1999–2009 Trends in Prevalence, Unawareness, Treatment and Control of Hypertension in Geneva, Switzerland

Idris Guessous1,2,3, Murielle Bochud2, Jean-Marc Theler1, Jean-Michel Gaspoz1, Antoinette Pechère-Bertschi3

1 Unit of Population Epidemiology, Division of Primary Care Medicine, Department of Community Medicine, Primary Care and Emergency Medicine, Geneva University Hospitals, Geneva, Switzerland, 2 Community Prevention Unit, University Institute of Social and Preventive Medicine, Lausanne University Hospital, Lausanne, Switzerland, 3 Unit of Hypertension, Departments of Specialties of Medicine and Community Medicine and Primary Care and Emergency Medicine, Geneva University Hospitals, Geneva, Switzerland

Abstract

Background: There are no time trends in prevalence, unawareness, treatment, and control of hypertension in Switzerland. The objective of this study was to analyze these trends and to determine the associated factors.

Methods/Findings: Population-based study conducted in the Canton of Geneva, Switzerland, between 1999 and 2009. Blood pressure was measured thrice using a standard protocol. Hypertension was defined as mean systolic or diastolic blood pressure ≥140/90 mmHg or self-reported hypertension or anti-hypertensive medication. Unawareness, untreated and uncontrolled hypertension was determined by questionnaires/blood pressure measurements. Yearly age-standardized prevalences and adjusted associations for the 1999–2003 and 2004–2009 survey periods were reported. The 10-year survey included 9,215 participants aged 35 to 74 years. Hypertension remained stable (34.4%). Hypertension unawareness decreased from 35.9% to 17.7% (P<0.001). The decrease in hypertension unawareness was not paralleled by a concomitant absolute increase in hypertension treatment, which remained low (38.2%). A larger proportion of all hypertensive participants were aware but not treated in 2004–2009 (43.7%) compared to 1999–2003 (33.1%). Uncontrolled hypertension improved from 62.2% to 40.6% between 1999 and 2009 (P = 0.02). In 1999–2003 period, factors associated with hypertension unawareness were current smoking (OR = 1.27, 95%CI, 1.02–1.59), male gender (OR = 1.56, 1.27–1.92), hypercholesterolemia (OR = 1.31, 1.20–1.44), and older age (OR 65–74yrs vs 35–49yrs = 1.56, 1.21–2.02). In 1999–2003 and 2004–2009, obesity and diabetes were negatively associated with hypertension unawareness, high education was associated with untreated hypertension (OR = 1.45, 1.12–1.88 and 1.42, 1.02–1.99, respectively), and male gender with uncontrolled hypertension (OR = 1.49, 1.03–2.17 and 1.65, 1.08–2.50, respectively). Sedentarity was associated with higher risk of hypertension and uncontrolled hypertension in 1999–2003.

Conclusions: Hypertension prevalence remained stable since 1999 in the canton of Geneva. Although hypertension unawareness substantially decreased, more than half of hypertensive subjects still remained untreated or uncontrolled in 2004–2009. This study identified determinants that should guide interventions aimed at improving hypertension treatment and control.

Introduction

Hypertension is one of the major causes of disease burden worldwide [1]. It affects approximately 37–55% of the adult population in Europe [2]. Hypertension is the most important modifiable cardiovascular risk factor for stroke, coronary artery disease, heart failure and end-stage renal disease, and it also increases all-cause mortality [3].

Trends in hypertension prevalence differ according to geographic and population characteristics and definition of arterial hypertension. In the United States, the last NHANES 1988–2008 analysis reported an increase in prevalence from 23.9% in 1988–1994 to 28.5% in 1999–2000. The prevalence remained stable since then [4]. The population-based prevalence of hypertension was also stable (19.7%–21.6%) in Canada between 1992 and 2009.

Abstract

Background: There are no time trends in prevalence, unawareness, treatment, and control of hypertension in Switzerland. The objective of this study was to analyze these trends and to determine the associated factors.

Methods/Findings: Population-based study conducted in the Canton of Geneva, Switzerland, between 1999 and 2009. Blood pressure was measured thrice using a standard protocol. Hypertension was defined as mean systolic or diastolic blood pressure ≥140/90 mmHg or self-reported hypertension or anti-hypertensive medication. Unawareness, untreated and uncontrolled hypertension was determined by questionnaires/blood pressure measurements. Yearly age-standardized prevalences and adjusted associations for the 1999–2003 and 2004–2009 survey periods were reported. The 10-year survey included 9,215 participants aged 35 to 74 years. Hypertension remained stable (34.4%). Hypertension unawareness decreased from 35.9% to 17.7% (P<0.001). The decrease in hypertension unawareness was not paralleled by a concomitant absolute increase in hypertension treatment, which remained low (38.2%). A larger proportion of all hypertensive participants were aware but not treated in 2004–2009 (43.7%) compared to 1999–2003 (33.1%). Uncontrolled hypertension improved from 62.2% to 40.6% between 1999 and 2009 (P = 0.02). In 1999–2003 period, factors associated with hypertension unawareness were current smoking (OR = 1.27, 95%CI, 1.02–1.59), male gender (OR = 1.56, 1.27–1.92), hypercholesterolemia (OR = 1.31, 1.20–1.44), and older age (OR 65–74yrs vs 35–49yrs = 1.56, 1.21–2.02). In 1999–2003 and 2004–2009, obesity and diabetes were negatively associated with hypertension unawareness, high education was associated with untreated hypertension (OR = 1.45, 1.12–1.88 and 1.42, 1.02–1.99, respectively), and male gender with uncontrolled hypertension (OR = 1.49, 1.03–2.17 and 1.65, 1.08–2.50, respectively). Sedentarity was associated with higher risk of hypertension and uncontrolled hypertension in 1999–2003.

Conclusions: Hypertension prevalence remained stable since 1999 in the canton of Geneva. Although hypertension unawareness substantially decreased, more than half of hypertensive subjects still remained untreated or uncontrolled in 2004–2009. This study identified determinants that should guide interventions aimed at improving hypertension treatment and control.

