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Spatial distribution and risk factors for hypertension among the elderly in Central Java province based on 2023 SKI data

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Abstract

This study examines the spatial distribution of hypertension among elderly populations in Central Java and the contributing risk factors using 2023 Indonesia Health Survey dataThis research employed descriptive analysis to provide a comprehensive overview of the prevalence and distribution of hypertension within the study area. Logistic regression analysis was then applied to identify significant risk factors associated with hypertension and to assess the magnitude of their influence on disease occurrence. In addition, spatial mapping combined with the Hypertension Health Index (IKH) was utilized to visualize the geographic distribution of hypertension risk and to identify areas with varying levels of vulnerability. These approaches enabled a more detailed understanding of both the determinants and spatial patterns of hypertension, thereby supporting targeted public health interventions and evidence-based decision-making. Results indicate regional variations with high-prevalence clusters in urban and coastal areas, influenced by biological, socio-economic, and behavioral factors, including gender, education, physical activity, and dietary habits. High IKH values were observed in areas with significant combined risk factors, while urban regions showed high prevalence but lower IKH due to mitigating factors. These findings highlight the importance of area-based health interventions, including nutrition education, early detection, and community-based physical activities for the elderly, alongside enhanced risk monitoring in urban settings

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Introduction

The aging of the population is one of the significant demographic shifts occurring in various countries, including Indonesia (Bappenas, 2021). The increase in the number of older adults implies a rising burden of noncommunicable diseases, particularly hypertension, which is a chronic condition characterized by persistently elevated blood pressure and is a major risk factor for cardiovascular diseases, such as stroke, coronary heart disease, and heart failure (WHO, 2021, ; Nabila et al., 2025). Hypertension is one of the leading causes of death and disability worldwide, including in developing countries such as Indonesia (WHO, 2021).

The risk of hypertension in older adults increases with age, leading to physiological changes in the cardiovascular system, including reduced vascular elasticity, altered kidney function, and hormonal imbalances (Hanif et al., 2021; Budiana et al., 2022). In addition to biological factors, hypertension in the elderly is influenced by lifestyle factors, such as high salt intake, low physical activity, obesity, and smoking (Saco-Ledo et al., 2020; Hidayah, 2022,).

Most studies in Indonesia focus on individual determinants, such as age, gender, education, and health behaviors (Rahma et al., 2025; Prihanto et al., 2024). While this approach is important for understanding individual risk factors, it remains limited in explaining regional variations in the distribution of hypertension. Geographic variations, environmental conditions, and regional socioeconomic characteristics are believed to influence the distribution of noncommunicable diseases, including hypertension (Yunandar et al., 2025; Guraci et al., 2025).

Health geography and spatial analysis are now widely used to understand the distribution of diseases (Laohasiriwong et al., 2018; Imtinani & Qurniyawati, 2022). Spatial analysis enables the identification of distribution patterns, regional variations in risk, and disease clusters influenced by environmental and socioeconomic factors. Previous studies have shown spatial autocorrelation in hypertension, where cases are concentrated in areas with similar characteristics (Laohasiriwong et al., 2018; Imtinani & Qurniyawati, 2022). This supports the need for area-based public health interventions.

However, research on the spatial characteristics of hypertension among older adults in Indonesia using the latest national survey data remains limited. Most studies have focused on individual factors, so spatial variations across districts and cities have not been extensively explored (Nabila et al., 2025; Prihanto et al., 2024).

The research questions that arise are: What is the spatial distribution of hypertension among the elderly in Central Java Province, and what factors contribute to this distribution pattern? Based on these questions, the research hypothesis posits that the prevalence of hypertension among the elderly is influenced by demographic factors, health behaviors, and regional characteristics, and exhibits specific spatial clusters.

The problem-solving framework involved descriptive analysis to assess the prevalence of hypertension, regression analysis to identify risk factors, and spatial analysis (choropleth maps and spatial overlays) to explore the relationship between hypertension distribution and risk factors by region.

