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ARTICLE

Opportunistic screening for hypertension: what does it say about the true epidemiology?

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Abstract

This study aimed to assess the reliability of opportunistic screening programs in estimating the prevalence, treatment, and control rate of hypertension in the general population. Two recent epidemiological surveys obtained data on hypertension in the adult general population in Greece. The EMENO (2013–2016) applied a multi-stage stratified random sampling method to collect nationwide data. The MMM (2019) collected data through opportunistic (voluntary) screening in five large cities. Hypertension was defined as blood pressure (BP) ≥ 140/90 mmHg (single occasion; average of 2nd–3rd measurement; electronic devices) and/or use of antihypertensive drugs. Data from a total of 10,426 adults were analyzed (EMENO 4,699; MMM 5,727). Mean age (SD) was 49.2 (18.6)/52.7 (16.6) years (EMENO/MMM, $p < 0.001$), men 48.6/46.5% ($p < 0.05$) and body mass index 28.2 (5.7)/27.1 (5.0) kg/m^2 ($p < 0.001$). The prevalence of hypertension in EMENO/MMM was 39.6/41.6% ($p < 0.05$) and was higher in men (42.7/50.9%, $p < 0.001$) than in women (36.5/33.6%, $p < 0.05$). Among hypertensive subjects, unaware were 31.8/21.3% (EMENO/MMM, $p < 0.001$), aware untreated 2.7/5.6% ($p < 0.001$), treated uncontrolled 35.1/24.8% ($p < 0.001$), and treated controlled 30.5/48.3% ($p < 0.001$). In conclusion, the prevalence of hypertension was similar with random sampling (EMENO) and opportunistic screening (MMM). However, opportunistic screening underestimated the prevalence of undiagnosed hypertension and overestimated the rate of hypertension treatment and control. Thus, random sampling national epidemiological studies are necessary for assessing the epidemiology of hypertension. Screening programs are useful for increasing awareness of hypertension in the general population, yet the generalization of such findings should be interpreted with caution.

Introduction

High blood pressure (BP) remains the strongest modifiable risk factor for cardiovascular disease and death, affecting more than one-third of the adult population worldwide [1, 2]. An analysis of 1479 studies showed that in the last 40 years the prevalence of hypertension has almost doubled, which is largely attributed to population aging, the obesity epidemic, and unfavorable lifestyle [1–3].

Countries worldwide have set up epidemiological surveys for assessing the prevalence of hypertension and other modifiable cardiovascular risk factors, aiming to develop tailored interventional programs for cardiovascular disease prevention [4]. These surveys have shown major differences in the prevalence, as well as the awareness, treatment, and control of hypertension in the general population. Thus, the prevalence of hypertension in Europe is higher than in North America by 60%, which has important consequences as it is associated with higher mortality from stroke [5]. Moreover, awareness, treatment, and control of hypertension in the general population differ considerably among countries, being higher in high- compared to low- and middle-income countries [3]. Eventually, the rate of hypertension control in the general population varies considerably ranging from 20% to >60% and is higher in North America than in Europe, and even lower in

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Eastern European countries [2, 6–8]. Thus, it is important that each country conducts national epidemiological surveys, aiming to estimate the prevalence and control rate of hypertension in its own population.

In Greece, several epidemiological studies conducted in the last two decades showed the prevalence of hypertension at about 30% [9–13]. Recently, two studies provided data on the epidemiology of hypertension in the adult population in Greece. The National Survey of Morbidity and Risk Factors (EMENO) study applied a multi-stage stratified random sampling method in the general adult population of Greece [14], aiming to obtain a representative sample of the adult people living in Greece, whereas the May Measurement Month (MMM) survey performed opportunistic screening for hypertension in five large cities within the context of a worldwide campaign led by the International Society of Hypertension [15].

This study aimed to evaluate the reliability of opportunistic screening in providing reliable information on the epidemiology of hypertension in the general population. For this purpose, the findings of the MMM study regarding the prevalence, awareness, treatment, and control of hypertension were compared with those of the EMENO study, which was taken as reference.

