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Original Article

Spatial analysis of hypertension in Peruvian adults, 2022

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ABSTRACT

Objective. To perform a spatial analysis of hypertension in the Peruvian adult population to identify geographic patterns with a higher concentration of cases. **Materials and methods.** A spatial analysis was conducted using data from the Demographic and Family Health Survey (ENDES) 2022. A sample of 29,422 adults was included, and the global Moran's index and Getis-Ord Gi* analysis were used to evaluate spatial autocorrelation and cluster concentration. **Results.** The age-standardized prevalence of hypertension was 19.2%. Clusters with a high concentration of hypertension were observed in departments along the Peruvian coast such as Tumbes, Piura, Lambayeque, La Libertad, Ancash, and Lima, as well as in the northern regions of the Highlands. Clusters were also found in the regions of Loreto and Madre de Dios in the Peruvian jungle. **Conclusions.** This study revealed geographic patterns of hypertension in Peru, with a higher concentration of cases along the Peruvian coast and in certain regions of the Highlands and Jungle. These findings highlight the need to develop strategies for the prevention and control of the disease, especially in the areas identified as high-prevalence clusters.

Keywords: Spatial Analysis; Hypertension; Health Surveys; Peru (source: MeSH-NLM).

Introduction

Hypertension is a chronic disease of multifactorial nature and significant burden of illness, affecting approximately 1,280 million people worldwide [1,2]. According to the World Health Organization (WHO) report of 2022, approximately 22% of the global population presented arterial hypertension. Furthermore, the prevalence in six Latin American countries (Argentina, Brazil, Chile, Colombia, Peru, and Uruguay) reached 32.3% [3], with rates of 68% and 32% in urban and rural areas of these countries, respectively.

Excessive alcohol consumption, smoking, sedentary lifestyle, unhealthy diets, and chronic stress are some of the known risk factors for hypertension. Additionally, some reports indicate that age, gender, and area of residence (urban or rural) are related to the disease [2,4,5]. A recent systematic review with meta-analysis revealed a higher prevalence of hypertension in urban areas (30.5%) compared to rural areas (27.9%) worldwide [6]. These findings underscore the need for preventive and control measures, particularly in urban areas where habits and lifestyles may pose a higher risk of developing the condition [7]. Moreover, the elevated prevalences of hypertension in rural areas, where awareness, treatment, and control levels remain significantly lower compared to urban areas, highlight the necessity of directing strategies towards this population group to prevent an increase in hypertension frequency [6]. It is important to mention that inadequate disease control could lead to a higher incidence of cerebrovascular accidents, myocardial infarctions, chronic kidney disease, and even death among the population [8].

In 2022, a national report on non-communicable diseases (NCDs) conducted in Peru showed that approximately 5.5 million people over the age of 15 had hypertension, equivalent to 22.1% of this population

group [9]. Regarding the country's geographical distribution, the region with the greatest prevalence of hypertension was the coast (24.4%), followed by the highlands (18.7%), and the jungle (17.2%). However, the greatest prevalence was reported in urban areas of the country, with 17.2% compared to 11.9% in rural areas. In contrast, at the departmental level, the greatest prevalences were recorded in Lima (27.1%), Loreto (24.0%), and Tumbes (23.2%), whereas the departments with the lowest prevalence were Apurímac (12.9%) and Ucayali (9.4%) [10]. In this sense, it can be mentioned that the results regarding the prevalence of hypertension depend significantly on the stage of urbanization at the country level and the socio-economic development. Therefore, a more detailed analysis of the spatial distribution of hypertension in Peru is required to target interventions and reduce the harmful effects of this disease, which is a modifiable risk factor for cardiovascular mortality [8]. The aim of the present study was to perform a spatial analysis of arterial hypertension in the Peruvian population to identify geographical patterns with a higher concentration of cases. The results obtained will allow for a better understanding of the spatial distribution of hypertension, serving as a basis for the development of prevention strategies in the identified areas.