Method

Data Collection and Analysis

This study employs a quantitative approach using descriptive, spatial, and logistic regression analyses to examine hypertension among older adults in Central Java Province. The data used were drawn from the 2023 Indonesian Health Survey (SKI).The research procedure was conducted in several stages. First, a descriptive analysis was conducted to describe the distribution of hypertension prevalence among older adults in each district/city. Prevalence was categorized

according to WHO criteria: low (<20%), moderate (20–29%), high (30–39%), and very high (≥40%) (WHO, 2021). Second, a spatial analysis using choropleth maps was conducted to visualize the distribution of hypertension prevalence across regions. These maps display color gradients corresponding to prevalence levels, allowing the geographic distribution patterns to be observed visually. Third, logistic regression analysis was conducted to identify risk factors for hypertension, including demographic factors, health behaviors, and regional characteristics. The purpose of this analysis was to identify variables that are statistically significantly associated with the prevalence of hypertension among older adults. Fourth, a spatial overlay analysis was conducted by combining maps of hypertension distribution and significant risk factors identified by logistic regression, using a composite index method. This approach allows the identification of areas with high concentrations of risk and the assessment of the association between the spatial distribution of hypertension and risk factors.

The entire spatial analysis and mapping process was conducted using ArcGIS geographic information system (GIS) software to produce informative thematic maps that support area-based decision-making. It may include the steps or procedures followed in data collection as well as the data analysis techniques used in the study. The methods section may also describe the approach taken to address the research questions in the article.

Result and Discussion

According to the World Health Organization (WHO) classification, the prevalence of hypertension in the population is divided into four categories: low (<20%), moderate (20–29%), high (30–39%), and very high (≥40%) (WHO, 2021). Globally, the prevalence of hypertension in the adult population is estimated to reach 30–45%, and rises to over 60% in the over-60 age group. Fig 1, which illustrates the prevalence patterns of hypertension among the elderly in Central Java Province, shows regional variations.

Fig 1. Prevalence of Hypertension Among the Elderly in Central Java, Source: SKI 2023 (2026, adapted)

The study results show that most regencies and cities in Central Java Province fall into the low-prevalence category. Of the total 35 regions, 27 regencies and cities (77.1%) have a prevalence below 20%, including Cilacap (15.5%), Banyumas (15.7%), Purbalingga (14.7%), Purworejo (17.7%), Klaten (18.6%), Karanganyar (18.0%), Grobogan (18.8%), and Pekalongan City (19.3%).

A total of 6 regions (17.1%) fall into the moderate category (20–29%), namely Banjarnegara (20.9%), Magelang (20.1%), Jepara (23.9%), Tegal (21.9%), Brebes (20.8%), Salatiga City (26.2%), Semarang City (27.3%), and Tegal City (28.1%). Two regions (5.7%) fall into the high category (30–39%), namely Magelang City (32.2%) and Surakarta City (31.1%). No regions have a very high prevalence (≥40%). In terms of prevalence rates, the areas with the highest rates of hypertension are Magelang City (32.2%) and Surakarta City (31.1%). In comparison, the areas with the lowest rates are Blora Regency (11.4%), Batang Regency (13.5%), and Kendal Regency (14.3%).

In general, the distribution pattern indicates that urban areas tend to have a higher prevalence of hypertension than rural areas, as evidenced by the dominance of cities in the moderate-to-high categories. This variation reflects regional differences in hypertension risk, which can be further analyzed using a spatial approach to identify clusters of hypertension risk in Central Java Province.

Further analysis of Table 1 shows that a combination of demographic, social, and behavioral factors influences hypertension among older adults. Older women are at higher risk than older men, while older adults with lower levels of education are more likely to have hypertension than those with higher levels of education. Older adults living in urban areas and those who are not employed also have a higher risk of hypertension.

