Statistical Model for Prediction of Future Trend in Hypertensive Disease in Adult Poplation of Romania

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ABSTRACT

Purpose: *The present study aims to analyse the past and future trend in HT's prevalence, awarness, treatment and control in adult Romanian population using statistical models based on the results of the three national-representative surveys.*

Methodology: *using the data from the three national-representative surveys: SEPHAR I, II and III conducted between 2005 and 2016, by means of Simple exponential smoothing and Brown linear smoothing analysis using IBM SPSS 20.0 software we evaluated the past in future trend (up to year 2020) of hypertension's prevalence, awareness, treatment and control in our adult population.*

Main findings: *The evolution of HT's prevalence is characterized by significant oscillations in the analysed period (2005-2016) and in 2020, is estimated to be 44%. Awareness of hypertension followed a steady trend of growth from 2005 to 2016. If in 2005 the percentage of hypertensive aware of their condition was 44.3%, in 2016 their percentage reached 80.9%, being expected to increase up to 96.2 % in 2020. The percentage of treated hypertensives increased to 59.2% in 2012 and 75.2% in 2016, and is expected to reach 91.2% in 2020 unless there are major events at the level of risk factor changes. In 2005, BP control rate was 19.9%, percentage which rose to 30.8% in 2016 and is expected to increase up to 36.6% by year 2020.*

Conclusions: *Based on the results of our study, in Romania, hypertension's prevalence has increased in the last 11 years and will continue on an upward trend,*

if no preventive strategies at population level will be implemented in the near future. Although being on a positive trend for HT's awareness, treatment and control, hypertension management will remain suboptimal in Romania in the future, if all the influencing conditions remain, on average, similar to previous years, leading to a continuous up-ward trend in cardiovascular mortality in our country.

Keywords*: statistical model, prediction, trend, hypertension, national, representative*

1. INTRODUCTION

Hypertension (HT) through cardiovascular diseases (CVD) is the most common cause of mortality in developed countries. Out of an estimated 55 million annually total deaths across the globe, about 30% are from cardiovascular causes [1-5].

In Europe, cardiovascular mortality has seen in recent decades a divergence trend between Central and Eastern Europe Cuontries, where it achieved very high rates, and Northern and Western Europe countries where cardiovascular mortality is on a steadily declining trend [1-5].

At the current stage, where the genetic condition of CVD is only deciphering, the most effective therapeutic approach is the intervention on major modifiable cardiovascular risk factors.

Among these, HT has the highest prevalence and one of the most important effects on cardiovascular morbidity and mortality, being recognized as a independent risk factor for the development of all manifestations of atherosclerosis. More, in the last 20 years, HT has risen in the ranking of top 20 leading cardiovascular risk factors on the first position [1-5].

From the perspective of public health policies, it is very important to know the prevalence of CV risk factors and the evolutionary trend of their prevalence in the general population, which would allow anticipation of the evolution of the CV mortality curve and the evaluation of the benefit of different CV prevention strategies.

Representative data for Romanian adult population regarding the prevalence of HT and other CV risk factors are availlable through the results of the three national representative surveys SEPHAR I, SEPHAR II and SEPHAR III conducted between 2005 and 2016 [1,2,6].

The present study aims to analyse the past and future trend in HT's prevalence, awarness, treatment and control in adult Romanian population using statistical models based on the results of the three national-representative surveys.

2. METHODOLOGY

Detailed description of SEPHAR I, II and III surveys' methodology has been previously published elsewhere, therefore below will detail only

those parameters that are object of the current paper, with an emphasis on the statistical methodology used [1,2,6].

Hypertension's definition

At each study visit, 3 consecutive BP measurements were taken at time interval of at least 1 minute, using an automatic oscillometric BP measuring device according to current guidelines for HT management [5]. Hypertension was defined as systolic blood pressure (SBP) $\geq$ 140mmHg and/or diastolic blood pressure (DBP) $\geq$ 90mmHg at both study visits, using the arithmetic mean of the second and third BP measurement of each study visit (without taking into consideration the first BP measurement from each visit), or previously diagnosed HT under treatment during the last two weeks, regardless of BP values.

The prevalence of HT is calculated by the ratio between the number of subjects identified as being hypertensive and the total number of the subjects enrolled in the survey.

Hypertension's awareness definition

Awareness of HT was defined by the percent of hypertensive subjects who declared being previously diagnosed with HT by a doctor.

