Original Article

Prevalence, awareness, treatment and control of hypertension in Greece: EMENO national epidemiological study

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Objective: The evidence on the epidemiology of hypertension in Greece is limited. The prevalence and control of hypertension was assessed in randomly selected adults of the general population in Greece within the nationwide epidemiological study EMENO.

Method: On the basis of 2011 census, EMENO applied a multistage stratified random sampling method involving 577 areas throughout Greece (2013–2016). Participants were assessed at home visits with standardized questionnaires, blood tests and triplicate seated blood pressure (BP) measurements (validated upper-arm automated oscillometric device Microlife BPA100 Plus). Hypertension was defined as BP at least 140/90 mmHg (average of second–third measurement) and/or use of antihypertensive drugs. Sampling weights were applied for study design and post-stratification weights to match the age/sex distribution to the general population in Greece. Nonresponse was adjusted by inverse probability weighting.

Results: A total of 6006 individuals were recruited and 4699 with valid data were analysed [mean (SD) age 49.2 (18.6) years, men 48.6%, BMI 28.2 (5.7) kg/m^2]. The prevalence of hypertension was 39.6% and was higher in men than women (42.7 vs. 36.5%, $P < 0.001$). Among patients with hypertension, 31.8% were unaware (men/women 39.2/23.6%, $P < 0.001$), 2.7% aware but untreated (men/women 2.9/2.5%, $P =$ NS), 35.1% treated uncontrolled (32.1/38.3%, $P < 0.01$) and 30.5% treated controlled (25.8/35.6%, $P < 0.001$).

Conclusion: The prevalence of hypertension in Greece seems to be rising and affects 40% of the adults. One-third of them are undiagnosed and only 30% are controlled with treatment. Nationwide programmes are needed to prevent hypertension and improve its awareness and control aiming at reducing the rate cardiovascular diseases.

Keywords: antihypertensive therapy, cross-sectional, detection, epidemiology, high blood pressure, national, prevalence

Abbreviations: BP, blood pressure; SD, standard deviation

INTRODUCTION

In the twenty-first century, high blood pressure (BP) remains a major public health issue globally, as it is the strongest modifiable risk factor for cardiovascular disease and death and affects more than one-third of the adult population worldwide [1,2]. Importantly, its prevalence is rising, particularly in low and middle-income countries, mainly due to ageing of the population, unfavourable lifestyle changes and increasing prevalence of obesity [1–3].

A recent synthetic analysis of BP measurements from 19.1 million adults reported in 1479 studies [1] showed that the number of adults with raised BP increased from 594 million in 1975 to 1.13 billion in 2015 [1]. The global prevalence of raised BP was 24.1% in men and 20.1% in women and was increased in low and some middle-income countries and decreased in high and some middle-income countries [1]. National surveys between 1986 and 1999 showed higher hypertension prevalence in Europe than in North America by 60% (44 versus 28%), which is associated with higher mortality from stroke [4].

Numerous randomized long-term outcome trials including many thousands of patients have successfully tested the efficacy of several classes of BP-lowering drugs in preventing cardiovascular events and death [5,6]. It has been shown

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that in clinical practice by implementing hypertension management programmes with effective use of the currently available drugs and close patient monitoring, control of BP can be achieved in more than 90% of people with hypertension [7].

Unfortunately, population-based studies published between 1995 and 2014 and including almost one million people from 90 countries showed awareness of hypertension 67%, treatment 56% and control 28% in high-income countries, and 38, 29 and 8%, respectively, in low and middle-income countries [3]. The control rate of hypertension is worse in Europe than in North America [8] and even worse in Eastern European countries [2,9]. In the USA, the control rate of hypertension reached 48.3% [10] and in Canada 68.1% [11].

In Greece, epidemiological studies have estimated the prevalence of hypertension at about 30%, yet based on selected samples, which may not represent the general population [12–16]. The European Cardiovascular Disease Statistics 2017 reported the prevalence of hypertension in Greece in 2014 at 18.4%, which was slightly lower than in 2010 [2].

The National Survey of Morbidity and Risk Factors (EMENO) is a cross-sectional epidemiological survey in a representative general population sample of adults nationwide in Greece, aiming to assess cardiovascular and respiratory risk factors and diseases [17]. This article presents the EMENO findings on the prevalence, awareness, treatment and control of hypertension.

PARTICIPANTS AND METHODS

Study design

EMENO was conducted from May 2013 to June 2016 in randomly selected adults in Greece. Participants were first assessed at a home visit by trained interviewers using standardized questionnaires. A second visit followed by trained physicians who performed BP measurements, physical examination and blood tests. The EMENO study was approved by Ethics and Deontology Committee of the National and Kapodistrian University and by the Hellenic Data Protection Authority whereas all participants provided signed informed consent. Details on the protocol have been published [17].