Table 1. Results of the Regression Analysis of Risk Factors for Hypertension in the Elderly in Central Java

Variable	Category	P-Value	OR (Exp B)
Gender	Women	0.000	1.85
Education	Low (≤SD)	0.011	1.67
Place of Residence	Rural	0.023	1.42
Employment Status	Unemployed	0.032	1.58
Consumption of Salty Foods	Frequent (>3 times/week)	0.0010	2.75
Consumption of Fatty Foods	Frequent (>3 times/week)	0.0010	1.64
Physical Activity	Low	0.0001	1.53

Behavioral factors have a significant impact. Older adults who frequently consume salty foods have the highest risk of hypertension, followed by those who consume fatty foods and have low levels of physical activity. These findings suggest that interventions to prevent hypertension in older adults must not only address individual factors but also account for regional characteristics, social conditions, and community behavioral patterns. With an understanding of these spatial distributions and risk factors, public health strategies can be focused on areas with high prevalence and the most vulnerable groups, particularly in urban areas

The analysis of the Hypertension Health Index (HHI) among the elderly in Central Java Province, shown in Fig 2, reveals clear spatial variations across districts and cities. Based on the

HHI classification, areas can be grouped into four categories: Very High (≥66), High (63–65.9), Moderate (57–62.9), and Low (<57). The results show that areas with very high IKH scores are found in several cities and regencies along the northern coast and in the western part of Central Java Province, including Tegal City (68.9), Pemalang (67.2), Rembang (66.8), and Brebes (66.5). High categories were also found in several regencies in the central and western regions, such as Banjarnegara (65.5), Batang (64.8), Temanggung (63.9), and Purbalingga (63.0).

Fig 2. Prevalence of Hypertension Among the Elderly in Central Java by Risk Factor
Source: SKI 2023 (2026, adapted)

Most areas fall into the moderate category, including Magelang Regency (61.7), Surakarta City (61.1), Sragen (60.7), Blora (60.6), Grobogan (60.4), and Semarang Regency (57.2). Meanwhile, areas in the low category are mostly located in southern regencies and small cities, such as Sukoharjo (56.4), Magelang City (56.3), Kendal (56.2), Semarang City (55.0), Purworejo (54.9), and Cilacap (49.7). Spatially, the distribution of the IKH indicates that urban areas and districts with high population densities tend to have higher IKH values. In comparison, districts with rural characteristics tend to have lower IKH values. This pattern suggests that environmental factors, urbanization, lifestyle, and access to dietary patterns influence the risk of hypertension among older adults. These findings provide a comprehensive spatial overview of hypertension risk distribution in Central Java Province, which can serve as a basis for planning area-based public health interventions, particularly in areas with high to very high hypertension indices.

The analysis shows that the prevalence of hypertension among the elderly in Central Java Province is uneven and tends to cluster in certain urban and semi-urban areas. Areas with high population density, such as the cities of Surakarta and Magelang, exhibit a higher prevalence of hypertension than rural areas. These findings align with the social-ecological determinants theory of hypertension, which emphasizes that environmental conditions including levels of urbanization, air quality, access to green open spaces, and lifestyle influence blood pressure in the elderly (Dzhambov et al., 2018; Groenewegen et al., 2018). The spatial relevance of this distribution is important because it shows that hypertension is influenced not only by individual factors but also by environmental factors that vary across regions. For example, areas with high prevalence are often located near areas with high levels of economic activity and transportation, as seen in the

cities of Surakarta and Magelang, which increase stress and exposure to pollution. Conversely, areas with low prevalence typically have greater access to green open spaces and higher levels of physical activity. Low physical activity is more common in urban areas due to sedentary lifestyles, higher gadget usage, and a lack of sports facilities (Sapnita et al., 2024; Central Java Provincial Health Office, 2023).

This cluster phenomenon underscores the need for public health interventions targeting older adults to account for spatial context: effective strategies for managing hypertension will vary across urban, semi-urban, and rural areas. By adopting a spatial approach, governments and healthcare providers can identify areas at high risk for hypertension, target prevention programs, and adjust resource allocation to prioritize high-risk older adults. Variations in the prevalence of hypertension in Central Java Province are influenced by various risk factors—including biological, socioeconomic, and lifestyle factors—in line with recent research findings (Kearney et al., 2005; Whelton et al., 2018). As people age, blood vessel elasticity decreases, peripheral resistance increases, and kidney function changes, thereby increasing the risk of hypertension (O'Rourke & Safar, 2005). Older women exhibit a higher prevalence of hypertension compared to men, likely due to postmenopausal hormonal changes (Chobanian et al., 2003).