Hypertension's control definition

Controlled BP values was defined by SBP < 140mmHg and DBP < 90mmHg in hypertensive subjects who were treated for at least 2 weeks before (current treatment) [5], taking into account the maximum value between the two SBP/DBP values from each visit, in t

The therapeutic control rate was defined by the ratio between treated hypertensive subjects with controlled BP values and the total number of hypertensive subjects under current treatment.

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics 20.0 software at a significance level of $p \leq 0,05$. The statistical methods used for each trend analysis in our study are detailed in Table 1. Since all the SEPHAR surveys used in this study were conducted on representative samples for Romanian adult populations selected by a multi-stratified sampling procedure that had age categories, genders, place of residence and territorial regions as sampling strata, all trend analysis were adjusted for these parameters.

Statistical methods used for each analysis. HT: hypertension

Table 1

Analysis	Statistical Method
HT's prevalence trend	Simple Exponential Smoothing
HT's awarness trend	Brown Linear Smoothing
HT's treatment rate trend	Brown Linear Smoothing
HT's control rate trend	Brown Linear Smoothing

Description of the "Simple exponential smoothing" analysis

The "Simple Exponential Smoothing" method [7-9] is a method that predicts the value of a variable based on the trend observed in the evolution of some variables in the past. In practice, we can see how a variable has evolved in the past and, on the basis of these observations, it is stated how it could evolve in the future if the conditions in the last year under analysis remain constant.

As a working principle, the method starts from the observation of how the values evolved from the first to the last observation. Then, with multiple iterations, an optimal value of a generically defined factor "alpha" (or smoothing factor) that manages to predict the fewest errors the values already observed is identified. That alpha factor that worked best to identify past values is then used to predict future values, with the specification that this alpha factor is calculated at different levels for more recent values than for older values.

This prediction method is used predominantly to predict data for which there is no constant pattern of evolution over time of values (steady or steady decrease) or seasonal evolution patterns. Its advantage over other methods of predicting is that more recent observations are attributed to a higher weight in establishing the trend than the older observations. As such, it is most effective in making predictions based on a limited number of observations. Also, this method has the ability to be less sensitive to values that are inconsistent with a central trend and to eliminate the effect generated by them.

The main limitation of the "Simple Exponential Smoothing" method is that it does not take into account the influence of explanatory variables. Models that also account for the effect of some other parameters on the predicted value require a higher number of observed values. In the case of three observations, the value predicted by the models that take into account the effect of additional variables (eg ARIMA) is only a statistical artefact (being, in fact, equal to the average of the three observations).

Description of the "Brown linear smoothing" analysis

The "Brown linear smoothing" method [7-9] is similar to that described in Appendix 3 as a working principle, except that instead of being used for variables that exhibit irregularities in time oscillation follows a clear linear trend over time (either just increase or decrease).

For each trend prediction model we calculated the following parameters:

- Root Mean Square Error (RMSE) that is a Measure of how connected the data are around the best model fit
- Mean absolute percentage error (MAPE) that is a measure of prediction accuracy
- Mean absolute error (MAE) that is a measure of forecast error
- Normalized Bayesian Information Criterion (NBIC) that measures How efficient the model is in terms of predicting the data

3. RESULTS AND DISCUSSIONS

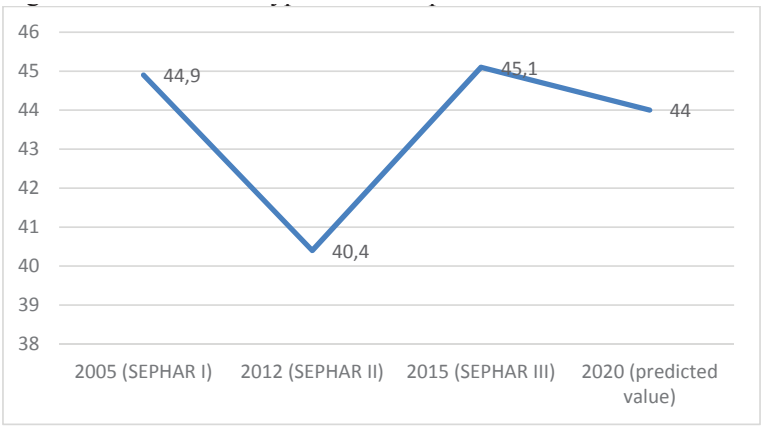
3.1 Past and future trend in hypertension's prevalence

As depicted in Figure 1, the evolution of HT's prevalence is characterized by significant oscillations in the analysed period (2005-2016). Although a slight decrease in HTA prevalence is observed between 2005 and 2012, it is not sustained for a longer period, so that in 2016 a higher HT's prevalence is achieved than in the case of the initial measure.