Subjects and methods

EMENO

The nationwide epidemiological cross-sectional study EMENO was conducted from May 2013 to June 2016 in randomly selected adults in Greece. Details on the study protocol have been published [14]. In brief, the country was divided into 22 geographical areas and 577 sampling points were randomly selected. Within each sampling point, eligible households were selected and one adult aged ≥18 years per house was randomly selected. Each participant was assessed during 2 home visits. In the first visit, the participants completed a standardized questionnaire and in the second, BP measurements, physical examination, and blood tests were performed by trained physicians. The target sample size was 6000 subjects. The EMENO was approved by Ethics and Deontology Committee of the National and Kapodistrian University of Athens and by the Hellenic Data Protection Authority, and signed informed consent was obtained by each participant.

MMM

MMM is an annual worldwide campaign organized by the International Society of Hypertension aiming to improve BP control by increasing awareness globally [15]. In 2019 MMM collected data from 1,508,130 adults from 92 countries [15]. In 2019 the Hellenic Society of Hypertension organized a national MMM initiative in Greece aiming to collect data on hypertension from 6000 adults. The survey took place in public spaces in five urban areas (Athens, Thessaloniki, Heraklion, Ioannina, Kavala). Adults who were passing by were invited to participate on a voluntary basis. In each participant, a questionnaire was filled and BP measurements were taken. The Ethics and Deontology Committee of the National and Kapodistrian University of Athens was informed about the survey.

Blood pressure measurement

Both studies obtained measurements of BP on a single occasion after 5 min sitting rest. The participant's arm was resting on table, mid-arm at heart level, back supported on a chair, legs uncrossed and feet flat on the floor, and talking was avoided during and between BP measurements [16, 17]. Both studies used validated automated oscillometric upper arm cuff devices [18] with appropriate cuff size according to the individual participant's arm circumference. In the EMENO the Microlife BPA100 Plus (Microlife AG, Widnau, Switzerland) was used [18, 19] and in the MMM the Omron M3 HEM-7131-E (Omron Kyoto, Japan) [18, 20]. Both studies obtained triplicate BP measurements in each individual and the average of 2nd and 3rd was used in the analysis [16, 17].

Hypertension diagnosis

Based on BP measurements and/or self-reported use of antihypertensive medication participants were divided into four categories:

- Normotensives: untreated subjects with systolic BP < 140 mmHg and diastolic <90 mmHg.
- Hypertension: systolic BP ≥ 140 mmHg and/or diastolic ≥90 mmHg, and/or self-reported use of drugs for hypertension.
- Hypertension awareness: self-reported previous diagnosis of hypertension.
- Treated hypertension: self-reported current use of drugs for hypertension.
- Treated uncontrolled hypertension: systolic BP ≥ 140 mmHg and/or a diastolic ≥90 mmHg with self-reported use of drugs for hypertension.
- Treated controlled hypertension: systolic BP < 140 mmHg and diastolic <90 mmHg with self-reported use of drugs for hypertension.

Statistical analysis

In the EMENO study sampling weights were applied to adjust for study design, with post-stratification weighting to match age, gender, and geographical distribution of the sample to that of the adult Greek population. Inverse probability weighting was applied to adjust for non-response as a sub-sample of the interviewed participants did not have available BP measurements. Weighted means and standard deviations were used for continuous variables and weighted percentages for categorical variables. In MMM study, sampling weights and adjustments were not applied. Chi-square tests were used to analyze categorical variables between and within the two studies. STATA software (version 13.0; Stata Corp, College Station, TX) and SPSS Statistics 25 were used.

Results

In the EMENO study, a total of 6006 adults were recruited. Thirteen subjects with missing data on age, 54 on treatment, and 1240 on BP measurements were excluded and 4699 with complete data were analyzed. Characteristics of subjects included are presented in Table 1. Excluded subjects were more likely to be aged >70 years, to live in urban areas, to have lower family monthly income, and less likely to report 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. Values of three BP measurements were available in 4212 (89.6%) and the last two were used, whereas in 487 (10.4%) the average of three measurements was recorded. The prevalence, awareness, treatment, and control of hypertension are shown in Table 2 and Fig. 1.

In the MMM study, a total of 5848 individuals were recruited. One-hundred twenty-one subjects with missing data on age, gender, BP measurements, hypertension, treatment or aged <18 years were excluded and 5727 subjects with complete data were analyzed (Heraklion 25.8%, Athens 25.5%, Thessaloniki 23.6%, Ioannina 18.7%, Kavala 6.4%). Characteristics of subjects included are presented in Table 1. The prevalence, awareness, treatment, and control of hypertension are shown in Table 2 and Fig. 1.