Copyright: © 2012 Guessous et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: The Bus Sante study is funded by the Geneva University Hospitals through the General Directorate of Health (Canton of Geneva) and the Swiss School of Public Health Plus. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: MB is an Academic Editor for PLoS ONE. This does not alter the authors' adherence to all the PLoS ONE policies on sharing data and materials.

* E-mail: Idris.Guessous@hcuge.ch
Compared to North America, European countries have a higher prevalence of hypertension [6]. In Switzerland, the prevalence of hypertension, based on measured blood pressure (BP), varied with age and gender between 20% and 50% [7,8]. There are no reliable recent trend summaries of hypertension changes (taking into account anti-hypertensive drugs information) from Europe [9].

To control the public health burden of hypertension, several guidelines recommend the screening, treatment and control of high BP [10,11]. Hypertension awareness, treatment and control have generally increased in the last decades [4,5,12,13]. Yet, the rates of uncontrolled hypertension remain greater than 50% in recent reports [4,12,13]. Factors such as smoking, obesity, education, alcohol consumption and age have been associated with the risk of untreated and uncontrolled hypertension [7,14–16].

In Switzerland, there are no recent time trends in hypertension treatment, control and unawareness. We analyzed the 1999–2009 trends from a large ongoing population-based study conducted in Switzerland.

Specifically, the aims of this study were to assess 10-year trends in hypertension prevalence, unawareness, treatment and control for the adult population living in the canton of Geneva, Switzerland. We also aimed to identify factors associated with these four outcomes.

**Methods**

**Participants**

The ‘Bus Santé’ is an ongoing cross-sectional population-based study, which collects information on cardiovascular risk factors, diet and physical activity. Yearly, a representative stratified sample of 500 men and 500 women from the population of the Geneva Canton is recruited and studied [17]. Three stations receive participants. The first two stations are fixed and are based within the Geneva University Hospitals. The third station is a medical mobile unit, which visits three parts of the canton of Geneva. Four trained collaborators interview and examine participants. All procedures are reviewed and standardized across technicians on a regular basis.

Subjects are selected independently throughout each year to represent the canton’s approximately 100,000 male and 100,000 female non-institutionalized residents aged 35 to 74 years. Eligible subjects are identified using a standardized procedure using an annual residential list established by the local government. This listing includes all potential eligible participants except persons living illegally in the country. Stratified random sampling based on the list by gender within 10-year age strata is proportional to the corresponding population distributions. Selected subjects are mailed an invitation to participate, and, if they do not respond, up to 7 telephone attempts are made at different times on various days of the week. If telephone contact is unsuccessful, 2 more letters are mailed. Subjects not reached are replaced using the same selection protocol. Subjects who refuse to participate are not replaced. Each participant receives several self-administered, standardized questionnaires covering the risk factors for the major lifestyle chronic diseases, socio-demographic characteristics, educational and occupational histories, and reproductive history for women. The 1999–2009 mean participation rate was 60% (range: 53%–65%).

**Measurements**

Each participant brings along their filled-in questionnaires, which are checked for correct completion by trained inter-viewers (a full visit can be watched on http://epidemiologiepopulation.hug-ge.ch/video_busSante.html). In a temperature-controlled room, body weight is measured with the subject lightly dressed without shoes using a medical scale (precision 0.5 kg), and standing height is measured using a medical gauge (precision 1 cm). BP is measured thrice in the sitting position on the right arm after at least 10 minutes rest using a standard protocol. Between 1999 and 2003, BP was measured using a manual mercury sphygmomanometer. Since 2004, BP was measured using a validated automated oscillometric sphygmomanometer (Omron® HEM-907, Matsuoka, Japan).

**Prevalence, Unawareness, Treatment and Control of Hypertension**

Hypertension was defined as mean systolic and/or diastolic BP $\geq$ 140/90 mmHg or self-reported hypertension or presence of anti-hypertensive medication. We considered as unaware participants with high BP values who responded negatively to the question “Have you ever been told that you had high BP?” Self-reported anti-hypertensive medication in participants determined treated hypertension. Uncontrolled hypertension was defined as a mean systolic and/or diastolic BP $\geq$ 140/90 mmHg based on the Seventh Joint National Committee (JNCVII) on Detection, Evaluation, and Treatment of High Blood Pressure [10].

**Physical Activity and Alcohol Consumption**

Physical activity levels were quantified using a physical activity frequency questionnaire (PAFQ), developed in the Geneva general adult population and validated using heart rate monitoring [18]. Sedentarity was defined as 10 or less percent of total daily energy expenditure (EE) (kcal/day) spent in activities demanding $\geq$ 4 MET as suggested elsewhere [19].

Alcohol consumption (kcal/day) was estimated using a validated food frequency questionnaire [20,21]. Alcohol consumption was categorized into tertiles (lower, middle, upper tertiles).

**Education, Citizenship, Medical History and Comorbidities**

Self-reported information on education was categorized as high (Maturity/Baccalaureat or university) and low (Elementary school or apprenticeship). Citizenship was categorized as Swiss and non-Swiss according to self-reported nationality. Self-reported information on lifestyle, medical history and comorbidities included smoking status (never smokers, ex-smokers, and current smokers), history of myocardial infarction, diabetes, and hypercholesterolemia. Diabetes and hypercholesterolemia were defined as follows: positive responses to the questions: “Have you ever been told that you had diabetes/high cholesterol?” and “If so, are you taking a drug for it?”.

**Socioeconomic Status**

Since 2003, socioeconomic information is collected in the ‘Bus Santé’ study. Self-reported monthly household income is collected using the following ranges: <3’000 CHF; 3’000–4’999 CHF; 5’000–6’999 CHF; 7’000–9’499 CHF; 9’500–13’000 CHF; >13’000 CHF (Swiss Francs CHF =1.1 US$=0.80€ as on January 2012). Job position information was categorized as non-manual, manager or independent; non-manual, employed; manual, independent; manual, employed; women/man-at-home; retired or jobless.
Statistical Analyses

Statistical analyses were performed using Stata 11.0 (Stata Corp, College Station, USA). Continuous variables were expressed as mean ± standard deviation (SD). Categorical variables were expressed as number of subjects and percentage. To determine whether the prevalence, unawareness, treatment and control of hypertension changed between 1999 and 2009, yearly data were used and trend test performed. To test the associations between potential determinants (e.g., smoking status) and study outcomes (e.g., untreated hypertension), period 1999–2003 and 2004–2009 were used. The periods were so defined because of the publication of the last Joint National Committee (JNCVII) on Detection, Evaluation, and Treatment of High Blood Pressure report (2003) [10], and because of the change in BP measurement (1999–2003: mercury sphygmomanometer; 2004–2009: automated oscillometric sphygmomanometer). To adjust for the age (a major risk factor of hypertension) structure between survey periods, we reported age-standardized prevalence, using the 2010 Geneva Census population. We determined the associations of characteristics with hypertension, hypertension unawareness, untreated and uncontrolled hypertension using multiple logistic regressions.