Materials and Methods

Design and study population

A spatial analysis was conducted using georeferenced data from the Demographic and Family Health Survey (ENDES – acronym in Spanish) 2022 in Peru. The National Institute of Statistics and Informatics of Peru (INEI) conducts this survey annually to collect data on households, women of reproductive age, and their children under five years old. Additionally, ENDES includes a health questionnaire for a household member aged 15 years or older and for all children under 12 years old, with the aim of providing information on modifiable risk factors, prevalence, and access to treatment of non-communicable diseases, as well as access to health services, among others [10].

Sampling and selection of participants

The sampling process of the ENDES 2022 was probabilistic, two-stage, stratified, and independent. The target population consisted of usual residents of private households, including those who were not residents but stayed in the household the night before the survey. The final report and technical sheet of the survey contain further methodological details about the ENDES 2022 [10]. The sampling frame was based on statistical and cartographic information from the XI National Population Census and VI Housing Census of 2017, as well as cartographic material prepared for the implementation of the ENDES 2022. The data collection method involved direct interviews in selected households conducted by trained interviewers by the INEI.

The present study included a subsample of respondents aged 18 years or older who participated in the health questionnaire of the ENDES. In total, 29,422 adults were included after excluding those under 18 years old and records with incomplete data in the variable of interest.

Variables

The primary study variable was the presence of hypertension. The primary study variable was the presence of arterial hypertension. If the mean arterial pressure was found to be above 140 mmHg in systolic blood pressure (SBP) and/or 90 mmHg in diastolic blood pressure (DBP) [11], the variable was categorized as 1 (presence of arterial hypertension); otherwise, it was coded as 0 (no arterial hypertension). To determine the blood pressure value, two measurements of SBP and DBP were taken, and the average value of SBP and the average value of DBP were used [10]. Blood pressure measurements were taken using an automatic sphygmomanometer of the OMRON brand, model HEM-7113, with a measurement range from 0 to 299 mmHg and an accuracy of ±3 mmHg [10]. Two types of cuffs were used, one standard (220 to 320 mm) and the other for larger arms (320 to 420 mm) [10].

The variables used for the spatial analysis were the latitude and longitude of the cluster where the respondent's household was geolocated. These variables were collected using the Global Positioning System (GPS) included in a tablet, placed one meter from the main entrance of the household. Further information about the geolocation process measurement in the ENDES 2022 can be found in the survey's manual [12].

Finally, the following variables were included to characterize the study population: sex (male/female); age group (18-29/30-59/60 or older); educational level (up to primary/secondary/higher); ethnic self-identification (non-native, native, Afro-Peruvian); married or cohabiting in the last 12 months (yes/no); nutritional status (up to normal/overweight/obese); previous diagnosis of diabetes (no/yes); current smoker (no/yes); current drinker (no/yes); wealth index (poorest/poor/middle/rich/richest); region of residence (Metropolitan Lima, rest of the coast/highlands/jungle), and area of residence (urban/rural).

Statistical analysis

Data were processed and analyzed using Stata version 17 (StataCorp, College Station, TX, USA). First, a descriptive analysis was performed, and the prevalence of hypertension was estimated

according to the characteristics of the included participants. Additionally, age-standardized prevalence of hypertension was estimated using the WHO population standard [13]. The chi-square test was applied to assess differences between the variable of interest and the evaluated characteristics. Secondly, a spatial analysis was conducted following the methodology used in previous articles [14].

The spatial analysis included an assessment of spatial autocorrelation (global Moran's index and Anselin Local Moran's I) and a hotspot analysis (Getis-Ord Gi* statistic) at the district level (exploratory analysis) using ArcGIS Desktop version 10.5 Geographic Information System software (ESRI Inc., Redlands, CA, USA). In the present study, the global Moran's index evaluated the overall pattern and trend of hypertension cases to determine whether they were clustered, dispersed, or randomly distributed. The global Moran's index ranges from -1 to +1, where a positive value indicates spatial clustering, a value of 0 indicates a randomly distributed pattern, and negative values indicate a dispersed pattern.