Sample selection

All adults aged at least 18 years were eligible for inclusion. A multistage stratified sampling method based on the 2011 census was applied to select the sample. Briefly, the country was divided into 22 geographical areas, where each area was composed of three strata, based on rates of urbanization. Of these areas, 577 sampling points were randomly selected; within each sampling point, eligible houses were selected via systematic sampling, whereas one adult from each eligible house was selected randomly [17]. The target study population was 6000.

Blood pressure measurement

BP was measured by trained physicians in a quiet room during a single visit at each participants' home. A validated automated (oscillometric) upper-arm cuff device was used, which has been successfully validated in adults (Microlife BPA100 Plus; Microlife AG, Widnau, Switzerland) [18]. Three cuffs were used (small, medium and large for arm circumference 17–22, 23–32 and 33–52 cm, respectively). Triplicate BP measurements were taken after 5 min sitting rest, with the participants' arm resting on table, mid-arm at heart level, back supported on chair, legs uncrossed and feet flat on floor [5,6]. Participants were asked before the measurements to abstain from smoking and caffeine for 1 h and physical exercise for 2 h. According to current hypertension guidelines, the average of the second and third BP readings was used in the analysis [5,6].

Hypertension diagnosis

Hypertension status was defined on the basis of BP measurement (average of second and third measurement) and the use of drugs for hypertension as follows: *Normotension*: untreated individuals with SBP less than 140 mmHg and DBP less than 90 mmHg; *Hypertension*: SBP at least 140 mmHg and/or DBP at least 90 mmHg, and/or reported use of drugs for hypertension; *Hypertension awareness*: reported previous diagnosis of hypertension (treated or untreated); *Treated hypertension*: reported use of drugs for hypertension; *Treated controlled hypertension*: SBP less than 140 mmHg and DBP less than 90 mmHg with reported use of drugs for hypertension; *Treated uncontrolled hypertension*: SBP at least 140 mmHg and/or a DBP at least 90 mmHg with reported use of drugs for hypertension.

Statistical analysis

Sampling weights were applied to adjust for study design, with an additional post-stratification weighting to match the age, sex and geographical distribution of the sample to that of the Greek population based on the 2011 census provided by the National Statistics Agency. To adjust for nonresponse, as a subsample of the interviewed individuals refused to have physical examination, the inverse probability weighting method was applied. Weights were the reciprocal of the response probabilities, estimated through weighted multivariable logistic regression. Weighted means and standard deviations for continuous variables and weighted percentages for categorical variables were provided. Differences in categorical variables were tested using Chi-square test for survey data and differences in continuous variables with weighted linear regression. The statistical analysis was performed by STATA software (version 13.0; Stata Corp, College Station, Texas, USA).

RESULTS

In total, 6006 participants were enrolled in the study with the response rate being 72% [17]. Thirteen with unknown age (necessary to estimate for post-stratification weights) were excluded. Among the remaining 5993, 4753 had completed questionnaires and BP measurements. Of those, 54 were excluded because they could not be classified for hypertension status, as they had normal BP, but it was unknown whether they were receiving drugs for hypertension resulting in a total of 4699 individuals included in the current analysis. Characteristics of the individuals included in the analysis are presented in Table 1. Excluded individuals were more likely to be more than 70 years old, to live in

TABLE 1. Characteristics of individuals included in the analysis overall and according to sex [mean (SD)]

	Total ($N = 4699$)	Men ($N = 2006$)	Women ($N = 2693$)	P[a]
Age (years)	49.2 (18.6)	48.2 (17.1)	50.2 (19.8)	0.002
Height (cm)	166.4 (10.3)	173.7 (7.4)	159.6 (7.7)	<0.001
Weight (kg)	78.1 (17.3)	85.2 (14.6)	71.3 (17.1)	<0.001
BMI[b] (kg/m^2)	28.2 (5.7)	28.2 (4.5)	28.1 (6.8)	NS
Overweight (%)	37.5	44.8	30.5	<0.001
Obesity (%)	32.1	30.5	33.6	<0.05
Current smokers (%)	37.4	43.1	31.9	<0.001
Diabetes mellitus[b] (%)	11.5	12.2	10.9	NS
Cardiovascular disease[b] (%)	5.7	7.0	4.5	<0.001
SBP (mmHg)	128.3 (18.9)	131.5 (16.0)	125.3 (21.1)	<0.001
DBP (mmHg)	77.6 (10.9)	80.4 (10.1)	75.0 (11.0)	<0.001
Hypertension, % (95% CI)	39.6 (37.8–41.3)[c]	42.7 (34.4–38.7)[c]	36.5 (37.8–41.3)[c]	<0.001