In the years 2005 through 2008 the annual average number of participants was lower than the other years because another cohort study was conducted relying on the same infrastructure. This is why sample size is smaller for the 2004–2009 than for the 1999–2003 period. Trends in prevalence of hypertension, hypertension unawareness, untreated and uncontrolled hypertension were further determined by income level in a sub-population taking into account information on job position status.

Ethics

The ‘Bus Santé’ study complied with the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the University of Geneva (Paul Bovier, Bernard Baertschi, Patrick Bovier, Jacqueline Bursik, Beat Stoll, Marinette Ummel). All participants gave written informed consent.

Results

Population Characteristics

A total of 9,215 subjects were included in the analyses (50% women). Overall mean age was 51.5 yrs (SD, 10.8). There were 4,402 subjects between 35–49 yrs (47.8%), 3,462 between 50–64 yrs (37.6%) and 1,351 between 65–74 yrs (14.7%) (Table 1). Forty-five percent of the subjects were never-smokers, 30% were current smokers and 25% ex-smokers. Average BMI was 25.1 (SD 4.2) kg/m². Twelve percent had a BMI of 30 kg/m² or more (obesity). Twenty-six percent had hypercholesterolemia, 6.1% diabetes, 1.9% a history of myocardial infarction. About half of the participants were between 60 yrs (37.6%) and 1,351 between 65–74 yrs (14.7%) (Table 1).

Compared to participants, non-participants were more likely to be women (52.2% vs 30.0%, p value <0.001), older (52.7 years (SD 11.1) vs 51.5 (SD 10.8), p value <0.001) and to have the Swiss citizenship (62.9% vs 54.2%, p value <0.001). There was no difference with respect to smoking status (47.0% vs 44.9% were never smokers, 29.2% vs 29.7% were current smokers, and 23.9% vs 23.5% were ex-smokers, p value = 0.06).

The mean systolic and diastolic BP were 125.9 mmHg (19.4) and 78.0 mmHg (11.2), respectively. The percentages of participants by BP categories were as follow: systolic and diastolic BP<120/<80, 33.4%; systolic or diastolic BP 120–139/80–89, 38.1%; systolic or diastolic BP 140–159/90–99, 20.7%; and systolic or diastolic BP≥160/≥100, 7.8%.

The number of participants were 6,020 (65.3%) and 3,195 (34.7%) in the 1999–2003 and 2004–2009 survey period, respectively. The prevalence of smoking status, diabetes, hypercholesterolemia, education level, Swiss citizenship, and alcohol consumption differed significantly between the two periods. The mean diastolic BP was lower in the second period than the first period (79.1 vs 76.0, p<0.05), and the overall distribution of the grades or stages of hypertension differed between the two periods.

Trends in Hypertension, Unawareness, Untreated and Uncontrolled Hypertension Prevalences

The overall age-standardized prevalence of hypertension was 34.4%. This prevalence remained stable between 1999–2009 (Figure 1, Tables S1 and S2) in both men and women. The prevalence of hypertension unawareness decreased between 1999 and 2009, in men and in women specifically (p<0.001). In 1999, 35.9% of hypertensive participants were unaware of having hypertension, whereas 17.7% of hypertensive participants were unaware of having hypertension in 2009. The increasing tendency of the prevalence of untreated hypertension observed in men and in women specifically was only statistically significant (from 53.9% to 61.8%, p = 0.04) when men and women participants were combined and thus power increased. The prevalence of uncontrolled hypertension decreased between 1999 and 2009 (p<0.05); from 62.2% to 40.6% in men and women combined, from 60.6% to 49.6% in men, and from 72.2% to 37.8% in women.

Determinants of Hypertension

Multivariate associations of characteristics with hypertension are reported by periods in Table 2. In the 1999–2003 period, male gender, sedentarity, obesity, hypercholesterolemia, diabetes, older age, and alcohol consumption were all positively associated with the risk of hypertension. Compared to never and ex-smokers, current smokers were less likely to have hypertension.

Similar associations were found in the 2004–2009 with the exception of sedentarity, alcohol consumption, and education level. The first two were not positively associated with hypertension in the second survey period. Of note, high education was significantly negatively associated with hypertension in the second survey period.

Determinants of Hypertension Unawareness

In the 1999–2003 period, current smokers were more likely to be unaware of having hypertension compared to never and ex-smokers. Male gender, hypercholesterolemia, older age were positively associated with the risk of hypertension unawareness. Participants with BMI ≥30 kg/m² (and diabetes were less likely to be unaware of having hypertension. In the 2004–2009 period, only obesity and diabetes remained independently associated with hypertension unawareness.

Determinants of Untreated Hypertension

In the first survey period, sedentarity, hypercholesterolemia, and older age were associated with a lower risk of untreated hypertension. Participants with high education were more likely to have untreated hypertension than participants reporting low level of education. Older age and education level remained associated with untreated hypertension in the 2004–2009 period.

Determinants of Uncontrolled Hypertension

Male gender and sedentarity were associated with increased risk of uncontrolled hypertension in the first survey period, while only
male gender remained associated with uncontrolled hypertension in the second survey period.

Prevalence of Hypertension, Unawareness, Untreated and Uncontrolled Hypertension, by Monthly Household Income and Job Position

Information on monthly household income and job position collected since 2005 was available for 2,024 (22.0%) participants whose main characteristics are presented in Table S3. The age-standardized prevalence of hypertension, unawareness, untreated and uncontrolled hypertension varied with job position (Table S4). To adjust for the effect of job position, trends with household monthly income were further adjusted for job position. After full adjustment, no clear trends were found.