Ethical aspects

The study did not require the approval from an ethics committee due to its nature as a secondary data analysis, utilizing publicly available data that does not permit identification of the included participants.

Results

A total of 29,422 Peruvian adults were included. A higher frequency of participants were female (52.1%), aged between 30 and 59 years (54.5%), self-identified as non-native (58.7%), married or cohabiting in the last 12 months (65.7%), living in Metropolitan Lima (37.4%) and in urban areas (81.8%) **(Table 1).** The age-standardized prevalence of hypertension was 19.2% (95% CI: 18.3-20.1). A higher prevalence of hypertension was found in men (21.6%), adults aged 60 years or older (35.3%), individuals with educational level up to primary school (21.4%), non-native individuals (18.0%), individuals with obesity (27.2%), or a previous diagnosis of diabetes (33.7%), in the wealthiest quintile (21.7%), residents of Metropolitan Lima (22.1%), and in urban areas (18.2%) **(Table 2)**. The lowest prevalences were found in adults aged 18 to 29 years (5.3%), with a nutritional status up to normal (11.9%), and residents in the jungle region (12.1%) **(Table 2).**

The spatial autocorrelation analysis identified clusters of participants with hypertension (global Moran's index 0.099587, $p < 0.001$, and z-score 19.44). Clusters with a high concentration of respondents with arterial hypertension were identified in the coastal departments of Peru, such as Tumbes, Piura, Lambayeque, La Libertad, Ancash, and Lima, as well as in the northern highland regions of Cajamarca and Amazonas **(Figure 1A and 1B).** The district-level Moran analysis found clusters with a high concentration of participants with hypertension surrounded by clusters with similar characteristics (high-high clusters) in the aforementioned coastal regions, including Moquegua and Tacna. High-high clusters were also found in the Peruvian jungle departments of Loreto and Madre de Dios **(Figure 1C and 1D).** Overall, clusters with a low frequency of respondents with hypertension surrounded by clusters of similar characteristics (low-low clusters) were located in the Peruvian highland departments **(Figure 1).**

Discussion

The aim of this study was to perform a spatial analysis of arterial hypertension in the Peruvian population to identify geographical patterns with a higher concentration of cases. The study revealed a national prevalence of arterial hypertension of 19.2%, which is similar to the findings reported by the WHO, indicating a prevalence of hypertension in Peru of 18% in women and 23% in men (15). However, a meta-analysis on the prevalence and incidence of hypertension determined that the frequency of this condition ranged from 20% to 25% [16]. Peru is one of the 10 countries with the lowest prevalence of hypertension compared to countries such as Paraguay (51%), Tuvalu (51%), Dominican Republic (49%), Jamaica (48%) [15], among others. In Mexico, approximately one-third of the population is reported to have hypertension (17), whereas Algeria has a prevalence of 31.6% [18], and the Middle East reports a prevalence of 24.4% [19].

According to our findings, the highest number of high-high clusters of hypertension is concentrated in Metropolitan Lima and the coastal region of Peru. This could be attributed to the fact that the Peruvian coast is predominantly urban (20), where a higher number of hypertensive individuals is observed compared to the rural areas. This concentration of hypertension in urban areas may be associated with less physical activity and higher rates of smoking and alcohol consumption among the population [21]. Understanding the actual spatial distribution of one of the most prevalent non-communicable diseases, such as arterial hypertension, is valuable in identifying strategic points to target immediate preventive strategies.

The greatest number of hypertensive respondents were concentrated in departments along the Peruvian coast, such as Tumbes, Piura, Lambayeque, La Libertad, Ancash, and Lima. This could be attributed to the greater availability of healthcare

Table 1. Description of characteristics of included respondents (n=29,422).