The two studies analyzed data of similar sample sizes. However, the MMM participants were older than in the EMENO, more likely to be women than men, and less likely to be obese, or smokers (Table 1). Average systolic BP was lower in the MMM, yet the prevalence of hypertension was slightly higher (Table 1). Both studies showed women to have higher rates of hypertension diagnosis, treatment, and control than men (Table 2). However, in the MMM the awareness of hypertension was considerably higher than in the EMENO, as well as the rate of hypertension treatment and control (Table 2, Fig. 1).

Table 1 Participants' characteristics in the EMENO and MMM studies [mean (SD)].

	EMENO[a]	MMM	*P*
Participants	4699	5727	–
Age (years)	49.2 (18.6)	52.7 (16.6)	<0.001
Men/Women (%)	48.6/51.4	46.5/53.5	<0.05
Height (cm)	166.4 (10.3)	169.1 (9.4)	<0.001
Weight (kg)	78.1 (17.3)	77.5 (16.2)	NS
BMI (kg/m^2)	28.2 (5.7)	27.1 (5.0)	<0.001
Overweight (%)	37.5	39.4	<0.05
Obesity (%)	32.1	24.2	<0.001
Current smokers (%)	37.4	24.7	<0.001
Diabetes mellitus (%)	11.5	12.0	NS
Cardiovascular disease (%)	4.3	5.0	NS
Systolic BP (mmHg)	128.3 (18.9)	123.5 (17.3)	<0.001
Diastolic BP (mmHg)	77.6 (10.9)	77.4 (10.4)	NS
Hypertension, %	39.6	41.6	<0.05

BP blood pressure, *BMI* Body mass index.

[a]Weighted estimates.

Discussion

The EMENO and the MMM studies collected data on hypertension in the general population in Greece from similar numbers of adults and in close periods. However, the sampling methodology was different, with the EMENO being a classic epidemiological study using multi-stage stratified random sampling allover Greece, whereas the MMM performed opportunistic screening in selected urban areas and on voluntary basis. In addition, there are major differences in the statistical analysis of the data, as the EMENO applied sampling weights and adjustments for age, gender, geographical distribution, and non-responses, whereas in the MMM sampling weights and adjustments were not applied. Thus, the EMENO was a pure epidemiological study and was regarded as the gold standard method for assessing the reliability of the epidemiological information provided by the MMM.

The important methodological differences between the two studies are expected to result in differences in the participants' characteristics. Indeed, the sampling method in the MMM resulted in a clear selection bias, with the voluntary opportunistic screening including older subjects and more women, but fewer obese subjects and smokers than the EMENO (Table 1). Thus, differences between the two studies in their findings on the prevalence, treatment, and control of hypertension are well expected. The fact that MMM was conducted

Table 2 Prevalence, awareness, treatment, and control of hypertension in the EMENO and the MMM studies [% (95% CI)].

	Hypertension prevalence	Unaware untreated	Aware untreated	Treated uncontrolled	Treated controlled
EMENO[a]	39.6 (37.8, 41.3)*	31.8 (29.4, 34.3)**	2.7 (2.1, 3.6)**	35.1 (32.7, 37.5)**	30.5 (28.2, 32.8)**
Men	42.7 (40.1, 45.4)$^{+++}$	39.2 (35.9, 42.7)$^{+++}$	2.9 (2.0, 4.2)	32.1 (29.0, 35.3)$^{++}$	25.8 (23.0, 28.8)$^{+++}$
Women	36.5 (34.4, 38.7)	23.6 (20.8, 26.6)	2.5 (1.6, 3.8)	38.3 (35.0, 41.8)	35.6 (32.4, 38.9)
MMM	41.6 (40.4, 42.9)	21.3 (19.7, 22.9)	5.6 (4.7, 6.5)	24.8 (23.1, 26.5)	48.3 (46.3, 50.4)
Men	50.9 (49.1, 52.9)$^{+++}$	22.9 (20.7, 25.2)$^{+}$	6.9 (5.5, 8.2)$^{++}$	27.4 (25.0, 29.8)$^{+++}$	42.8 (40.2, 45.5)$^{+++}$
Women	33.6 (31.9, 35.2)	19.2 (16.8, 21.6)	3.9 (2.7, 5.1)	21.3 (18.8, 23.8)	55.6 (52.6, 58.7)

*P value < 0.05; **<0.001 compared to the MMM study.