Results from weighted analysis.
[a]P-values for men versus women.
[b]Prevalence estimated based on available data: 4663 for BMI, 4283 for diabetes, 4565 for cardiovascular disease.
[c]95% confidence intervals.

urban areas, to have lower family monthly income and less likely to have reported a chronic disease, to be of Greek origin, to be unemployed or to have kids. A weighted logistic regression model adjusted for all these factors was fitted to estimate response probability.

Among 4699 individuals included in the analysis, in 4212 (89.6%) the values of each of three individual BP measurement were available, whereas in 487 (10.4%), the average of three measurements was recorded. Of 4699 individuals analysed, 48.6% were men, 36.1% were aged 18–39 years, 33.3% 40–59 years and 30.6% at least 60 years [17]. Participants from urban areas were 63.6%, suburban 16.1% and rural 20.3%. Education was primary in 29.2%, secondary/post-secondary in 47.0% and high 23.8%.

There was a steep increase in SBP with increasing age, with younger men having higher levels than women, whereas DBP increased up to the age of 50–60 years and thereafter it was decreased (Fig. 1). The prevalence of hypertension was considerably increased with ageing, exceeding 80% in both men and women older than 80 years (Fig. 2). The prevalence, awareness, treatment and control of hypertension are summarized in Table 2. Women and older individuals with hypertension were less likely to be unaware of the diagnosis and more likely to be treated and to have their BP controlled than men and younger individuals, respectively (Table 2). Using a lower BP threshold (≥130/80 mmHg), the prevalence of hypertension reached 58.8% and the control rate 9.5% (Table 3). Among treated hypertensive individuals, the BP levels and the control rate of hypertension appeared to be similar irrespective of the number of drugs administered (Table 4). Moreover, normotensive individuals had lower BP than all hypertensives, including those with controlled BP (Table 4).

DISCUSSION

The EMENO nationwide epidemiological study in 4699 adults provided methodologically appropriate data on the prevalence, treatment and control of hypertension in the general adult population in Greece in the twenty-first century. Key findings are (i) the prevalence of hypertension is high at 39.6%; (ii) 31.8% of hypertensive individuals are undiagnosed, 35.1% treated but uncontrolled and 30.5% treated and controlled; (iii) men had higher prevalence of hypertension than women and higher rates of undiagnosed, untreated and uncontrolled hypertension; (iv) the prevalence of hypertension was considerably increased with ageing, yet unaware, untreated and uncontrolled hypertension were much more common in those aged less

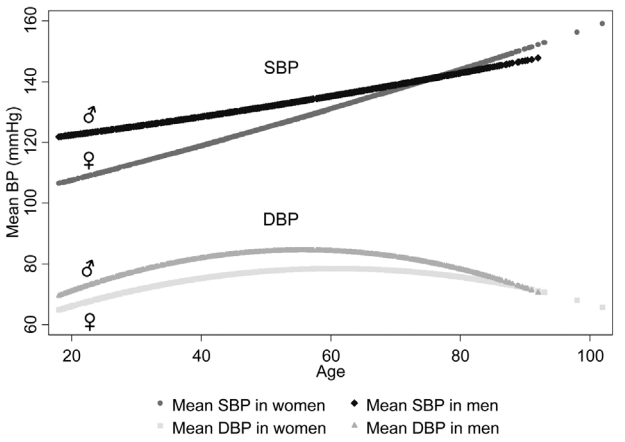

FIGURE 1 SBP and DBP levels according to age and sex.

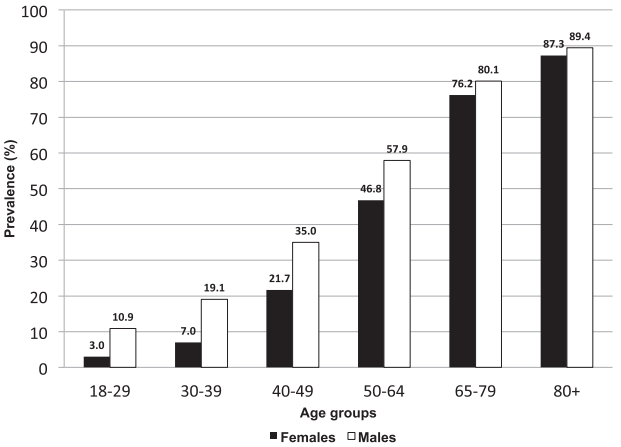

FIGURE 2 Prevalence of hypertension according to age and sex.