Characteristics	n	%*
Sex		
Male	12,707	47.9
Female	16,715	52.1
Age group (in years)		
18-29	8,378	26.9
30-59	16,825	54.5
60 or older	4,219	18.6
Educational level		
Up to primary	7,946	22.9
Secondary	12,665	43.3
Higher	8,811	33.8
Ethnic self-identification**		
Non-native	13,895	58.7
Native	11,048	29.3
Afro-Peruvian	3,055	12.0
Married or cohabiting in the last 12 months **		
Yes	20,782	65.7
No	8,638	34.3
Nutritional status		
Up to normal	10,717	34.7
Overweight	11,394	38.6
Obesity	7,311	26.6
Previous diagnosis of diabetes		
No	28,283	94.6
Yes	1,139	5.4
Current smoker		
No	26,617	90.0
Yes	2,805	10.0
Current drinker		
No	19,330	61.9
Sí	10,092	38.1
Wealth index		
Poorest	9,498	18.5
Poor	7,554	20.3
Middle	5,498	21.3
Rich	3,982	20.5
Richest	2,890	19.5
Region of residence		
Metropolitan Lima	3,426	37.4
Rest of the Coast	8,246	25.9
Highlands	10,660	24.2
Jungle	7,090	12.5
Area of residence		
Urban	18,998	81.8
Rural	10,424	18.2

* Estimation included the weighting factor and the sampling design of the Demographic and Family Health Survey 2022.
** The variable contains missing values.

resources in the coastal region, making it more feasible to conduct more screenings and thus capture a larger number of hypertensive individuals. In contrast, in the Peruvian highlands, particularly in rural settings, the population is less likely to visit health centers or receive visits from healthcare personnel in their homes [16]. As a result, a smaller number of hypertensive respondents are identified, explaining the presence of low-low clusters in the highland regions, except for the northern highlands where the departments of Cajamarca and Amazonas are located, which have high population density [22], as well as the Loreto region, where high clusters have also been found. High-high clusters were also identified in Madre de Dios, which is probably due to the rapid urban development of that region after the construction of the interoceanic highway. This development contributes to sedentary lifestyles, poor dietary habits, and obesity, which are known risk factors for hypertension. Additionally, other theories attribute the presence of this disease to mercury contamination resulting from informal mining activities [23,24], although no prospective studies have confirmed these hypotheses.

The present study provides a general approach to understanding the spatial distribution dynamics of hypertension in Peru. In this regard, it is crucial for existing hypertension policies to incorporate comprehensive guidelines for effective prevention, treatment, and epidemiological surveillance. These guidelines should place special emphasis on the most vulnerable populations. It is imperative to emphasize that policies should not only address the recognition and intervention of hypertension risk factors but also require the State to develop programs that provide social support, alongside education, to ensure the effectiveness of these policies.

Among the limitations of the study, first, the cross-sectional design prevents the establishment of causality. Second, there is a possibility of bias due to potential problems in the measurement technique or information bias related to errors or omissions by the interviewers, as well as social desirability bias, where respondents may alter their responses to conform to socially accepted norms, such as denying tobacco and alcohol consumption due to being perceived as negative habits. Additionally, the district-level hotspot analysis is exploratory, considering the lack of representativeness of the ENDES at the district level. Regarding the diagnosis of arterial hypertension, it is recommended to consider the possibility of differences between the first and second blood pressure measurements and to have a third measurement in the ENDES, following the recommendations applied for hypertension diagnosis in a clinical setting [25]. Although blood pressure measurements were taken using equipment not listed as validated automatic devices for blood pressure measurement [25],

Table 2. Prevalence of hypertension according to characteristics of the Peruvian adult population.