Educational and occupational status influence hypertension through health literacy, access to information, and lifestyle. Older adults with low educational attainment or retirees from physically demanding jobs are more vulnerable to hypertension due to a lack of understanding regarding healthy eating, physical activity, and stress management (Grotto et al., 2008; Lusardi et al., 2021). Lack of physical activity and consumption of foods high in salt, fat, or calories increase the risk of hypertension (Saco-Ledo et al., 2020). Aerobic activity and resistance training have been shown to lower blood pressure, making regular exercise an important preventive strategy among older adults (Cornelissen & Smart, 2013). Environmental factors such as pollution, noise, and population density can increase stress and blood pressure in older adults (Dzhambov et al., 2018). These factors are assessed based on where older adults live, whether in rural or urban areas. Therefore, hypertension is influenced not only by biological factors but also by the social and environmental conditions that affect the daily lives of older adults.

The results of the IKH scores and their relationship to risk factors among older people in Central Java reveal several interesting findings. Spatial patterns indicate that the IKH for older people in Central Java varies across districts/cities, classified as follows: (1) Very High (≥66): Tegal City, Pemalang, Rembang, Brebes, (2) High (63–65.9): Banjarnegara, Batang, Temanggung, Purbalingga, (3) Moderate (57–62.9): Magelang (Reg.), Surakarta City, Sragen, Blora, Grobogan, Pekalongan City, Wonosobo, Klaten, Pati, Pekalongan (Reg.), Jepara, Boyolali, Tegal (Reg.), Semarang (Reg.), (4) Low (<57): Sukoharjo, Magelang City, Kendal, Wonogiri, Semarang City, Purworejo, Demak, Banyumas, Salatiga City, Karanganyar, Kebumen, Kudus, Cilacap.

The IKH score combines hypertension risk variables, such as older age, education, occupation, physical activity, and dietary patterns. A high IKH score indicates a greater potential risk of hypertension in the future, even though the current prevalence may not yet be at its peak.
The spatial pattern indicates that there is a relationship between risk factors and regional characteristics, namely:

Coastals Area

Areas with very high HAI (Tegal, Pemalang, Rembang, and Brebes) are largely located along the northern coast of Central Java. Socioeconomic determinants such as educational level, unstable income, and a sedentary lifestyle in coastal communities are associated with the prevalence of hypertension and obesity (Kumar & Limaye, 2020; Bello et al., 2021). Characteristics

specific to coastal areas associated with hypertension include high salt intake, access and lifestyle, and social-economy.

Salted fish, shrimp paste, and processed seafood are staple foods high in sodium, increasing the risk of hypertension (He et al., 2013; Campbell et al., 2018). Dietary patterns in coastal areas vary, with higher fish consumption, yet they are also prone to high intake of processed carbohydrates. This affects nutritional status and the risk of obesity (Ernitasari et al., 2022; Romauli, 2014). The consumption patterns and lifestyles of coastal communities show a trend toward a shift from traditional diets to high-energy diets and low physical activity, which contributes to rising rates of obesity and metabolic diseases (Sari & Pamungkas, 2020; Smith et al., 2019)." Salted fish, shrimp paste, and processed seafood are staple foods high in sodium, increasing the risk of hypertension (He et al., 2013; Campbell et al., 2018). Dietary patterns in coastal areas vary, with higher fish consumption, yet they are also prone to high intake of processed carbohydrates. This affects nutritional status and the risk of obesity (Ernitasari et al., 2022; Romauli, 2014). The consumption patterns and lifestyles of coastal communities show a shift from traditional diets to high-energy diets and low physical activity, contributing to rising rates of obesity and metabolic diseases (Sari & Pamungkas, 2020; Smith et al., 2019).

Coastal communities have moderate to low levels of physical activity among older people because their primary occupations are largely related to fishing or small-scale businesses that do not require much physical activity.

Coastal areas tend to have lower levels of education and limited access to health information, resulting in low awareness of blood pressure management. Coastal areas have economic, social, and service access characteristics that differ from those of urban and inland areas, including fluctuating incomes and relatively low levels of education, which can influence people's lifestyles and health (Jones & Henderson, 2019; Paterson et al., 2021).

Rural county

Physical Activity and Social Factors in Regencies with high to moderate IKH scores (Banjarnegara, Temanggung, Purbalingga, Magelang Regency) are predominantly rural areas with an agrarian lifestyle include moderate physical activity, work and stress and access to health care.

