ORIGINAL ARTICLE

Prevalence of isolated systolic and diastolic hypertension and its relathionship with sociodemographic variables and healthy habits in 193,462 spanish workers

Rosa González Casquero[1], Ángel Arturo López González[1], Juan Antonio Roberto Martin[1], Elisa Leal Matilla[1], María del Mar Divieso[1], María Gil-Llinás[1]

1. Multiprofessional Teaching Unit of Occupational Health, Balearic Islands, Spain.

Correspondence

Ángel Arturo López González, Multiprofessional Teaching Unit of Occupational Health. Balearic Islands. Spain.

e-mail

angarturo@gmail.com

ORCID ID of the author(s):

RGC: 0000-0003-3408-8963
AALG: 0000-0002-7439-8117
JARM: 0000-0001-6380-0513
ELM: 0009-0002-2491-3034
MMD: 0009-0004-7903-9510
MGL: 0000-0002-3001-6789

Abstract

Objective: Hypertension (HTN) is one of the leading risk factors for cardiovascular diseases, contributing significantly to the global burden of morbidity and mortality. Among the different types of hypertension, isolated systolic hypertension (ISH) and isolated diastolic hypertension (IDH) are distinguished, both with particular clinical implications. The aim of this study is to assess how certain sociodemographic variables and healthy habits influence the prevalence of ISH and IDH.

Material and methods: A descriptive, cross-sectional study of 193,462 Spanish workers, evaluating the influence of age, gender, social class, educational level, tobacco consumption, physical exercise, and adherence to the Mediterranean diet on the prevalence of ISH and IDH.

Results: The prevalence of ISH increases with age, in men, in individuals of lower social and educational levels, and in those who are sedentary. The prevalence of IDH is higher in men, individuals with lower socioeconomic status, those who are sedentary, and those with low adherence to the Mediterranean diet (p<0.05 for each comparison).

Conclusion: Both ISH and IDH are influenced by male gender, sedentary lifestyle, and low socioeconomic status. Advanced age is a factor in ISH, while low adherence to the Mediterranean diet influences IDH.

Introduction

Hypertension (HTN) is one of the leading risk factors for cardiovascular diseases worldwide, significantly contributing to global mortality. Among the types of hypertension, isolated systolic hypertension (ISH) and isolated diastolic hypertension (IDH) are recognized, both with distinct clinical implications and prognoses. ISH, characterized by elevated systolic blood pressure (SBP) with normal diastolic blood pressure (DBP), is prevalent in older individuals and is strongly associated with increased arterial stiffness, a common process in vascular aging (1,2). On the other hand, IDH, defined by elevated DBP with normal SBP, is more common in young adults and seems to be related to greater peripheral vascular resistance (3,4).

ISH has been linked to a higher risk of cardiovascular events, such as myocardial infarction and stroke, compared to diastolic hypertension (5). Aging is a key factor in the development of ISH, as the stiffness of large arteries contributes to an increase in SBP and a decrease in DBP (6,7). Moreover, other variables, such as body mass index (BMI), blood lipid levels, smoking, and excessive sodium intake, have been observed to influence the development of ISH (8,9). Obesity, in particular, has been identified as a significant risk factor for both forms of hypertension, as it contributes to peripheral vascular resistance and increased cardiac output (10,11).

On the other hand, although less studied, IDH also carries significant risks, especially in younger individuals, where it has been associated with the development of left ventricular hypertrophy and a higher risk of coronary heart disease in the future (12,13). IDH has been suggested to be linked to alterations in vascular tone and endothelial function, particularly in individuals with a family history of hypertension (14,15). Additionally, lifestyle factors, including sedentary behavior and alcohol intake, have been highlighted as key modulators in the development of this form of hypertension (16,17).

Recent findings underscore the need for a differentiated clinical approach in managing these conditions, as each presents specific risks and responds to different therapeutic strategies (18,19). This study investigate the different factors that influence the onset of isolated systolic and diastolic hypertension.