Características	Hypertension		p value *
	No (*n*=25,821) % (95% CI)	Yes (*n*=3,601) % (95% CI)	
Overall	82.8 (82.0-83.6)	17.2 (16.4-18.0)	
Age-standardized overall **	80.8 (79.9-81.7)	19.2 (18.3-20.1)	
Sex			
Male	78.4 (77.2-79.7)	21.6 (20.3-22.8)	<0.001
Female	86.8 (85.8-87.8)	13.2 (12.2-14.2)	
Age group (in years)			
18-29	94.7 (93.7-95.5)	5.3 (4.5-6.3)	<0.001
30-59	83.1 (82.0-84.2)	16.9 (15.8-18.0)	
60 or older	64.7 (62.3-67.1)	35.3 (32.9-37.7)	
Educational level			
Up to primary	78.6 (77.0-80.2)	21.4 (19.8-23.0)	<0.001
Secondary	83.5 (82.2-84.7)	16.5 (15.3-17.8)	
Higher	84.8 (83.5-86.0)	15.2 (14.0-16.5)	
Ethnic self-identification			
Non-native	82.0 (80.9-83.1)	18.0 (16.9-19.1)	0.001
Native	85.2 (83.9-86.4)	14.8 (13.6-16.1)	
Afro-Peruvian	82.8 (80.6-84.9)	17.2 (15.1-19.4)	
Married or cohabiting in the last 12 months			
Yes	84.0 (83.0-84.9)	16.0 (15.1-17.0)	<0.001
No	80.6 (79.0-82.0)	19.4 (18.0-21.0)	
Nutritional status			
Up to normal	88.1 (86.9-89.2)	11.9 (10.8-13.1)	<0.001
Overweight	84.9 (83.7-86.1)	15.1 (13.9-16.3)	
Obesity	72.8 (71.1-74.4)	27.2 (25.6-28.9)	
Previous diagnosis of diabetes			
No	83.8 (83.0-84.5)	16.2 (15.5-17.0)	<0.001
Yes	66.3 (61.6-70.7)	33.7 (29.3-38.4)	
Current smoker			
No	83.0 (82.2-83.9)	17.0 (16.1-17.8)	0.097
Yes	80.9 (78.3-83.3)	19.1 (16.7-21.7)	
Current drinker			
No	82.4 (81.4-83.4)	17.6 (16.6-18.6)	0.205
Sí	83.4 (82.1-84.6)	16.6 (15.4-17.9)	
Wealth index			
Poorest	87.3 (86.2-88.4)	12.7 (11.6-13.8)	<0.001
Poor	85.5 (84.1-86.8)	14.5 (13.2-15.9)	
Middle	82.2 (80.4-83.8)	17.8 (16.2-19.6)	
Rich	81.0 (79.1-82.8)	19.0 (17.2-20.9)	
Richest	78.3 (76.0-80.4)	21.7 (19.6-24.0)	
Region of residence			
Metropolitan Lima	77.9 (76.1-79.6)	22.1 (20.4-23.9)	<0.001
Rest of the Coast	83.7 (82.5-84.8)	16.3 (15.2-17.5)	
Highlands	86.9 (85.9-87.8)	13.1 (12.2-14.1)	
Jungle	87.9 (86.7-89.0)	12.1 (11.0-13.3)	
Area of residence			
Urban	81.8 (80.9-82.8)	18.2 (17.2-19.1)	<0.001
Rural	87.2 (86.2-88.1)	12.8 (11.9-13.8)	

Data are shown as row-weighted % unless otherwise indicated.
All estimates included the weighting factor and the sampling design of the Demographic and Family Health Survey 2022.
* p-value estimated using the Rao-Scott adjusted chi-square test.
** World Health Organization population-standardized prevalence.