Older adults in rural areas typically still engage in small-scale farming or gardening, which can help control blood pressure; however, other factors, such as a high-fat diet and a lack of health education, still increase the risk. Regular physical activity can lower blood pressure by improving blood vessel elasticity, enhancing insulin sensitivity, and reducing peripheral resistance (Indriani et al., 2022). Physically active older adults show a lower risk of developing hypertension compared to less active older adults (Jasmin et al., 2023b). Physical activity helps lower blood pressure by improving cardiovascular function, regulating glucose metabolism, and reducing stress (Chasanah et al., 2022)

Older adults who are still working or managing a family business may experience chronic stress, a risk factor for hypertension (Chobanian et al., 2003). Older adults in rural areas who face declining physical abilities, health problems, or social isolation are particularly vulnerable to stress. This stress triggers physiological reactions, including increased blood pressure, elevated stress hormones (cortisol, epinephrine), and other organ disorders, thereby increasing the risk of degenerative diseases (Hidaayah, 2023). Stress in older adults reflects an imbalance among biological, psychological, and social conditions, closely linked to responses to threats and dangers encountered in later life. Stress can be a causative factor in the onset of disease, and even after older adults develop a specific illness, it can lead to further stress (Hidaayah, 2023). Degenerative diseases, physical impairments, or medical procedures that limit the mobility of the elderly can

cause psychological stress, leading to depression, low self-esteem, and social difficulties. This creates a mutually reinforcing stress–disease cycle (Hidaayah, 2023).

Healthcare facilities in rural areas tend to be limited, resulting in low rates of early hypertension detection and exacerbating potential risks. The issue of hypertension in rural areas is generally more complex due to limited access to healthcare services, lifestyle factors, dietary habits, and the uneven distribution of healthcare workers (Teshome et al., 2022; Astutik et al., 2021). In rural areas, limited access to healthcare services, distance to medical facilities, and limited social support increase the risk of stress among older adults. The role of family and community becomes crucial in mitigating the impact of this stress (Hidaayah, 2023).

Major City / Urban

The areas with low IKH (Semarang City, Magelang City, Salatiga City, Sukoharjo) are mostly urban or semi-urban have a better education and access to healthcare, modern lifestyle and contradiction between prevelance and risk.

Older adults have easier access to routine checkups, education on healthy lifestyles, and medications for hypertension. According to Zulkardi (2015), easy access to transportation and shorter travel distances can promote hypertension prevention, making it easier for urban residents to utilize health care facilities. Based on Riskesdas (2018), the prevalence of hypertension in urban areas tends to be more detected due to better health education and easier access to health services. Notoatmodjo (2014) emphasizes that the availability of health facilities and infrastructure, as well as health education, influences the community's preventive behavior, and that this is more optimal in urban areas because facilities and information are more easily accessible.

Physical activity levels may be low, but awareness of low-sodium diets and community exercise programs is higher. According to Marlita, Lestari, & Ningsih (2022), the prevalence of hypertension in urban areas tends to be more readily detected due to better health education and easier access to healthcare services. Lifestyle factors such as excessive salt intake, lack of physical activity, and smoking contribute to hypertension; however, the availability of healthcare facilities and healthy living education programs in urban areas facilitates the prevention and control of this disease (Marlita, Lestari, & Ningsih, 2022)

Some cities have a high prevalence of hypertension among the elderly, but a low HAI because other risk factors (such as education, employment, and physical activity) are better than in rural or coastal areas. This indicates that the HAI serves as a composite risk predictor, not merely a measure of current prevalence. Cities with low UHI still require monitoring because urbanization may increase future risks, particularly those related to stress and dietary patterns. Hypertension issues in rural and coastal areas tend to be more complex due to limited access to healthcare services, uneven distribution of healthcare personnel, and community lifestyle and dietary factors (Teshome et al., 2022; Astutik et al., 2021). The prevalence of hypertension in rural areas, such as Banyuwangi Regency (27.8%), is lower than in urban areas such as Surabaya City (37.25%); however, the risk remains high among the elderly, individuals with high salt and alcohol intake, poor sleep quality, and minimal social support (Astutik et al., 2021; Chang et al., 2022; Yazawa et al., 2022).