Material and methods

A descriptive, cross-sectional study was performed in 193,462 spanish workers (116,407 men y 77,055 women) between January 2018 and December 2019 Workers. 1,214 workers were previously excluded (129 were < 18 or > 69 years old, 387 did not agree to participate and 698 did not have blood pressure values). The flow chart was given in Figure 1.
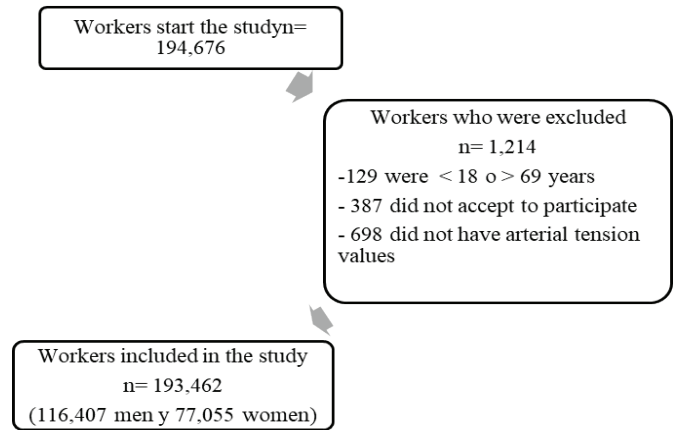

Figure 1: Flow chart of participants

Inclusion Criteria

One of the inclusion criteria for selecting the sample was being between 18 and 69 years old. Additional criteria included having an employment contract with one of the participating companies in the study, signing a consent form to participate in the research, and granting permission for the data to be used in epidemiological studies.

Exclusion criteria

Individuals younger than 18 or older than 69 years and who did not provide informed consent for the use of their data were excluded. Workers without recorded blood pressure values were excluded from the analysis.

Determinations of variables

The healthcare professionals from the various participating companies determined the anthropometric, analytical, and clinical variables necessary for calculating different cardiometabolic risk scales. Measurement techniques were standardized to minimize potential biases in obtaining these variables.

Measurements were taken with the individual standing upright and the abdomen relaxed. A SECA scale was used to measure both weight and height. The waist circumference was measured in this position using a tape measure placed parallel to the floor at the level of

the last rib. To obtain our hip circumference, we must place the tape measure at the point where our hips are the widest, including the buttocks.

Blood pressure was measured using an OMRON-M3 sphygmomanometer. After ten minutes of rest, three readings were taken, with a one-minute interval between each, and the average of the three was calculated. We understand isolated systolic hypertension as the presence of high systolic blood pressure (SBP) values with normal diastolic blood pressure (DBP) values, while diastolic hypertension occurs when DBP is elevated with normal SBP values.

After fasting for at least twelve hours, various techniques were used to measure blood glucose, triglycerides, and total cholesterol, along with precipitation methods for HDL-cholesterol. LDL-cholesterol was calculated using the Friedewald formula, which is valid for triglyceride levels up to 400 mg/dL. Each analytical parameter was expressed in milligrams per deciliter (mg/dL).

The established genders are male and female. Age is determined by subtracting the date of birth from the date of the medical examination. The highest level of education completed is the one considered, with three recognized levels: primary, secondary, and university education.

To determine social class, the criteria of the Spanish Society of Epidemiology, based on the types of jobs included in the 2011 National Classification of Occupations (CNO-11) (20), were applied. Three social class tiers were established:

- Social Class I: This includes university-trained professionals, artists, professional athletes, and managers.

- Social Class II: This covers skilled self-employed individuals and intermediate-level professions.

- Social Class III: This includes unskilled laborers.

Individuals are classified as smokers if they have smoked at least once in the last 30 days or if they quit smoking less than a year ago.

Adherence to the Mediterranean diet is assessed using a 14-question survey, scored on a scale of 0 or 1. A score of nine or higher indicates high adherence (21,22).

To determine an individual's level of physical activity, the International Physical Activity Questionnaire (IPAQ) is used (23). This self-administered questionnaire aims to measure the amount of physical activity performed.

Ethical approval

The 2013 Helsinki Declaration and all other ethical guidelines governing research have been followed. Participants' privacy and anonymity have always been guaranteed. The study was approved by the Balearic Islands Research Ethics Committee (CEI-IB), which issued consent under number IB 483/20.

Since all of the data are coded, only the lead investigator is aware of the identities of the participants. The Organic Law 3/2018, which was passed on December 5, 2018, stipulates that study participants will always be able to access, correct, cancel, and object to the use of the data that has been gathered. It also safeguards digital rights.