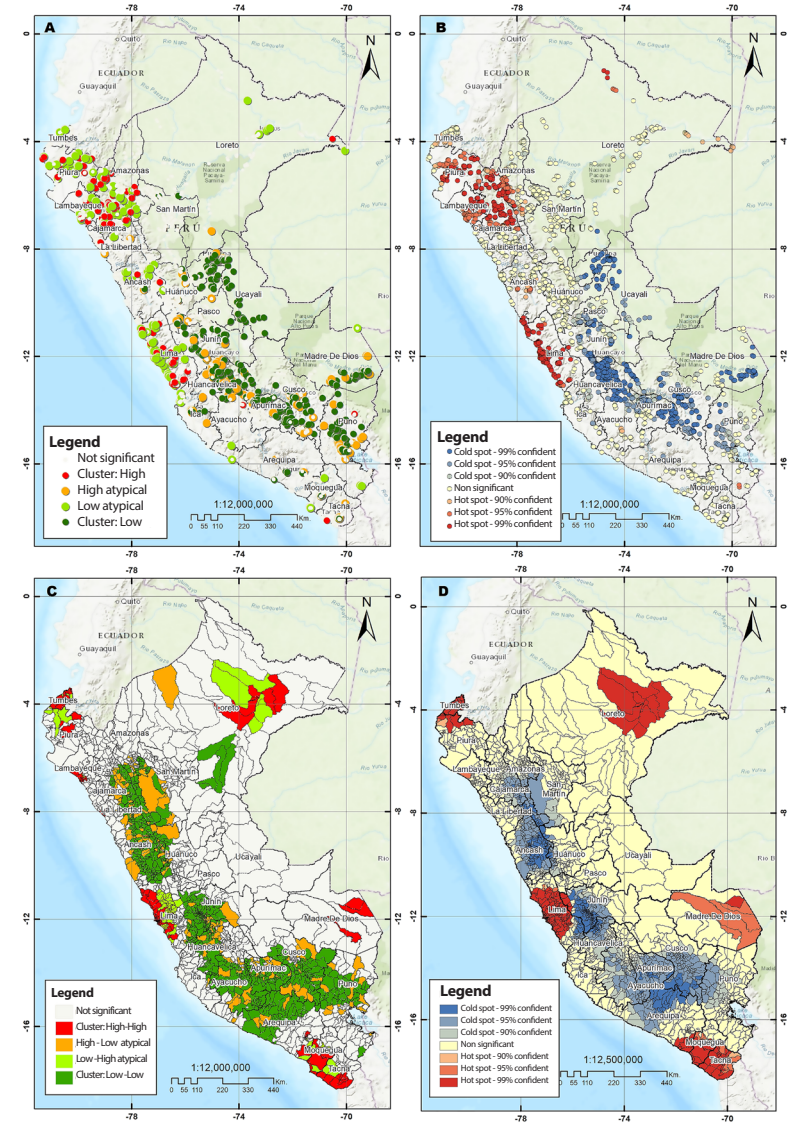

Figure 1. Analysis of arterial hypertension in Peruvian adults based on the Demographic and Family Health Survey 2022. **A.** Cluster analysis and outliers by Morán analysis. **B.** Hotspot analysis based on Getis-Ord's Gi* statistic. **C.** District-level cluster and outlier analysis by Moran's local index. **D.** District-level hotspot analysis based on Getis-Ord Gi* statistic.

it is important to note that the validation of device accuracy is not mandatory before distribution in the market, and validation results are specific to the analyzed population. Therefore, these devices may not always provide accurate measurements in individuals from such a heterogeneous population as the Peruvian population. However, the ENDES collects a large amount of national and departmental information based on the information gathered from the household and individual questionnaires, which is very useful because of the wide variety of variables it contains. In addition, these types of spatial studies are not very common; most of them are conducted in local or departmental health facilities. Therefore, the information from the ENDES, being more general, allows for better extrapolation of national realities and can be useful in developing strategies for hypertension prevention and control. Finally, these studies are influenced by geographic extensions and event densities under study.