Prevalences in Mutually Exclusive Groups

Figure S2 illustrated the prevalences of the four mutually exclusive groups among participants with hypertension: unaware; aware, not treated; aware, treated, not controlled; aware, treated, and controlled. The prevalences of these mutually exclusive groups for the period 1999–2003 and 2004–2009 were respectively 38.6% (809/2095) and 24.9% (272/1094), 33.2% (695/2095) and 43.8% (479/1094), 17.0% (357/2095) and 18.9% (207/1094), 11.2% (234/2095) and 12.4% (136/1094).

| Table 1. Participants’ characteristics, values are Mean (SD) or N (%) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                  | ALL             | Period 1 (1999–2003) | Period 2 (2004–2009) | P value        |
| Age, mean, (yrs) | 51.5 (10.8)     | 51.5 (10.8)       | 51.5 (10.9)       | 0.88           |
| Age group        |                 |                  |                  |                |
| 35-49yrs         | 4,402 (47.8)    | 2,874 (47.7)      | 1,528 (47.8)      | 0.89           |
| 50-64yrs         | 3,462 (37.6)    | 2,270 (37.7)      | 1,192 (37.3)      |                |
| 65–74yrs         | 1,351 (14.7)    | 876 (14.6)        | 475 (14.9)        |                |
| Female           | 4,605 (50.0)    | 2,977 (49.5)      | 3043 (50.5)       | 0.17           |
| Smoking status   |                 |                  |                  |                |
| Never smokers    | 4,140 (44.9)    | 2,681 (44.5)      | 1,459 (45.7)      | 0.001          |
| Current smokers  | 2,739 (29.7)    | 1,741 (28.9)      | 998 (31.2)        |                |
| Ex-smokers       | 2,336 (25.3)    | 1,598 (26.5)      | 738 (23.1)        |                |
| BMI, mean, (kg/m²) | 25.1 (4.2)   | 25.1 (4.2)        | 25.0 (4.2)        | 0.26           |
| BMI categories,  |                 |                  |                  |                |
| BMI <25 kg/m²    | 4,852 (52.7)    | 3,160 (52.5)      | 1,692 (53.0)      | 0.91           |
| BMI 25–29.9 kg/m² | 3,273 (35.5)  | 2,147 (35.7)      | 1,126 (35.2)      |                |
| BMI ≥30 kg/m²    | 1’090 (11.8)    | 713 (11.8)        | 377 (11.8)        |                |
| Diabetes         | 563 (6.1)       | 343 (5.7)         | 220 (6.9)         | 0.02           |
| Hypercholesterolemia | 2,408 (26.1) | 1,525 (25.3)     | 883 (27.6)        | <0.0001        |
| Myocardial infarction history | 177 (1.9) | 123 (2.0) | 54 (1.7) | 0.24 |
| SBP, mm Hg, mean | 125.9 (19.4)    | 126.1 (19.7)      | 125.5 (18.8)      | 0.13           |
| DBP, mm Hg, mean | 78.0 (11.2)     | 79.1 (11.0)       | 76.0 (11.2)       | <0.0001        |
| HTN stages       |                 |                  |                  | <0.0001        |
| S/DBP≥160/≥100 mm Hg | 716 (7.8) | 507 (8.4) | 209 (6.5) |                  |
| S/DBP 140–159/90–99 mm Hg | 1’908 (20.7) | 1,369 (22.7) | 539 (16.9) |                  |
| S/DBP 120–139/80–89 mm Hg | 3’510 (38.1) | 2,328 (38.7) | 1,182 (37.0) |                  |
| S/DBP <120/<80 mm Hg | 3’081 (33.4) | 1,816 (30.2) | 1,265 (39.6) |                  |
| Education level  |                 |                  |                  |                |
| Low = Elementary school or apprenticeship | 4,429 (48.1) | 2,837 (47.1) | 1,592 (49.8) | 0.01 |
| High = Maturity/baccalaureat or university | 4,786 (51.9) | 3,183 (52.9) | 1,603 (50.2) |                  |
| Swiss citizenship | 4,916 (54.2) | 3,321 (55.3) | 1,595 (52.2) | 0.007 |
| Sedentarity      | 5,863 (63.6)   | 3,836 (63.7)      | 2,027 (63.4)      | 0.79           |
| Alcohol consumption |                 |                  |                  | <0.0001        |
| Lower tertile    | 3,086 (33.5)    | 1,963 (32.6)      | 1,123 (35.1)      |                  |
| Middle tertile   | 3,073 (33.4)    | 1,963 (32.6)      | 1,110 (34.7)      |                  |
| Upper tertile    | 3,056 (33.2)    | 2,094 (34.8)      | 962 (30.19)       |                  |

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HTN, hypertension. doi:10.1371/journal.pone.0039877.t001
Hypertension is the most prevalent cardiovascular disorder in high-income countries, where it affects 20% to 50% of the adult population [2,22]. In a representative population of adults in Geneva, the 2004–2009 age-adjusted prevalence of hypertension were 41.7% and 27.3% in men and women, respectively. These prevalences are higher than the ones reported in the United States, but similar to what is found in most European countries [23–28]. This is in line with previous reports showing that hypertension prevalences are higher in Europe than in North America. Wolf Maier et al. found that hypertension prevalence was 28% in the North American countries and 44% in 6 European countries [6].

Our analyses showed no significant changes in hypertension prevalence in adults from 1999 to 2009. A 1993–2000 analysis conducted in the same source population reported, a decline in hypertension prevalence in men and women [29]. Our results showing an absence of further decline in hypertension prevalence in recent years are in line with other major surveys. The most recent NHANES survey reported an increase in hypertension prevalence followed by a stable prevalence around 29% in the 2007–2008 period [4]. Data from the MONICA studies reported different trends in Belgium, Finland and Germany; a decline, a stable, and an increase prevalence of hypertension, respectively [2]. The Health Survey for England conducted in 1994 and 1998 reported similar prevalence of hypertension (about 37%) [2]. Thus, much needs to be done to decrease the burden of hypertension in the canton of Geneva and population-based strategies, such as reduction of sodium intake, are of utmost importance.