TABLE 2. Prevalence, awareness, treatment and control of hypertension according to age and sex (% weighted)

Age (years)	*N* (%)	Hypertension prevalence	Untreated unaware	Untreated aware	Treated uncontrolled	Treated controlled
18–29	449 (17.7)	30 (7.1)	27 (88.9)	0 (0.0)	1 (4.2)	2 (6.9)
30–39	640 (18.3)	74 (13.1)	60 (85.1)	5 (5.5)	4 (4.3)	5 (5.1)
40–49	834 (17.7)	223 (28.3)	123 (57.2)	12 (6.3)	32 (14.7)	56 (21.8)
50–64	1,378 (22.3)	728 (52.2)	237 (35.1)	21 (3.0)	228 (29.8)	242 (32.1)
65–79	1,096 (18.4)	860 (77.9)	126 (14.3)	8 (0.8)	417 (47.4)	309 (37.5)
≥80	302 (5.6)	269 (88.2)	24 (8.4)	10 (3.1)	145 (55.0)	90 (33.5)
P[a]		<0.001	<0.001	<0.001	<0.001	<0.001
Sex						
Men	2006 (48.6)	1033 (42.7)	337 (39.2)	30 (2.9)	377 (32.1)	289 (25.8)
Women	2693 (51.4)	1151 (36.5)	260 (23.6)	26 (2.5)	450 (38.3)	415 (35.6)
P[a]		<0.001	<0.001	NS	<0.01	<0.001
Total	4699 (100%)	2184 (39.6)	597 (31.8)	56 (2.7)	827 (35.1)	704 (30.5)

[a]*P*-values for among age-groups and sex comparison in each column.

TABLE 3. Prevalence and control of hypertension by using a lower BP threshold (≥130/80 mmHg) according to age (% weighted)

Age (years)	Hypertension prevalence *N* (%)	Treated controlled *N* (%)
18–29	106 (24.4)	1 (1.0)
30–39	222 (36.6)	2 (0.4)
40–49	421 (53.4)	30 (5.9)
50–64	1041 (75.6)	93 (8.4)
65–79	980 (88.9)	148 (15.8)
≥80	281 (92.4)	51 (18.9)
P	<0.001	<0.001
Total	3051 (58.8)	325 (9.5)

than 50 years; (v) among treated hypertensive individuals, the rate of uncontrolled BP was similar, irrespective of the number of antihypertensive drugs.

The EMENO showed a particularly high prevalence of hypertension (39.6%), which is similar to that of other European countries [4]. The high rate of overweight and obesity (69.6%), certainly is a powerful contributor linked with increased BP. In the last two decades, several cross-sectional studies have attempted to assess the epidemiology of hypertension in Greece [12–16]. However, none of them included a random sample of the general population, but recruited individuals from a rural [12], or urban area [13], local workers [14], volunteers [15], or people attending health centres [16]. Overall, these studies showed lower hypertension prevalence (about 30%) [12–16], apart from the EPIC study [15], which probably overestimated the prevalence of hypertension (40%), as it recruited volunteers and assessed BP with two readings in a single visit. The EMENO data suggest that the prevalence of hypertension was increased in the last decades, which is in line with findings in other Eastern European countries [2,9]. Thus, in Greece, the prevalence of raised BP is well above the estimated global average [1] and has been greatly underestimated in the 2017 European Cardiovascular Disease Statistics report [2].

Previous epidemiological data in Greece estimated that about 50% of people with hypertension were undiagnosed, 40% treated and only 20% were controlled [12–16]. The EMENO data suggest that there is an improvement in the diagnosis and control of hypertension in Greece. However, there is considerable potential for improvement, as indeed achieved in other countries [10,11] by applying well planned hypertension management programs in clinical practice [7].