In conclusion, the departments of the northern coast, northern highlands, such as Cajamarca and Amazonas, and the jungle region, such as Loreto and Madre de Dios, are the ones that present high-high clusters of hypertensive individuals. Therefore, it is imperative to conduct research to identify the factors contributing to the high prevalence of hypertension in these departments, with the aim of developing policies that benefit the population.

Author contributions

AHV: Conceptualization, Methodology, Validation, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision. EYTC: Methodology, Validation, Formal analysis, Writing - Review & Editing. BNCM, VCAG, y DA: Investigation, Writing - Original Draft, Writing - Review & Editing. All authors approved the final version of the article.

References

1. Organización Mundial de la Salud. Hipertensión [Internet]. 2023 [cited July 9, 2023]. Available from: https://www.who.int/es/news-room/fact-sheets/detail/hypertension
2. Brouwers S, Sudano I, Kokubo Y, Sulaica EM. Arterial hypertension. The Lancet. 2021;398(10296):249–61. doi: 10.1016/S0140-6736(21)00221-X.
3. Camafort M, Alcocer L, Coca A, Lopez-Lopez JP, López-Jaramillo P, Ponte-Negretti CI, *et al*. Registro Latinoamericano de monitorización ambulatoria de la presión arterial (MAPA-LATAM): una necesidad urgente. Revista Clínica Española. 2021;221(9):547–52. doi: 10.1016/j.rce.2021.02.002
4. Koye DN, Melaku YA, Gelaw YA, Zeleke BM, Adane AA, Tegegn HG, *et al*. Mapping national, regional and local prevalence of hypertension and diabetes in Ethiopia using geospatial analysis. BMJ Open. 2022;12(12):e065318. doi: 10.1136/bmjopen-2022-065318.
5. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223–37. doi: 10.1038/s41581-019-0244-2.
6. Ranzani OT, Kalra A, Di Girolamo C, Curto A, Valerio F, Halonen JI, *et al*. Urban-rural differences in hypertension prevalence in low-income and middle-income countries, 1990–2020: A systematic review and meta-analysis. Basu S, editor. PLoS Med. 2022;19(8):e1004079. doi: 10.1371/journal.pmed.1004079.
7. Sani RN, Connelly PJ, Toft M, Rowa-Dewar N, Delles C, Gasevic D, *et al*. Rural-urban difference in the prevalence of hypertension in West Africa: a systematic review and meta-analysis. J Hum Hypertens. 2022. doi: 10.1038/s41371-022-00688-8.
8. Ettehad D, Emdin CA, Kiran A, Anderson SG, Callender T, Emberson J, *et al*. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. The Lancet. 2016;387(10022):957–67. doi: 10.1016/S0140-6736(15)01225-8.
9. Ministerio de Salud. En el Perú, existen 5.5 millones de personas mayores de 15 años que sufren de hipertensión arterial [Internet]. 2022 [cited July 9, 2023]. Available from: https://www.gob.pe/institucion/minsa/noticias/607500-en-el-peru-existen-5-5-millones-de-personas-mayoresde-15-anos-que-sufren-de-hipertension-arterial
10. Instituto Nacional de Estadística e Informática. Perú: Enfermedades No Transmisibles y Transmisibles 2022 [Internet]. Lima: Instituto Nacional de Estadística e Informática; 2023 [cited July 9, 2023]. Available from: https://proyectos.inei.gob.pe/endes/2022/SALUD/ENFERMEDADES_ENDES_2022.pdf
11. Chobanian AV. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood PressureThe JNC 7 Report. JAMA. 2003;289(19):2560. doi: 10.1001/jama.289.19.2560.