Following the eleven-year evolution that has been the subject of the study, it is expected that in 2020 the HT's prevalence will be 44%. This value is slightly lower than in 2016, but not enough to mark a lasting downward trend. However, the projected value should be interpreted with caution as the prevalence of HTA is sensitive to any change in traditional risk factors of this disease such as salt-intake, smoking, obesity and diabetes mellitus. The predicted value is if the future conditions remain similar to those prevailing in the previous 11 years.

The trend in hypertension's prevalence

Figure 1

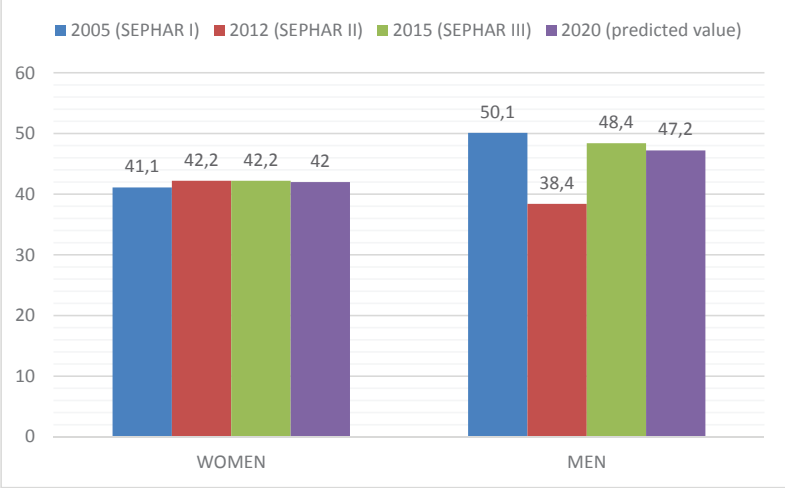


Trend model parameters: RMSE = 3,055; MAPE = 4,699; MAE = 1,96; NBIC = 2,6

Analysing the prevalence of HT by genders, it can be seen that, except in 2012, HT's prevalence was higher among men than women. This situation is also expected to persist in 2020 when the prevalence among women is estimated to be 42% and among men in whom the HT's prevalence is estimated to be 47.2%. At the same time, based on the above data, the following situation can be noticed: for women, the general trend is the stagnation in HT's prevalence, while for men there is a more significant decrease than in 2012. This fact makes the differences between women and men in terms of HT's prevalence diminish as time passes.

The trend in hypertension's prevalence by gender

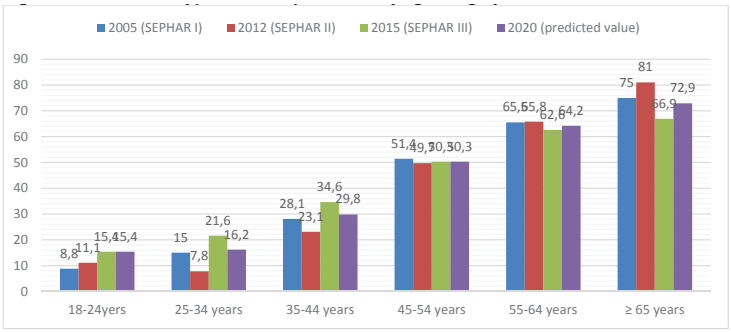
Figure 2



Taking this time in analysis the age-related HT's prevalence, it can be seen that the prevalence of HT increases in general with age, with the highest percentages of hypertensive individuals being found in subjects over the age of 65. What appears to be remarked is that while for people over 45 years of age, HT's prevalence has either a stagnation trend or a downward trend (albeit with some fluctuations), for people under 44, the values indicate an up-ward trend in HT's prevalence, more evident among people aged 18-24 years.