Hypertension awareness improved between 1999 and 2009 in the Geneva population. Similar favorable trends have been reported in other, yet scarce, longitudinal reports on hypertension awareness [5,12,31–33]. In the last period (2004–2009), about 25% of the participants were unaware of having hypertension. Smoking has been consistently described as a barrier to preventive medicine such as screening, but association between smoking and hypertension unawareness has rarely been looked at or found [7,14,16,36]. In a representative sample of the Chinese population (n = 15 838), higher unawareness was also found, with the same magnitude as in our study population (OR = 1.27) [15]. Men with hypertension were less frequently aware than women, a finding consistent with the literature [4,7,28,35,37]. It has been
Table 2. Multivariate associations (odds ratios, 95%CI, p values) of characteristics with hypertension, hypertension unawareness, untreated hypertension and uncontrolled hypertension, for the period 1999–2003 and 2004–2009.

| Period        | Hypertension          | Hypertension unawareness | Untreated hypertension | Uncontrolled hypertension |
|---------------|-----------------------|--------------------------|------------------------|---------------------------|
|               | 1999–2003 | 2004–2009 | 1999–2003 | 2004–2009 | 1999–2003 | 2004–2009 | 1999–2003 | 2004–2009 |
| Current smoker vs never/ex-smoker | 0.82* (0.72–0.94) | 0.75* (0.69–0.92) | 1.27* (1.02–1.59) | 1.17 (0.80–1.70) | 1.07 (0.78–1.47) | 1.29 (0.83–2.00) | 0.99 (0.65–1.49) | 0.96 (0.55–1.68) |
| Male vs female | 1.64* (1.45–1.88) | 1.97* (1.64–2.36) | 1.56* (1.27–1.92) | 1.32 (0.96–1.83) | 1.00 (0.74–1.34) | 0.78 (0.55–1.12) | 1.49* (1.03–2.17) | 1.65* (1.08–2.50) |
| Swiss vs non-Swiss | 1.00 (0.88–1.13) | 0.92 (0.78–1.10) | 0.84 (0.70–1.01) | 0.93 (0.70–1.25) | 0.91 (0.70–1.19) | 1.36 (0.98–1.89) | 0.83 (0.59–1.15) | 0.75 (0.51–1.12) |
| Sedentarity | 1.22* (1.08–1.39) | 1.05 (0.88–1.26) | 1.05 (0.86–1.28) | 0.87 (0.64–1.19) | 0.72* (0.54–0.95) | 0.91 (0.64–1.30) | 1.56* (1.08–2.24) | 1.09 (0.71–1.69) |
| Obesity | 3.19* (2.67–3.81) | 2.84* (2.21–3.66) | 0.73* (0.58–0.92) | 0.65* (0.44–0.97) | 0.83 (0.61–1.14) | 0.77 (0.51–1.15) | 1.31 (0.89–1.94) | 0.92 (0.58–1.47) |
| Hypercholesterolemia | 1.09* (1.03–1.14) | 1.13* (1.01–1.27) | 1.31* (1.20–1.44) | 1.17 (0.96–1.42) | 0.59* (0.45–0.77) | 0.75 (0.54–1.06) | 0.96 (0.69–1.34) | 0.90 (0.60–1.35) |
| Diabetes | 1.86* (1.44–2.39) | 2.01* (1.44–2.80) | 0.36* (0.25–0.51) | 0.41* (0.26–0.70) | 0.69 (0.45–1.05) | 0.71 (0.44–1.16) | 0.96 (0.61–1.52) | 1.15 (0.69–1.94) |
| 50–64y vs 35–49y | 2.94* (2.57–3.35) | 3.18* (2.63–3.85) | 1.14 (0.91–1.43) | 1.02 (0.71–1.47) | 0.23* (0.17–0.31) | 0.14* (0.09–0.22) | 1.32 (0.81–2.16) | 0.99 (0.46–2.13) |
| 65–74y vs 35–49y | 7.64* (6.39–9.14) | 8.60* (6.66–11.10) | 1.56* (1.21–2.02) | 1.00 (0.66–1.50) | 0.06* (0.04–0.10) | 0.06* (0.03–0.09) | 1.97 (1.17–3.32) | 1.03 (0.47–2.26) |
| Alcohol consumption middle vs lower tertile | 0.97 (0.83–1.13) | 1.05 (0.85–1.30) | 0.93 (0.73–1.18) | 1.04 (0.71–1.51) | 1.07 (0.76–1.50) | 0.83 (0.54–1.25) | 1.03 (0.68–1.56) | 0.61 (0.37–1.00) |
| Alcohol consumption upper vs lower tertile | 0.97 (0.83–1.13) | 1.05 (0.85–1.30) | 0.93 (0.73–1.18) | 1.04 (0.71–1.51) | 1.07 (0.76–1.50) | 0.83 (0.54–1.25) | 1.03 (0.68–1.56) | 0.61 (0.37–1.00) |
| Education High level vs low level | 0.90 (0.80–1.02) | 0.72* (0.61–0.86) | 1.08 (0.90–1.30) | 0.85 (0.63–1.14) | 1.45* (1.12–1.88) | 1.42* (1.02–1.99) | 1.00 (0.72–1.39) | 0.79 (0.53–1.18) |

Odds ratios with p values <0.05 are marked with an asterisk. doi:10.1371/journal.pone.0059877.t002
suggested that the gender difference in awareness is, in part, due to the more frequent lifetime contact of women with the medical staff.

