presented as a poster at the CHUV research days meeting held in Lausanne. The CoLaus study was supported by research grants from GlaxoSmithKline and from the Faculty of Biology and Medicine of Lausanne, Switzerland. Vincent Mooser is a full-time employee of GlaxoSmithKline.

References

1 Lawes CM, Van Der 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**:413–422.

2 Smith WC, Lee AJ, Crombie IK, Tunstall-Pedoe H. Control of blood pressure in Scotland: the rule of halves. *Br Med J* 1990; **300**:981–983.

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

4 Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J Hypertens* 2004; **22**:11–19.

5 Wolf-Maier K, Cooper RS, Kramer H, Banegas JR, Giampaoli S, Joffres MR, *et al*. Hypertension treatment and control in five European countries, Canada, and the United States. *Hypertension* 2004; **43**:10–17.

6 Wang YR, Alexander GC, Stafford RS. Outpatient hypertension treatment, treatment intensification, and control in Western Europe and the United States. *Arch Intern Med* 2007; **167**:141–147.

7 Hajjar I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988–2000. *JAMA* 2003; **290**: 199–206.

8 Marques-Vidal P, Arveiler D, Amouyel P, Bingham A, Ferrières J. Sex differences in awareness and control of hypertension in France. *J Hypertens* 1997; **15**:1205–1210.

9 Samal D, Greisenegger S, Auff E, Lang W, Lalouschek W. The relation between knowledge about hypertension and education in hospitalized patients with stroke in Vienna. *Stroke* 2007; **38**:1304–1308.

10 Giles T, Aranda JM Jr, Suh DC, Choi IS, Preblick R, Rocha R, *et al*. Ethnic/racial variations in blood pressure awareness, treatment, and control. *J Clin Hypertens (Greenwich)* 2007; **9**:345–354.

11 Brindel P, Hanon O, Dartigues JF, Ritchie K, Lacombe JM, Ducimetière P, *et al*. Prevalence, awareness, treatment, and control of hypertension in the elderly: the Three City Study. *J Hypertens* 2006; **24**:51–58.

12 Hyman DJ, Pavlik VN, Vallbona C. Physician role in lack of awareness and control of hypertension. *J Clin Hypertens* 2000; **2**:324–330.

13 Wietlisbach V, Paccaud F, Rickenbach M, Gutzwiller F. Trends in cardiovascular risk factors (1984–1993) in a Swiss region: results of three population surveys. *Prev Med* 1997; **26**:523–533.

14 Galobardes B, Costanza MC, Bernstein MS, Delhumeau CH, Morabia A. Trends in risk factors for the major 'lifestyle-related diseases' in Geneva, Switzerland, 1993-2000. *Ann Epidemiol* 2003; **13**:537–540.

15 Firmann M, Mayor V, Marques-Vidal P, Bochud M, Pécoud A, Hayoz D, *et al*. The CoLaus study: a population-based study to investigate the epidemiology and genetic determinants of cardiovascular risk factors and metabolic syndrome. *BMC Cardiovasc Disord* 2008; **8**:6.

16 Whitworth JA. 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. *J Hypertens* 2003; **21**:1983–1992.

17 Tunstall-Pedoe H, Kuulasmaa K, Tolonen H, Davidson M, Mendis S. *MONICA monograph and multimedia sourcebook. World's largest study of heart disease, stroke, risk factors, and population trends 1979–2002*. Geneva: WHO; 2003.

18 Office fédéral de la statistique. Hypertension artérielle. Enquête suisse sur la santé 2002–2006.

19 Tunstall-Pedoe H, Connaghan J, Woodward M, Tolonen H, Kuulasmaa K. Pattern of declining blood pressure across replicate population surveys of the WHO MONICA project, mid-1980s to mid-1990s, and the role of medication. *Br Med J* 2006; **332**:629–635.

20 Sun Z, Zheng L, Detrano R, Zhang D, Zhang X, Xu C, *et al*. The accelerating epidemic of hypertension among rural Chinese women: results from Liaoning Province. *Am J Hypertens* 2008; **21**:784–788.

21 Bovet P, Gervasoni JP, Ross AG, Mkamba M, Mtasiwa DM, Lengeler C, *et al*. Assessing the prevalence of hypertension in populations: are we doing it right? *J Hypertens* 2003; **21**:509–517.

22 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**:521–529.

23 Marques-Vidal P, Tuomilehto J. Hypertension awareness, treatment and control in the community: is the 'rule of halves' still valid? *J Hum Hypertens* 1997; **11**:213–220.

24 Orduñez-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**:845–849.

25 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.

26 Borzecki AM, Glickman ME, Kader B, Berlowitz DR. The effect of age on hypertension control and management. *Am J Hypertens* 2006; **19**:520–527.

27 Berlowitz DR, Ash AS, Hickey EC, Friedman RH, Glickman M, Kader B, *et al*. Inadequate management of blood pressure in a hypertensive population. *N Engl J Med* 1998; **339**:1957–1963.

28 Yiannakopoulou EC, Papadopulos JS, Cokkinos DV, Mountokalakis TD. Adherence to antihypertensive treatment: a critical factor for blood pressure control. *Eur J Cardiovasc Prev Rehabil* 2005; **12**:243–249.

29 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**:751–759.

30 Bovet P, Burnier M, Madeleine G, Waeber B, Paccaud F. Monitoring one-year compliance to antihypertension medication in the Seychelles. *Bull World Health Organ* 2002; **80**:33–39.

31 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**:1345–1352.

32 Anonymous. 2003 European Society of Hypertension-European Society of Cardiology guidelines for the management of arterial hypertension. *J Hypertens* 2003; **21**:1011–1053.

33 Pittrow D, Kirch W, Bramlage P, Lehnert H, Hofler M, Unger T, *et al*. Patterns of antihypertensive drug utilization in primary care. *Eur J Clin Pharmacol* 2004; **60**:135–142.

34 Wolf HK, Kuulasmaa K, Tolonen H, Ruokokoski E. Participation rates, quality of sampling frames and sampling fractions in the MONICA surveys. WHO MONICA Project 1998 September 15. Available from: URL: *http://www.ktl.fi/publications/monica/nonres/nonres.htm*

35 Galea S, Tracy M. Participation rates in epidemiologic studies. *Ann Epidemiol* 2007; **17**:643–653.

36 Taylor AW, Dal GE, Gill T, Chittleborough CR, Wilson DH, Adams RJ, *et al*. Do people with risky behaviours participate in biomedical cohort studies? *BMC Public Health* 2006; **6**:11.

37 Marques-Vidal P, Rodondi N, Bochud M, Pécoud A, Hayoz D, Paccaud F, *et al*. Predictive accuracy and usefulness of calibration of the ESC SCORE in Switzerland. *Eur J Cardiovasc Prev Rehabil* 2008; **15**:402–408.

38 Marques-Vidal P, Rodondi N, Bochud M, Chiolero A, Pécoud A, Hayoz D, *et al*. Predictive accuracy of original and recalibrated Framingham risk score in the Swiss population. *Int J Cardiol* 2008 [Epub ahead of print].