Statistical analysis

The Student's t test was used to examine quantitative data and determine means and standard deviations. For quantitative variables, the chi2 test was used to evaluate prevalence. The binomial logistic regression analysis was performed and odds ratios with 95% confidence intervals were computed. The statistical analysis was carried out using the SPSS 29.0 software. For this investigation, the accepted threshold of statistical significance was p<0.05

Results

The 193,462 workers in the study presented the following anthropometric, clinical, analytical, sociodemographic, and healthy habits data as shown in Table 1. The average age of the participants was slightly over 39 years. All variables, with the exception of LDL cholesterol, showed less favorable values in women.

Men made up 60.2% of the participants, while women accounted for 39.8%. The largest age group was between 30 and 49 years old. Most participants belonged to social class III and had only basic education. A Mediterranean diet was followed by 41% of men and 51.4% of women, while 47.8% of men and 54.5% of women exercised regularly. Smoking rates were 37.1% among men and 33% among women.

The prevalence of ISH and HDI is higher in women. The prevalence of ISH increases with age while the prevalence of HDI decreases with age. Both

Table 1: Characteristics of the population

	Women n=77,055	Men n=116,407	
	Mean (SD)	**Mean (SD)**	**p-value**
Age (years)	39.2 (10.2)	39.8 (10.3)	<0.0001
Height (cm)	161.2 (6.6)	173.9 (7.0)	<0.0001
Weight (kg)	65.3 (13.2)	81.1 (13.9)	<0.0001
BMI (kg/m²)	25.2 (4.9)	26.8 (4.2)	<0.0001
Waist circumference (cm)	73.9 (7.9)	87.7 (9.1)	<0.0001
Hip circumference (cm)	97.2 (8.9)	100.1 (8.4)	<0.0001
Systolic blood pressure (mmHg)	114.4 (14.8)	124.4 (15.1)	<0.0001
Diastolic blood pressure (mmHg)	69.7 (10.3)	75.4 (10.6)	<0.0001
Total cholesterol (mg/dL)	193.6 (36.4)	195.9 (38.9)	<0.0001
HDL-c (mg/dL)	53.7 (7.6)	51.0 (7.0)	<0.0001
LDL-c (mg/dL)	122.2 (37.0)	120.5 (37.6)	<0.0001
Triglycerides (mg/dL)	88.1 (46.2)	123.8 (88.0)	<0.0001
Glycaemia mg/dL)	84.1 (11.5)	88.1 (12.9)	<0.0001
	%	**%**	**p-value**
18-29 years	19.5	17.9	<0.0001
30-39 years	33.3	33.1	
40-49 years	29.4	29.7	
50-59 years	15.3	16.3	
60-69 years	2.5	3.0	
Elementary school	51.8	61.2	<0.0001
High school	40.7	34.0	
University	7.5	4.8	
Social class I	7.0	5.3	<0.0001
Social class II	33.2	17.5	
Social class III	59.8	77.3	
Yes physical activity	54.5	47.8	<0.0001
No physical activity	45.5	52.2	
Mediterranean diet	59.1	48.6	<0.0001
Non Mediterranean diet	41.0	51.4	
Non Smoker	67.0	62.9	<0.0001
Smoker	33.0	37.1	

BMI Body mass index, HDL-c High density lipoprotein-cholesterol, LDL-c Low density lipoprotein-cholesterol, SD Standard deviation

hypertensions increase with decreasing socioeconomic status, smoking, sedentary lifestyle and low adherence to the Mediterranean diet. The full data can be found in table 2.

Figure 2 shows the results of the binary logistic regression, in which we observe that, in order, the variables that most increase the risk of IHS are male gender, older age, sedentary lifestyle and low socioeconomic status. In turn, the risk of developing HDI increases with male gender, sedentary lifestyle, low socioeconomic status and low adherence to the Mediterranean diet.

Discussion

The ISH and HDI in our study are influenced by some of the socio-demographic variables and healthy habits analysed. The ISH is influenced by gender, advanced age, low social and economic status and sedentary lifestyle, while the HDI is also influenced by male gender, low socioeconomic status, sedentary lifestyle and low adherence to the Mediterranean diet.