Elevated BP is a risk factor for coronary heart disease, heart failure, stroke, peripheral arterial disease, and renal failure [30–41]. BP control is adequate when systolic and diastolic BPs are <140 mm Hg and <90 mm Hg, respectively [42,43]. Prevalence of uncontrolled BP in hypertensive patients varied from 10% to 65% across studies [22,24,44–51]. We found that hypertension was detected but often untreated in the Geneva population. In the last survey period, the prevalence of untreated hypertension was 58% in the canton of Geneva, which lies in the upper range of European’s estimates [25–27,35]. In France, the neighboring country of Geneva, the prevalence of untreated hypertension was only 20% in the 2003–2007 MONA LISA [35]. Our data suggested that untreated hypertension has been stable since 1999. The substantial decrease in hypertension unawareness between 1999–2003 and 2004–2009 was therefore not paralleled by a concomitant absolute increase in hypertension treatment. As a consequence, a larger proportion of all hypertensive participants were aware but not treated in 2004–2009 (43.7%) compared to 1999–2003 (43.7%) [Figure S2]. The observed gain in hypertension awareness is therefore unlikely to translate into public health benefit if no action is undertaken to control BP. We found that BP control was not controlled in half of hypertensive treated subjects, which corresponds to the control rate reported in 2009 in a Swiss city population-based study (48%) [7].

Hypertension treatment initiation and intensification once hypertension is detected are challenged by both patient- and physician-related factors, which may vary across regions [52]. Ouctlinc patients with inadequately controlled hypertension seemed to be less likely to receive a medication increase in the United States than in European countries [53]. In Switzerland, information on reasons for untreated and/or uncontrolled hypertension is limited. In a family practice based, open survey, physicians-related reasons for uncontrolled BP were to believe that baseline BP dictates the target, that a clear improvement in BP might be sufficient and that the full drug effect may take up to 4 months or more to be achieved [54]. Here, we provide information on patients-related characteristics of untreated and uncontrolled hypertension. This needs to be completed by additional patient- and physician-based studies conducted in Switzerland.

After adjustment, participants with high education level were at increased risk of untreated hypertension than participants with lower level of education. The associations between education and hypertension awareness, treatment and control are inconsistent. Some reports showed an inverse association or no association between education level and hypertension awareness, treatment or control [16]. In line with our results, untreated hypertension was positively associated with high education level in four Scottish MONICA cross-sectional surveys (1986, 1989, 1992 and 1995) [55]. Reason for this unexpected, yet replicated, association is not clear. It has been suggested that people with high education level might think they are able to manage their BP and might therefore not follow their GP’s advice. Because such interventions are highly dependent on educational level and motivation, we propose that, conversely, nonpharmacological lifestyle interventions might be more often presented by GPs to better educated subjects.

Our results have to be interpreted within the context of the Swiss health care system. Health insurance is compulsory for all citizens of Switzerland (7 millions) and insurance premiums are paid independently of earnings [36,57]. Subsidies are paid for citizens with low income. Health insurance covers the costs of medical treatment and hospitalisation of the insured. Everyone pays part of the cost of treatment through 1) an annual flat deductible, called the ‘franchise’, which ranges from CHF 300 to a maximum of CHF 2,500 (1CHF $≈ 1.35$), at the insured person’s choice (premiums are adjusted accordingly); and 2) a 10% deductible of the costs up to a stop-loss amount of CHF 700 per year. Some 40% of the Swiss population chooses to top up their insurance coverage with private health insurance, which offers a wider choice of treatments and health care professional, or more comfortable accommodation during a hospital stay. In contrast to basic insurance, insurers may refuse applicants for private insurance or only accept them subject to conditions. While all basic insurances will cover medical (primary care and specialist) consultations as well as anti-hypertensive treatment, the insured still pays 10% of the cost (i.e. out-of-pocket participation). Switzerland has the highest out of pocket participation within countries of the Organisation for Economic Co-operation and Development [58]. Thus, even though the Swiss health care insurance coverage is universal, patient’s financial resources may still influence the use of medical services and treatment. Yet, we found no independent associations between monthly household income – a proxy of an individual financial resources – and hypertension, awareness, treatment, or control.

Strengths and Limitations

When interpreting the findings of this study, one has to keep in mind its limitations. Non participants slightly differed from participants with respect to sex, age and Swiss citizenship. Given that our results suggested that age, smoking status and gender are significant predictors of study outcomes, these differences may somewhat limit the generalisability of our findings. Several informations were determined by the use of questionnaires. By nature of its reliance on self-reported data, this is a source of possible bias. Similarly to other large population-based studies, white coat effect, white coat hypertension, or masked hypertension could not be determined in this analysis. BP was measured with two different methods; mercury sphygmomanometer (1999–2003) and semi-automatic oscillometer (2004–2009). Although semi-automatic oscillometer are calibrated with mercury sphygmomanometer, we cannot exclude that some of the differences observed between the two periods are attributable to the method of BP measurement. Yet, it is also possible that the 2003 antihypertension-guidelines (e.g. the 2003 Seventh Joint National Committee [JNCVII] [10], the 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) and European statement on management of hypertension [11]) contributed to improve the levels of awareness and adherence of the medical staff to hypertension screening and control. The study which was conducted concomitantly to the Bus Santé study between 2005 and 2008 was a follow-up study involving different independent participants than the Bus Santé study. During this period, only a smaller number of subjects from the Geneva population were randomly selected and invited to participate to the Bus Santé study. The study protocol and procedures remained identical. Yet, we cannot exclude some interference between the two studies. The strengths of this study are the secular comparison of prevalences using the same definition, in the same source population, using the same number of BP readings. In addition, the large number of included subjects (>9’000), the recruitment strategy of the participants (representative sampling and low attrition), the time window (ten years with yearly data), and the inclusion of objective measures strengthen the findings.

In conclusion, in a representative sample of the canton of Geneva, Switzerland, the prevalence of hypertension remained
stable between 1999–2003 and 2004–2009. Population-based primary prevention measures are needed to decrease the burden of hypertension in this region. While favorable trends in hypertension unawareness and uncontrolled hypertension occurred during this period, about half of hypertensive subjects were not treated or had uncontrolled high BP in the latest 2004–2009 survey period. Factors associated with untreated and uncontrolled hypertension in our analyses could guide the implementation of targeted interventions aimed at reducing these rates.

Supporting Information

Figure S1 Flow chart of age-standardized prevalences of hypertension, unawareness, untreated, and uncontrolled hypertension, by survey period.

Figure S2 Age-standardized prevalences of the four mutually exclusive categories of participants with hypertension, by survey period.