The trend in hypertension's prevalence by age category

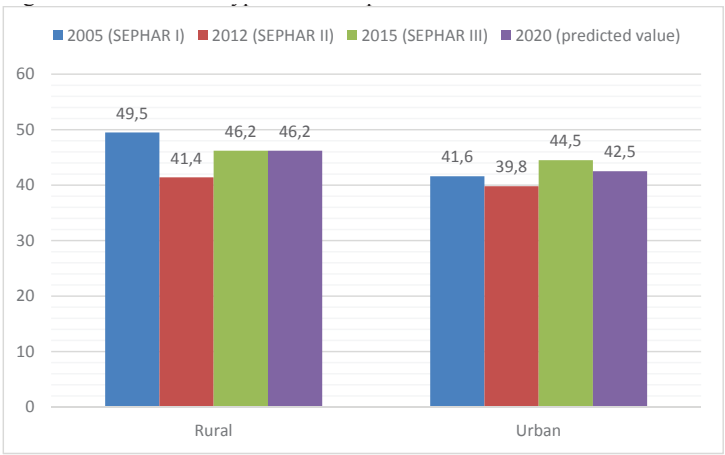
Figure 3



If in 2005 the prevalence of HT was significantly higher in the rural area compared to the urban environment, in the years to come the differentiation seems to diminish and the values found in the two residence environments are similar. However, predictions for the year 2020 point to a moderate increase in the differences between rural and urban areas, with higher HTA prevalence in rural areas than in urban areas.

The trend in hypertension's prevalence residence

Figure 4

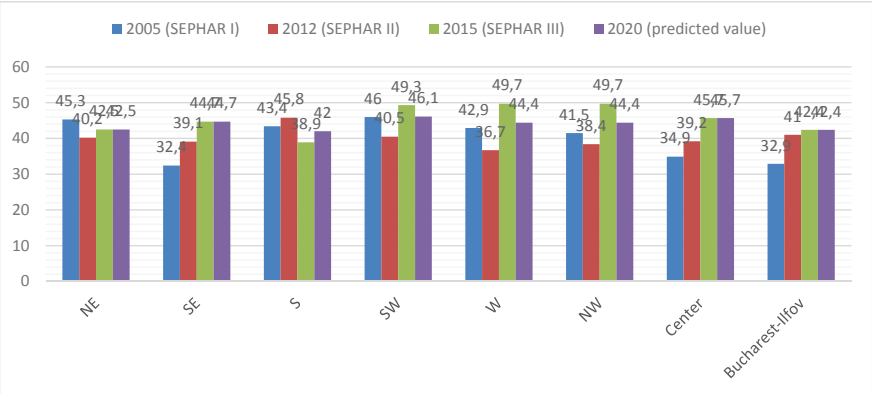


The analysis carried out at the level of the development regions highlights a tendency to increase the prevalence of HTA, especially in the South-East, Center and Bucharest regions. It is worth noting from Figure 5, that the year 2016 was characterized by a marked increase in HT's prevalence in several development regions, including South-East, South-West, West,

North-West, Center and Bucharest-Ilfov. In contrast, the South region shows a significant decrease in the percentage of hypertensives, which, however, due to the oscillatory effects is not expected to be maintained in 2020 as well.

The trend in hypertension's prevalence by regions

Figure 5

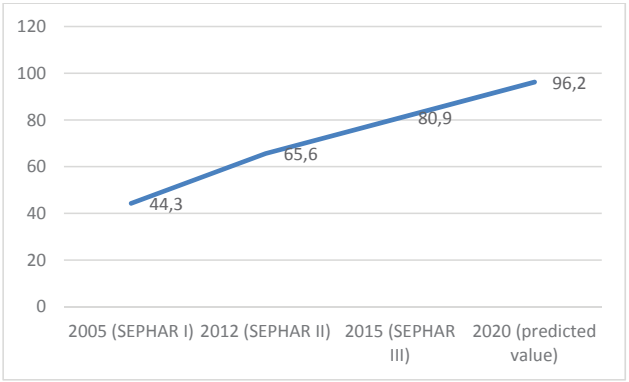


3.2 Past and future trend in awareness of hypertension

Awareness of hypertension followed a steady trend of growth from 2005 to 2016. If in 2005 the percentage of hypertensive aware of their condition was 44.3%, in 2016 their percentage reached 80.9%, being expected to increase up to 96.2 % in 2020 if the conditions remain, on average, similar.