Age is a crucial factor in the differentiation of these two forms of AHT. SAH increases with age due to changes in arterial elasticity, such as stiffening of the large arteries, which raises systolic blood pressure (SBP) (3,4). Studies have shown that from the age of 50 years onwards, SAH is more prevalent, while ADH tends to decrease (5). In contrast, ADH is more common in younger people due to increased peripheral vascular resistance, a phenomenon that decreases with ageing

Table 2: Prevalence of isolated systolic and diastolic hypertension according different sociodemographic variables and healthy habits.

	n	ISH % (95% CI)	p-value	IDH % (95% CI)	p-value
Men	116407	8.6 (8.6-8.6)	<0.0001	2.8 (2.8-2.8)	<0.0001
Women	77055	3.4 (3.3-3.4)		1.2 (1.2-1.3)	
18-29 years	35860	4.3 (4.2-4.4)	<0.0001	3.1 (3.0-3.2)	<0.0001
30-39 years	64176	4.4 (4.3-4.5)		2.6 (2.3-2.9)	
40-49 years	57182	6.2 (6.0-6.3)		2.3 (1.3-3.3)	
50-59 years	30772	11.7 (11.4-12.0)		1.8 (1.7-1.9)	
60-69 years	5472	18.8 (17.8-19.8)		0.7 (0.5-0.9)	
Elementary school	111152	7.6 (7.6-7.6)	<0.0001	2.2 (2.2-2.2)	<0.0001
High school	70958	5.2 (5.1-5.3)		2.1 (2.0-2.2)	
University	11352	4.0 (3.5-4.5)		1.5 (1.0-2.0)	
Social class I	11503	4.0 (3.5-4.5)	<0.0001	1.7 (1.2-2.2)	<0.0001
Social class II	45940	4.2 (4.0-4.4)		1.9 (1.7-2.1)	
Social class III	136019	7.5 (7.5-7.5)		2.2 (2.2-2.2)	
Yes physical activity	100246	8.6 (8.6-8.6)	<0.0001	3.2 (3.2-3.2)	<0.0001
No physical activity	93216	4.3 (4.2-4.3)		1.0 (1.0-1.0)	
Mediterranean diet	106146	8.4 (8.4-8.4)	<0.0001	3.1 (3.1-3.1)	<0.0001
Non Mediterranean diet	87316	4.3 (4.2-4.4)		1.0 (1.0-1.1)	
Non Smoker	124890	6.0 (5.8-6.3)	0.351	2.0 (1.9-2.1)	0.110
Smoker	68572	6.5 (6.3-6.7)		2.5 (2.4-2.6)	

ISH: Isolated systolic hypertension, IDH Isolated diastolic hypertension, SD Standard deviation.

(6). Gender also plays an important role. Young men tend to have a higher prevalence of ADH, possibly due to greater vascular reactivity and higher levels of sympathetic nervous system activity compared to women (11). These data are consistent with those found in our research.

Educational level and social class significantly influence the risk of developing hypertension (HTN) in any of its forms. Individuals with lower educational levels and lower socioeconomic status are at a higher risk

Figure 2: Binary logistic regression analysis

of developing HTN, including both isolated systolic hypertension (ISH) and isolated diastolic hypertension (IDH) (8,16). A study found that individuals with lower educational levels are more likely to have HTN, which could be attributed to reduced access to healthcare, less healthy diets, and greater exposure to stress factors (15). Data from the US National Health and Nutrition Examination and Surveys (NHANES) also showed that low socioeconomic status raised the prevalence of ISH, as did tobacco use (24). The results are consistent with those obtained in our research.

Data from the National Family Health Survey (NFHS), India that included more than 7 million people found that literacy and smoking were positive predictors of HDI, while they were negative predictors of HSI (25).

Tobacco consumption, as observed in our study, has a well-documented relationship with HTN. Smoking increases blood pressure in the short term due to nicotine-induced vasoconstriction (18). In the long term, chronic smoking has been found to be more associated with ISH, as it contributes to endothelial damage and arterial stiffness (9,14). However, it has also been observed that smokers have a lower risk of developing IDH, suggesting that smoking affects arteries differently depending on the type of hypertension (17).