Table S1 Age-standardized prevalences (95%CI) of hypertension, hypertension unawareness, untreated and uncontrolled hypertension, by survey year and gender (N = 9,215).

| Year | Hypertension | Unawareness | Untreated | Uncontrolled |
|------|--------------|-------------|-----------|-------------|
| 1999 | 12.3         | 6.5         | 8.0       | 22.8        |
| 2004 | 10.8         | 5.8         | 6.1       | 19.7        |

References

1. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ (2006) Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet 367: 1747–1757.
2. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J (2004) Worldwide prevalence of hypertension: a systematic review. J Hypertens 22: 11–19.
3. Lowe LP, Greenland P, Ruth KJ, Dyer AR, Stanler R, et al. (1986) Impact of major cardiovascular disease risk factors, particularly in combination, on 22-year mortality in women and men. Arch Intern Med 150: 2007–2014.
4. Egan BM, Zhao Y, Axon RN (2010) US trends in prevalence, awareness, treatment, and control of hypertension, 1988–2008. JAMA 303: 2043–2050.
5. McAlister FA, Wilkinson J, Joffres M, Leenen FH, Fodor G, et al. (2011) Changes in the rates of awareness, treatment and control of hypertension in Canada over the past two decades. CMAJ 183: 1007–1013.
6. Wolf-Maier K, Cooper RS, Banegas JR, Giampaoli S, Hense HW, et al. (2003) Hypertension prevalence and blood pressure levels in 6 European countries, Canada, and the United States. JAMA 289: 2363–2369.
7. Danon-Hersch N, Marques-Vidal P, Bovet P, Chiolero A, Paccoud F, et al. (2009) Prevalence, awareness, treatment and control of blood pressure in a Swiss city general population: the CoLaus study. Eur J Cardiovasc Prev Rehabil 16: 66–72.
8. Gaspoz JM, Beer-Borst S, Costanza MC, Morabia A (2009) Suivi des facteurs de risque cardiovasculaire dans la population genevoise de 1993 à 2007. Available at: <http://www.bag.admin.ch/themen/ernahrung_bewegung/05207/05213/index.html?lang=fr>. Accessed 15 May 2012.
9. European Union Public Health Information System (Euphias). Available at http://www.euphias.org/object_document/o5533n27415.html. Accessed 11 March 2012.
10. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, et al. (2000) Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 42: 1206–1252.
11. Whitworth JA (2003) 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. J Hypertens 21: 1983–1992.
12. Bovet P, Romain S, Shanlaye C, Mendis S, Daridi R, et al. (2009) Divergent fifteen-year trends in traditional and cardiometabolic risk factors of cardiovascular diseases in the Seychelles. Cardiovascular Diabetol 8: 34.
13. Cutter JA, Sorlie PD, Wolz M, Thom T, Fields LE, et al. (2008) Trends in hypertension prevalence, unawareness, treatment, and control rates in United States adults between 1988–1994 and 1999–2004. Hypertension 52: 818–827.
14. Tian S, Dong GH, Wang D, Liu MM, Lin Q, et al. (2011) Factors associated with prevalence, awareness, treatment and control of hypertension in urban adults from 33 communities in China: the CHPSNE Study. Hypertens Res 34: 1087–1092.
15. Munner P, Gu D, Wu X, Duan X, Wenq G, et al. (2004) Factors associated with hypertension awareness, treatment, and control in a representative sample of the Chinese population. Hypertension 43: 578–585.
16. Ayemang C, van Valkengoed I, Koopmans R, Stronks K (2006) Factors associated with hypertension awareness, treatment and control among ethnic groups in Amsterdam, the Netherlands: the SUNSET study. J Hum Hypertens 20: 674–681.
17. Morabia A, Bernstein M, Heritier S, Ylli A (1997) Community-based surveillance of cardiovascular risk factors in Geneva: methods, resulting distributions, and comparisons with other populations. Prev Med 26: 311–319.
18. Bernstein M, Sloutskin D, Kumanayika S, Sparri A, Schutz Y, et al. (1998) Data-based approach for developing a physical activity frequency questionnaire. Am J Epidemiol 147: 147–154.
19. Vano J, Martinez-Gonzalez MA, De Irala-Estevez J, Kearney J, Gibney M, et al. (2003) Distribution and determinants of sedentary lifestyles in the European Union. Int J Epidemiol 32: 138–146.
20. Bernstein M, Morabia A, Costanza MC, Landsd JR, Ross A, et al. (1994) [Nutritional balance of the diet of the adult residents of Geneva]. Soz Praventivmed 39: 333–344.
21. Morabia A, Bernstein M, Kumanayika S, Sorenson A, Mahlia I, et al. (1994) [Development and validation of a semi-quantitative food questionnaire based on a population survey]. Soz Praventivmed 39: 345–369.
22. From the Centers for Disease Control and Prevention (1999). Decline in deaths from heart disease and stroke–United States, 1900–1999. JAMA 282: 724–726.
23. Wagner A, Sadowsu A, Dallognville J, Ferrieres J, Amouyel P, et al. (2011) High blood pressure prevalence and control in a middle-aged French population and their associated factors: the MONA LISA study. J Hypertens 29: 43–50.
24. Wolf-Maier K, Cooper RS, Kramer H, Banegas JR, Giampaoli S, et al. (2004) Hypertension treatment and control in five European countries, Canada, and the United States. Hypertension 43: 10–17.
25. Elefratopoulos AD, Voykoi SM, Baltas AA, Vrazilias FA, Kriats DE, et al. (2006) Prevalence, awareness, treatment and control of hypertension in Hellas, Greece: the Hypertension Study in General Practice in Hellas (HYPERTENSION-SHELL) national study. Am J Hypertens 19: 53–60.
26. Macek ME, Lima MJ, Silva AO, Alcantara P, Ramalhinbo V, et al. (2005) Prevalence, awareness, treatment and control of hypertension in Portugal: the PAP study. J Hypertens 23: 1661–1666.
27. Cillova R, Skodova Z, Lansk a, Vanda K, Novozamska E, et al. (2004) 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 18: 571–579.
28. Dorobantu M, Darabont RO, Badila E, Giorghe-S T (2010) Prevalence, Awareness, Treatment, and Control of Hypertension in Romania: Results of the SEPHAR Study. Int J Hypertens: 970694.
29. Galobardes B, Costanza MC, Bernstein MS, Delftumeau CH, Morabia A (2003) Trends in risk factors for the major "lifestyle-related" diseases in Geneva, Switzerland, 1993–2000. Am J Epidemiol 13: 537–546.
30. Beer-Borst S, Costanza MC, Pechere-Bertschi A, Morabia A (2009) Twelve-year trends and correlates of dietary salt intakes for the general adult population of Geneva, Switzerland. Eur J Clin Nutr 63: 153–164.
31. Cifkova R, Skodova Z, Lanska V, Adamkova V, Novozamska E, et al. (2004) Trends in blood pressure levels, prevalence, awareness, treatment, and control of hypertension in the Czech population from 1985 to 2000/01. J Hypertens 22: 1479–1485.