TABLE 4. Blood pressure levels and hypertension control according to the hypertension status and the number of antihypertensive drugs (%, results from weighted analysis)

Hypertension status	Patients *N* (%)	SBP (mmHg)	DBP (mmHg)	Uncontrolled hypertension (≥140/90 mmHg), *N* (%)
Untreated hypertensives	653	146.9 (13.9)	90.6 (9.3)	–
Untreated unaware	597	146.3 (13.3)	90.3 (8.9)	–
Untreated aware	56	154.1 (18.0)	94.4 (13.5)	–
Treated hypertensives	1321	139.9 (22.0)	79.3 (12.8)	630 (47.4)
Treated uncontrolled	630	155.5 (17.7)	85.2 (13.2)	–
Treated controlled	691	125.8 (10.8)	74.0 (9.1)	–
Normotensives	2515	118.4 (10.6)	73.6 (7.6)	–
P		<0.001	<0.001	–
Number of drugs				
1	469 (36.0)	139.8 (21.6)	80.4 (11.9)	222 (47.0)
2	502 (36.9)	139.1 (21.8)	79.1 (12.9)	223 (44.3)
3	259 (19.8)	140.7 (22.1)	78.3 (14.0)	140 (53.2)
≥4	91 (7.4)	142.2 (24.1)	78.5 (13.0)	45 (49.1)
P		NS	NS	NS

In 1321 of 1531 individuals with data on antihypertensive drugs.

When the 2017 US threshold for defining hypertension was applied (BP ≥130/80 mmHg) [19], the prevalence of hypertension was increased to 58.8% and only 9.5% of treated hypertensives had BP levels lower than this threshold (Table 3). As the US guidelines were published after the EMENO survey has been completed, it is not known whether they have influenced the control rate of hypertension in Greece. However, the US strategy for hypertension seems to be unrealistic in Greece in the near future.

The higher prevalence of hypertension in men compared with women, with higher rates of undiagnosed, untreated and uncontrolled hypertension, and the very high rate of undiagnosed hypertension in those aged less than 40 years (>85%, mainly men), are in line with data from national surveys in other countries [1–4]. Thus, the predominance of cardiovascular events in middle-aged men [2] is not only due to a protecting effect of menstruation in women, but also due to an unfavourable profile of modifiable cardiovascular risk factors in men, with high rates of undiagnosed, untreated and uncontrolled hypertension, together with other modifiable risk factors such as smoking, obesity, dyslipidaemia and diabetes. Preventing measures in the general population, including targeting young men, are urgently needed aiming to increase awareness and control of hypertension and other cardiovascular risk factors, and thereby prevent the high incidence of cardiovascular events and death in middle age.

In line with data from other countries, the EMENO showed considerable increase in the prevalence of hypertension with ageing, with more than 80% of those aged more than 65 years having elevated BP [1–4]. Thus, ageing of the population is a benign factor contributing to the increased prevalence of hypertension globally.

The EMENO showed that among individuals treated for hypertension, the levels of BP and hypertension control were similar irrespective of the number of drugs received, which suggests that the potential of existing therapies for controlling hypertension have not been exhausted. This is probably due to physicians' inertia and reluctance to intensify therapy in patients with borderline BP control, and to inadequate compliance of patients in long-term follow-up. Indeed, the rate of antihypertensive drug prescriptions in Greece in 2013 was low compared to other European countries [2]. Physicians and patient education is needed on the importance of stepwise treatment intensification until optimal BP control is achieved.

The EMENO study data should be interpreted by considering several limitations. First, the diagnosis of hypertension has been based on BP measurements in a single occasion, whereas elevated BP is known to be reduced in succeeding visits [5,6]. Thus, the true prevalence of hypertension has been probably overestimated, which is the case in all classic epidemiological studies. To account for the alert BP reaction, triplicate measurements were taken after 5 min sitting rest and the first reading was discarded, as recommended by current hypertension guidelines [5,6]. Second, among 6006 individuals recruited, only 4699 provided adequate data and were analysed. The individuals included differed from those excluded in several characteristics. To limit the potential of induced bias, we applied the inverse probability weighting method. However, the possibility of unidentified confounders cannot be excluded.

In conclusion, the prevalence of hypertension in Greece seems to be rising and affects 40% of the adult population, with almost one-third of them remaining undiagnosed and less than one-third controlled with treatment. The high rate of obesity, which drives high BP as well as other modifiable cardiovascular risk factors (e.g. dyslipidaemia, diabetes) together with high smoking rate form a detrimental cardiovascular risk factor profile in Greek adults, which will eventually increase the incidence of cardiovascular events and deaths. Nationwide programmes need to be urgently implemented in the general population in Greece, aiming to prevent hypertension and other modifiable cardiovascular risk factors, and improve their awareness and control and, thereby, prevent a surge in the burden of cardiovascular diseases in the next decades.

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Conflicts of interest

GT has received EU and National resources grants as well as a grant from the Hellenic Diabetes Association, all paid to her institution, to support this study and grants unrelated to this study and paid to her institution from Gilead Sciences Europe, UCL, ECDC, EU, University of Bristol, Harvard University, and National funds; GS has received research grants and consultation fees by Microlife AG. Nothing to declare by other authors.

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