Regular exercise, especially aerobic exercise, has also been shown in other studies to have beneficial effects on blood pressure, reducing both systolic blood pressure (SBP) and diastolic blood pressure (DBP) (19). Exercise has been found to more effectively reduce IDH in young and physically active individuals, as it decreases peripheral resistance (10). In older adults, exercise can prevent the development of ISH by improving arterial elasticity (13).

However, not all authors agree on the beneficial effects of exercise. Several studies have shown that long-term aerobic training is one of the main factors contributing to isolated systolic hypertension (ISHY). In athletes, the increase in stroke volume, secondary to a low heart rate and high arterial elasticity, leads to an increase in peripheral pulse pressure. This explains why ISHY is more common in physically trained individuals compared to sedentary individuals (26).

The Mediterranean diet, rich in fruits, vegetables, fish, olive oil, and nuts, has been widely recognized for its beneficial effects on cardiovascular health (8). Adherence to this diet is associated with a significant reduction in both SBP and DBP, suggesting it may prevent both ISH and IDH (16). Recent studies have shown that the Mediterranean diet improves endothelial function and reduces vascular inflammation, key factors in the development of both forms of hypertension (4,15). Moreover, combining this diet with low sodium intake amplifies its beneficial effects in reducing blood pressure (19). Other authors found similar results with other foods (27).

Limitations

The study has some limitations that need to be considered. Firstly, as a cross-sectional study, it does not establish causality between sociodemographic factors, lifestyle habits, and hypertension types, limiting the ability to infer cause-and-effect relationships. Additionally, the reliance on self-reported data for certain variables, such as physical activity and dietary habits, may introduce recall bias or inaccuracies. While the large sample size enhances the generalizability of findings, the inclusion of only employed individuals may not fully represent the broader population, particularly those who are unemployed or in different work environments. The study also did not account for genetic factors or family history of hypertension, which could influence the prevalence of isolated systolic and diastolic hypertension. Lastly, the use of a single measurement for blood pressure, despite averaging multiple readings, may not fully capture daily variations in blood pressure levels.

Conclusions

Demographic and lifestyle factors such as age, gender, educational level, social class, tobacco consumption, physical exercise, and the Mediterranean diet significantly influence the prevalence and development of isolated systolic and diastolic hypertension. While ISH is more influenced by aging and factors such as arterial stiffness, IDH primarily affects younger individuals, being related to peripheral vascular resistance. These variations highlight the importance of an individualized approach to the prevention and management of HTN, taking into account not only the physiological differences between types of hypertension but also the social and behavioral factors that can modify the risk.

Contributions

Research concept and design: RGC, AALG, JARM

Data analysis and interpretation: RGC, AALG, ELM, MMD, MGL

Collection and/or assembly of data: JARM, ELM, MMD, MGL

Writing the article: RGC, AALG, JARM, ELM, MMD, MGL

Critical revision of the article: RGC, JARM, ELM, MGL

Final approval of the article: RGC, AALG, JARM, ELM, MMD, MGL

All authors read and approved the final version of the manuscript.

References

1. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002;360(9349):1903-13.

2. McEniery CM, Cockcroft JR, Roman MJ, Franklin SS, Wilkinson IB. Central blood pressure: current evidence and clinical importance. Eur Heart J. 2014;35(26):1719-25.

3. Mitchell GF, Parise H, Benjamin EJ, Larson MG, Keyes MJ, Vita JA, et al. Changes in arterial stiffness and wave reflection with advancing age in healthy men and women: the Framingham Heart Study. Hypertension. 2004;43(6):1239-45.

4. Laurent S, Boutouyrie P. Recent advances in arterial stiffness and wave reflection in human hypertension. Hypertension. 2022;49(6):1202-6.

5. Franklin SS, Gustin W 4th, Wong ND, Larson MG, Weber MA, Kannel WB, et al. Hemodynamic patterns of age-related changes in blood pressure. The Framingham Heart Study. Circulation. 1997;96(1):308-15.

6. Safar ME, O'Rourke MF. Arterial stiffness in hypertension. Lancet. 2020;355(9207):1285-90.

7. Laurent S, Boutouyrie P, Asmar R, Gautier I, Laloux B, Guize L, et al. Aortic stiffness is an independent predictor of all-cause and cardiovascular mortality in hypertensive patients. Hypertension. 2001;37(5):1236-41.