The trend in hypertension's awareness

Figure 6

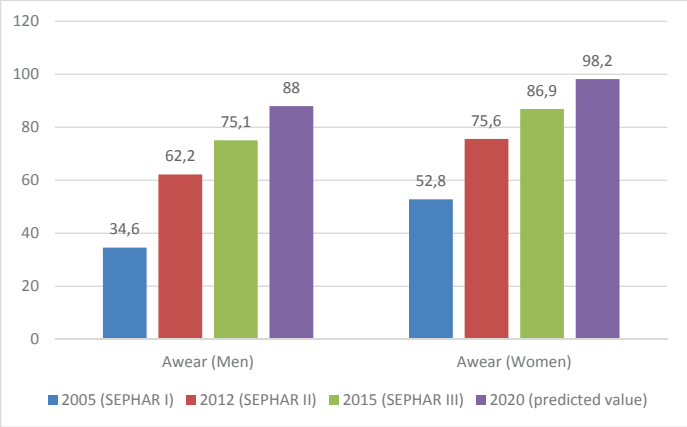


Trend model parameters: RMSE = 4.234; MAPE = 2.478; MAE = 2.003; NBIC = 3.257

Evolution of known hypertension follows an upward trend in both genders. In all the years undergoing the analysis (2005, 2012, 2016), the rate of HT's awareness has been shown to be higher among hypertensive women than hypertensive men, a situation that is expected to persist in 2020 as well.

The trend in hypertension's awareness by gender

Figure 7

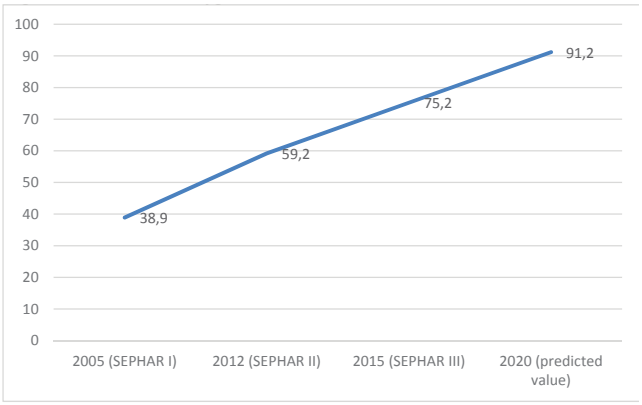


3.3 Past and future trend in hypertension treatment

In 2005, 38.9% of people with hypertension were treated. Their percentage increased to 59.2% in 2012 and 75.2% in 2016, and is expected to reach 91.2% in 2020 unless there are major events at the level of risk factor changes.

The trend in hypertension's treatment

Figure 8

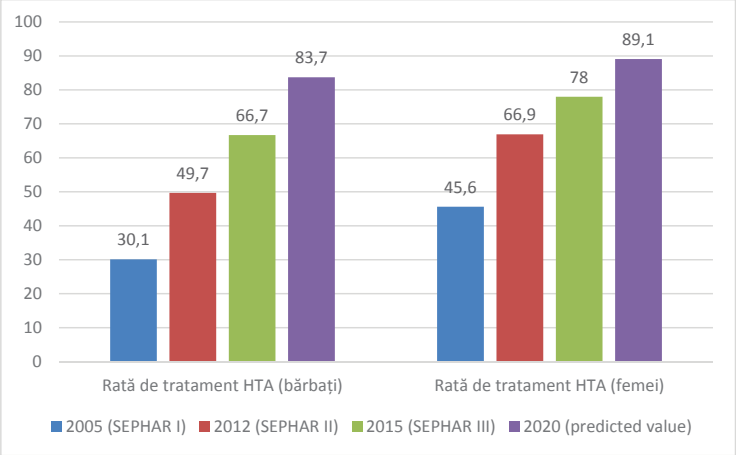


Trend model parameters: RMSE = 3.041; MAPE = 1.91; MAE = 1.453; NBIC = 2,59

As with awareness, the rate of treatment for high blood pressure is higher for women than for men. If in 2005 30.1% of men with high blood pressure were treated, in 2016 their percentage reached 66.7%, and it is expected to increase up to 83.7%. For women, in 2005, 45.6% of those with hypertension were treated, the percentage rising to 78% in 2016, and expected to reach 89.1% if all conditions remain similar.