12. Instituto Nacional de Estadística e Informática. Manual de la entrevistadora. Encuesta Demográfica y de Salud Familiar [Internet]. Lima: Instituto Nacional de Estadística e Informática; 2023 [cited July 9, 2023]. Available from: https://proyectos.inei.gob.pe/iinei/srienaho/Descarga/DocumentosMetodologicos/2022-5/ManualEntrevistadora.pdf
13. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. Age standardization of rates: a new WHO standard. Geneva: World Health Organization. 2001;9(10):1–14.
14. Hernández-Vásquez A, Vargas-Fernández R, Turpo Cayo EY. Determinants, inequalities, and spatial patterns of diarrhea in the Peruvian under-five population: findings from nationally representative survey data. Front Public Health. 2023;11:1170670. doi: 10.3389/fpubh.2023.1170670.
15. Organización Mundial de la Salud. Más de 700 millones de personas con hipertensión sin tratar [Internet]. 2021 [cited July 9, 2023]. Available from: https://www.who.int/es/news/item/25-08-2021-more-than-700-million-people-with-untreated-hypertension
16. Ruiz-Alejos A, Carrillo-Larco RM, Bernabé-Ortiz A. Prevalencia e incidencia de hipertensión arterial en Perú: revisión sistemática y metaanálisis. Rev Peru Med Exp Salud Publica. 2021;38(4):521–9. doi: 10.17843/rpmesp.2021.384.8502.
17. Palomo-Piñón S, Antonio-Villa NE, García-Cortés LR, Álvarez-Aguilar C, González-Palomo E, Bertadillo-Mendoza OM, *et al*. Prevalence and characterization of undiagnosed arterial hypertension in the eastern zone of Mexico. J of Clinical Hypertension. 2022;24(2):131–9. doi: 10.1111/jch.14414.
18. Moussouni A, Sidi-yakhlef A, Hamdaoui H, Aouar A, Belkhatir D. Prevalence and risk factors of prehypertension and hypertension in Algeria. BMC Public Health. 2022;22(1):1571. doi: 10.1186/s12889-022-13942-y.
19. Okati-Aliabad H, Ansari-Moghaddam A, Kargar S, Mohammadi M. Prevalence of hypertension and pre-hypertension in the Middle East region: a systematic review & meta-analysis. J Hum Hypertens. 2022;36(9):794–804. doi: 10.1038/s41371-021-00647-9.
20. Ministerio del Ambiente. Informe Nacional sobre el Estado del Medio Ambiente 2014-2019 [Internet]. 2021 [cited July 9, 2023]. Available from: https://sinia.minam.gob.pe/inea/indicadores/poblacion-censada-urbana-y-rural-segun-departamento-2017/
21. Wyszyńska J, Łuszczki E, Sobek G, Mazur A, Dereń K. Association and Risk Factors for Hypertension and Dyslipidemia in Young Adults from Poland. IJERPH. 2023;20(2):982. doi: 10.3390/ijerph20020982.
22. Instituto Nacional de Estadística e Informática. Perú: Crecimiento y distribución de la población, 2017 [Internet]. Lima: Instituto Nacional de Estadística e Informática; 2018 [cited July 9, 2023]. Available from: https://proyectos.inei.gob.pe/endes/2022/SALUD/ENFERMEDADES_ENDES_2022.pdf
23. Houston MC. Role of Mercury Toxicity in Hypertension, Cardiovascular Disease, and Stroke: Role of Mercury Toxicity in Hypertension. The Journal of Clinical Hypertension. 2011;13(8):621–7. doi: 10.1111/j.1751-7176.2011.00489.x.
24. Hu XF, Singh K, Chan HM. Mercury Exposure, Blood Pressure, and Hypertension: A Systematic Review and Dose–response Metaanalysis. Environ Health Perspect. 2018 Jul;126(7):076002. doi: 10.1289/EHP2863.
25. Mancia G, Kreutz R, Brunström M, Burnier M, Grassi G, Januszewicz A, *et al*. 2023 ESH Guidelines for the management of arterial hypertension The Task Force for the management of arterial hypertension of the European Society of Hypertension Endorsed by the European Renal Association (ERA) and the International Society of Hypertension (ISH). Journal of Hypertension. 2023. doi: 10.1097/HJH.0000000000003480.