Primary health care facilities such as community health centers (Puskesmas) play a strategic role in the prevention and control of hypertension through medical interventions, health education, and the use of community-based health technologies (Vedanthan et al., 2020; Jahan et al., 2020; Xiao et al., 2020). Social support and family involvement have been shown to reduce the prevalence of hypertension, making community-based programs crucial for rural areas (Yazawa et al., 2022).

There is a marked difference between urban and rural/coastal areas. Urban areas generally have a higher prevalence of hypertension than rural areas due to differences in access to healthcare services, lifestyle, and more modern dietary patterns. Risk factors such as high salt and fat consumption, low physical activity, and higher stress levels are frequently observed in urban populations. The availability of better healthcare facilities and health education in urban areas facilitates the detection and management of hypertension; however, changes in urban lifestyles actually increase the burden of this noncommunicable disease. Conversely, in rural and coastal areas, the prevalence of hypertension is often under-documented due to limited access to primary healthcare services, low health literacy, and uneven distribution of healthcare personnel, resulting in cases of hypertension among the elderly being underdiagnosed and more difficult to manage effectively (Astutik et al., 2021; Teshome et al., 2022).

A comprehensive comparison based on the Hypertension Health Index (HHI) also reveals significant spatial variations: some rural or coastal districts have high HHI scores, indicating that although prevalence may appear lower than in urban areas, the burden on health and lifestyle risk factors remains significant and requires intervention. Meanwhile, cities with low HHI—despite higher prevalence rates—indicate relatively greater effectiveness of health services and education; however, they still warrant vigilance, as urbanization, work-related stress, and modern consumption patterns could exacerbate hypertension trends in the future. Effective region-based health policies must take into account the socioeconomic context of the population at the district/city level. In rural/coastal areas with high HAI, priority strategies should include community-based interventions such as nutrition education programs that reduce salt and saturated fat intake in line with local dietary patterns, early detection services through Posbindu for older people or mobile health units, and the development of accessible community physical activities (e.g., exercise for the elderly and light agricultural activities). This approach simultaneously addresses limited access to health services and supports improved hypertension prevention behaviors.

Conversely, in urban areas, policies need to strengthen programs that address urban lifestyle risk factors, such as reducing stress through green spaces and physical activity programs, improving health education via digital media, and ensuring the sustainability of hypertension surveillance in primary health care facilities so that the prevalence of hypertension can continue to be reduced despite evolving urban challenges. Additionally, the importance of social support and family involvement also influences the effectiveness of hypertension control. Individuals who feel lonely have a higher prevalence of hypertension compared to those who receive adequate social support (Yazawa et al., 2022).

Conclusion

This study shows that hypertension is affected differently depending on the region. Rural and coastal areas with high HDI face a higher prevalence of hypertension due to limited access to health services, uneven distribution of health workers, and local lifestyle factors. At the same time, cities with low HDI remain at risk of increased hypertension in the future due to urbanization and changes in modern dietary patterns. The novelty of these findings highlights the importance of a region-based approach to hypertension control, where interventions in rural areas should focus on nutrition education, early detection through Posbindu or mobile services, and community-based physical activity, while in urban areas, there is a need to strengthen education, monitor lifestyle risks, and manage stress. These findings provide a basis for formulating city and district health policies that take into account local socioeconomic and environmental characteristics, and serve as a recommendation for further research to test the effectiveness of region-based interventions in sustainably reducing the prevalence of hypertension.

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Author Contribution

Conceptualization, M.S. Nurmaulid and A. Nikmah; Methodology, M.S. Nurmaulid; Data Curation, M.S. Nurmaulid; Formal Analysis, M.S. Nurmaulid and A. Nikmah; Investigation, M.S. Nurmaulid; Spatial Analysis and Visualization, M.S. Nurmaulid; Writing Original Draft Preparation, M.S. Nurmaulid; Writing Review and Editing, A. Nikmah; Supervision, A. Nikmah. All authors have read and agreed to the published version of the manuscript.

Data Availabilty

All data generated or analyzed during this study are presented in the tables and figures within this article.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this pape.

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