The trend in hypertension's treatment by gender

Figure 9

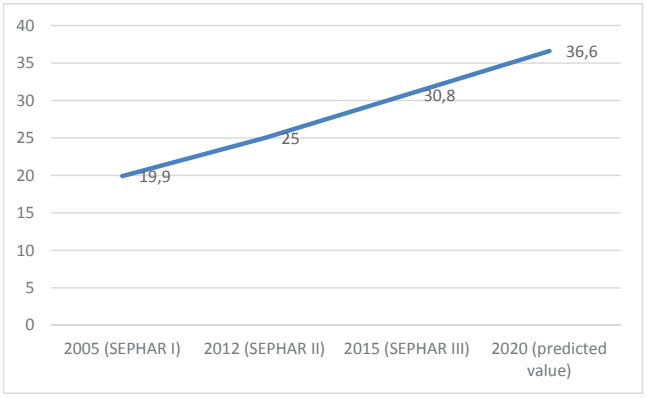


3.4 Past and future trend in hypertension's control

The therapeutic control rate of high blood pressure follows an upward trend. In 2005, the proportion of treated hypertensive patients with optimal BP control was 19.9%, percentage which rose to 30.8% in 2016. In 2020, the therapeutic control rate is expected to increase up to 36.6%.

The trend in hypertension's control

Figure 10

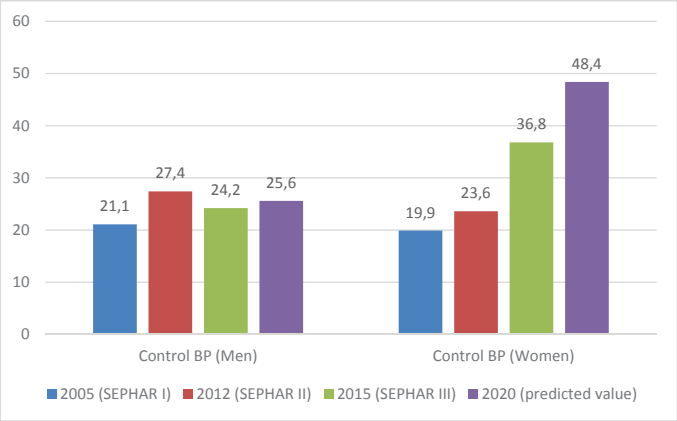


Trend model parameters: RMSE = 0.459; MAPE = 0.458; MAE = 0.234; NBIC = 1.04

As with previous variables, optimal blood pressure control rate is higher among women than in men. However, an ascending trend can only be predicted for hypertensive women whereas in hypertensive males, the rate of BP control is expected to be rather stagnant.

The trend in hypertension's control by gender

Figure 11



CONCLUSIONS

Based on the results of our study, in Romania, hypertension's prevalence has increased in the last 11 years. According to this past trend, HT's prevalence is expected to continue on an upward trend, increasing up to 44% by 2020, if no preventive strategies at population level will be implemented in the near future.

Although, our results point out that HT's awareness and treatment is continuously improving in our country (by 2020 awarness rate increasing up to 96.2% and treatment rate of HT up to 91.2%) current BP control rate, is farr for what is considered optimal (30.1%), and will remains so in 2020 (36.6%), if the conditions remain, on average, similar.

In the current picture Romania is and will remain a very high cardiovascular risk country if all the influencing conditions on HT's prevalence, treatment and control, will remain, on average, similar to previous years, leading to a continuous up-ward trend in cardiovascular mortality in our country.

A special emphasis should be addressed to young population between 18-24 years in which the up-ward trend in HT's prevalence is the most prevalent, and they should be the target of future preventive programs.

Study limits

The trend models provided by this analysis should be interpreted with caution due to inherent study limitations. The major limitation arise from the fact that the trend models are not sensitive to dependent variables change due to the limited number of time series observations (three for an

11-years period of observation). For a well specified forecasting model, the number of observed cases should exceed the number of predictive parameters. This specification could not have been achieved based on available data. As a consequence, the models could not handle the variety and complexity of the predicted phenomena, but they could reflect a situation that could be prognosticated if the current values of other factors that lead to hypertension remain constant in time.

Extensions of the research

SEPHAR survey project continuation with the conduction of a new epidemiological survey, SEPHAR IV, represent a necessary step in HT's management in our country, where, due to its cardiovascular complications, HT is responsible for over 62% of total deaths. Having an improved estimation of the real trend in HT's prevalence, treatment, and control, by increasing the number of time series observations, SEPHAR IV will serve serve as a more solid base for future prevention strategies, which are urgently needed in our very high CV risk country.

The influence of different socio-demographic characteristic of our adult population (such as level of education, area of residence, dietary habits) may have important influence upon HT prevalence, awareness, treatment and control and future studies addressing in depth factors associated with poor blood pressure control in Romania should conducted.

Aknowlegment

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