^{+}P value < 0.05; $^{++}$<0.01; $^{+++}$<0.001 compared to women in the same study.

[a]Weighted estimates.

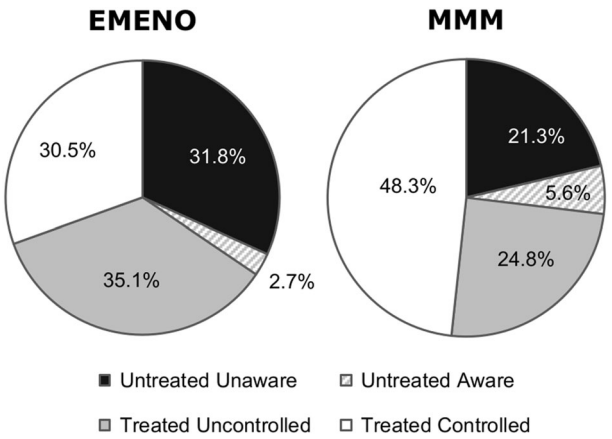

Fig. 1 Awareness, treatment, and control of hypertension in EMENO and MMM studies. MMM underestimated the prevalence of undiagnosed hypertension and overestimated rate of hypertension treatment and control.

4–5 years after the EMENO might also have played a role, yet visible changes in hypertension epidemiology take longer time or drastic measures at national level, which were not implemented in Greece in this period.

The prevalence of hypertension was surprisingly similar in the two studies (Table 1). This is probably due to the fact that, although the MMM participants were older than those of the EMENO, they had lower body mass index which counterbalanced the impact of older age on the prevalence of hypertension. In addition, both studies clearly showed that women have higher rates of diagnosis, treatment, and control of hypertension than men, which is in line with several previous reports [1–3, 5]. Interestingly, both studies suggest that the prevalence of hypertension in Greece has increased as compared to previous studies in the last two decades [9–13], which is in line with epidemiological data in other Eastern European countries [2, 8].

The most important finding of the present analysis is that the opportunistic screening of the MMM considerably overestimated the rate of awareness of hypertension, as well as the rate of hypertension treatment and control (Table 2). It seems that the voluntary opportunistic screening method of the MMM attracted people with diagnosed and treated hypertension, who took the opportunity to have their BP rechecked. On the other hand, people who neglect their BP checks and are undiagnosed or treated but uncontrolled were less likely to take an opportunity of having their BP measured.

In conclusion, each country needs to perform its own national epidemiological studies for assessing the prevalence, awareness, treatment, and control of hypertension in the general population, using appropriate sampling methodology to assure, as much as possible, population representativeness [4]. Opportunistic screening programs, such as the MMM global initiative by the International Society of Hypertension, are valuable for increasing the awareness of hypertension in the general population, aiming to improve hypertension control. They might also provide epidemiological information, yet these are subject to serious selection bias and overestimate the rate of hypertension awareness, treatment, and control. When opportunistic screening programs and epidemiological studies coincide in time, data from the epidemiological study might be used to adjust, at least in part, for selection bias in the opportunistic screening programs, for example by applying correction weights based on the different characteristics of the two populations. A study combining the two datasets and estimating correcting weights is underway, aiming to be applied in future opportunistic surveys. Such correction weights can be applied in future opportunistic screening programs, under the assumption that sources of the selection bias remain constant over time.

Summary

What is known about topic

- Screening programs aiming to evaluate the prevalence, treatment, and control of hypertension in the general population are necessary for each country.

- Such epidemiological data are collected by applying nationwide multi-stage stratified random sampling, or through opportunistic (voluntary) screening in selected areas. To what extend findings of the latter represent the general population of a country is questionable.

What this study adds

- This study compared the findings of an opportunistic screening program in urban areas with those of a random sampling national epidemiological study (reference method).
- The prevalence of hypertension was similar in the two studies, yet the opportunistic screening underestimated the prevalence of undiagnosed hypertension and overestimated the rate of hypertension treatment and control. These data should be considered in the interpretation of the findings of opportunistic screening programs.

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Compliance with ethical standards

Conflict 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; GSS has received research grants and consultation fees by Microlife AG, Switzerland, and lecturer and consultation fees by Omron Healthcare Japan & Europe. Nothing to declare by other authors.

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