32. Cifkova R, Skodova Z, Bruthans J, Holub J, Adamkova V, et al. (2010) Longitudinal trends in cardiovascular mortality and blood pressure levels, prevalence, awareness, treatment, and control of hypertension in the Czech population from 1963 to 2007/2008. J Hypertens 28: 2196–2203.

33. Leenen IH, Duman J, McClain NH, Turton P, Stratychuk L, et al. (2008) Results of the Ontario survey on the prevalence and control of hypertension. CMAJ 178: 1441–1449.

34. Zdrojewski T, Szpakowski P, Radosz P, Pajak A, Wieczk A, et al. (2004) Arterial hypertension in Poland in 2002. J Hum Hypertens 18: 557–562.

35. Wagner A, Sadoun A, Dallongeville J, Ferrieres J, Amonstel P, et al. (2011) High blood pressure prevalence and control in a middle-aged French population and their associated factors: the MONA LISA study. J Hypertens 29: 43–50.

36. Bergmann S, Stafford RS, Winkleby MA (2009) Predictors of hypertension awareness, treatment, and control among Mexican American women and men. J Gen Intern Med 24 Suppl 3: 521–527.

37. Brindel P, Hanon O, Dartigues JF, Ritchie K, Lacombe JM, et al. (2006) Prevalence, awareness, treatment, and control of hypertension in the elderly: the Three City study. J Hypertens 24: 51–58.

38. MacMahon S, Petro R, Cutler J, Collins R, Soelie P, et al. (1990) Blood pressure, stroke, and coronary heart disease. Part 1. Prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias. Lancet 335: 765–774.

39. Kannel WB (1996) Blood pressure as a cardiovascular risk factor: prevention and treatment. JAMA 275: 1571–1576.

40. Assmann G, Schulte H (1988) The Prospective Cardiovascular Munster (PROCAM) study: prevalence of hyperlipidemia in persons with hypertension and/or diabetes mellitus and the relationship to coronary heart disease. Am Heart J 116: 1713–1724.

41. Walker WG, Neaton JD, Cutler JA, Newman R, Cohen JD (1992) Renal function change in hypertensive members of the Multiple Risk Factor Intervention Trial: Racial and treatment effects. The MRFIT Research Group. JAMA 268: 3083–3091.

42. Mancia G, Grassi G (2008) The new European Society of Hypertension/European Society of Cardiology (ESH/ESC) Guidelines. Ther Adv Cardiovasc Dis 2: 5–12.

43. World Health Organization-International Society of Hypertension Guidelines for the Management of Hypertension. Guidelines Subcommittee. J Hypertens 17: 151–183.

44. Mancia G, Sega R, Milesi C, Cesana G, Zanchetti A (1997) Blood pressure control in the hypertensive population. Lancet 349: 454–457.

45. Bielecka-Dabrowa A, Aronow WS, Rysz J, Banach M (2011) The Rise and Fall of Hypertension: Lessons Learned from Eastern Europe. Curr Cardiovasc Risk Rep 3: 174–179.

46. Lloyd-Jones D, Adams R, Carnethon M, De Simone G, Ferguson TB, et al. (2009) Heart disease and stroke statistics–2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 119: e21–181.

47. Mohan S, Campbell NR (2008) Hypertension management in Canada: good news, but important challenges remain. CMAJ 178: 1458–1460.

48. Ordunez-Garcia F, Munoz JL, Pedraza D, Espinosa-Brito A, Silva LG, et al. (2006) Success in control of hypertension in a low-resource setting: the Cuban experience. J Hypertens 24: 845–849.

49. Kronborg GN, Hallas J, Jacobsen IA (2009) Prevalence, awareness, and control of arterial hypertension in Denmark. J Am Soc Hypertens 3: 19–24 e12.

50. Falaschetti E, Chaudhury M, Mendell J, Poulter N (2009) Continued improvement in hypertension management in England: results from the Health Survey for England 2006. Hypertension 53: 480–486.

51. Koteva K, Wood D, De Barker G, De Barcquer D, Pyorala K, et al. (2009) Cardiovascular prevention guidelines in daily practice: a comparison of EUROASPIRE I, II, and III surveys in eight European countries. Lancet 373: 929–940.

52. Whelton PK, He J, Muntner P (2004) Prevalence, awareness, treatment and control of hypertension in North America, North Africa and Asia. J Hum Hypertens 18: 545–551.

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

54. Ferrari P, Hess L, Pechere-Bertschi A, Muggli F, Burnier M (2004) Reasons for not intensifying antihypertensive treatment (RIAT): a primary care antihypertensive intervention study. J Hypertens 22: 1221–1229.

55. Chen R, Tuomilehto J, Morrisson C, Conaghan J, A’Brook R (2003) Trends and social factors in blood pressure control in Scottish MONICA surveys 1986–1995: the rule of halves revisited. J Hum Hypertens 17: 151–183.

56. Lloyd-Jones D, Adams R, Carnethon M, De Simone G, Ferguson TB, et al. (2009) Heart disease and stroke statistics–2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 119: e21–181.

57. Wolff H, Gaspoz JM, Guessous I (2011) Health care renunciation for economic reasons in Switzerland. Swiss Med Wkly 141: w13165.

58. OECD Health Data 2011 Available at http://www.oecd.org/document/30/0,3746,en_2649_37407_12960734_1_1_1_37407,00.html. Accessed 2012 May 15.