8. Kannel WB, Gordon T, Castelli WP. Obesity, lipids, and glucose intolerance: the Framingham Study. Am J Clin Nutr. 2021;32(1):1238-45.

9. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. BMJ. 2022;339.

10. Hall JE, do Carmo JM, da Silva AA, Wang Z, Hall ME. Obesity-induced hypertension: interaction of neurohumoral and renal mechanisms. Circ Res. 2021;116(6):991-1006.

11. Vasan RS, Larson MG, Leip EP, Evans JC, O'Donnell CJ, Kannel WB, et al. Impact of high-normal blood pressure on the risk of cardiovascular disease. N Engl J Med. 2001;345(18):1291-7.

12. Levy D, Larson MG, Vasan RS, Kannel WB, Ho KK. The progression from hypertension to congestive heart failure. JAMA. 1996;275(20):1557-62.

13. Verdecchia P, Schillaci G, Borgioni C, Ciucci A, Porcellati C. Prognostic significance of the white coat effect. Hypertension. 1997;29(6):1218-24.

14. Julius S, Nesbitt SD, Egan BM, Weber MA, Michelson EL, Kaciroti N, et al. Feasibility of treating prehypertension with an angiotensin-receptor blocker. N Engl J Med. 2006;354(16):1685-97.

15. Greenfield JR, Campbell LV. Relationship between inflammation, insulin resistance, and type 2 diabetes: 'cause or effect'? Curr Diab Rep. 2022;6(3):189-93.

16. Stamler R, Stamler J, Riedlinger WF, Algera G, Roberts RH. Weight and blood pressure. Findings in hypertension screening of 1 million Americans. JAMA.

1978;240(15):1607-10.

17. He FJ, MacGregor GA. Salt, blood pressure and cardiovascular disease. Curr Opin Cardiol. 2021;22(4):298-305.

18. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb Cet al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension. 2018;71(6):1269-1324.

19. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J. 2018;39(33):3021-3104.

20. Domingo-Salvany A, Bacigalupe A, Carrasco JM, Espelt A, Ferrando J, Borrell C; del Grupo de Determinantes Sociales de Sociedad Española de Epidemiología. Propuestas de clase social neoweberiana y neomarxista a partir de la Clasificación Nacional de Ocupaciones. Gac Sanit. 2013;27(3):263-72.

21. Hosking DE, Eramudugolla R, Cherbuin N, Anstey KJ. MIND not Mediterranean diet related to 12-year incidence of cognitive impairment in an Australian longitudinal cohort study. Alzheimers Dement. 2019;15(4):581-9.

22. Vieira LM, Gottschall CBA, Vinholes DB, Martinez-Gonzalez MA, Marcadenti A. Translation and cross-cultural adaptation of 14-item Mediterranean Diet Adherence Screener and low-fat diet adherence questionnaire. Clin Nutr ESPEN. 2020;39:180-9.

23. Cleland C, Ferguson S, Ellis G, Hunter RF. Validity of the International Physical Activity Questionnaire (IPAQ) for assessing moderateto vigorous physical activity and sedentary behaviour of older adults in the United Kingdom. BMC Med Res Methodol. 2018;18(1):176.

24. Grebla RC, Rodriguez CJ, Borrell LN, Pickering TG. Prevalence and determinants of isolated systolic hypertension among young adults: the 1999-2004 US National Health And Nutrition Examination Survey. J Hypertens. 2010;28(1):15-23.

25. Gupta P, Sarkar PG, Verma V, Kumar A, Arora S, Kotwal A, et al. Prevalence and determinants of isolated systolic and isolated diastolic hypertension in India: Insights from the national family health survey (NFHS)-4. J Family Med Prim Care. 2022;11(9):5738-45.

26. Palatini P. Regular physical activity: a major component of isolated systolic hypertension in the young. Minerva Med. 2022;113(5):798-806.

27. Ajebli M, Eddouks M. Antihypertensive activity of Petroselinum crispum through inhibition of vascular calcium channels in rats. J Ethnopharmacol. 2019;242:112039.

Publisher's Note: Unico's Medicine remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.