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Multilevel Analysis of District- and City-Level Contextual Factors Influencing Hypertension Risk Among Adults: An Analysis of Indonesian Health Survey Year 2023

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ABSTRACT

Background: Hypertension remains a major public health challenge in Indonesia, with prevalence continuing to rise across different population groups. The burden of hypertension varies across settings, including urban and rural areas, socioeconomic levels, and regional contexts. This study aimed to examine how district- and city-level contextual factors influence the risk of hypertension among adults in Indonesia.

Subjects and Method: A cross-sectional study included a sample of 48,878 adults who participated in the 2023 Indonesian Health Survey (*Survei Kesehatan Indonesia*). The data were analyzed using multilevel multiple linear regression.

Results: Multilevel analysis showed that the risk of hypertension increased among individuals aged ≥60 years (b= 4.12; 95% CI= 3.76 to 4.48; p < 0.001), compared with those aged <20 years. Senior high school or higher education (b= −0.40; 95% CI= −0.48 to −0.31; p <0.001) was associated with a lower risk of hypertension compared with individuals with no formal education. Higher BMI was associated with an increased risk of hypertension among individuals with BMI 18.5–25 kg/m² (b= 0.19; 95% CI= 0.09 to 0.30; p < 0.001) and BMI ≥25 kg/m² (b= 0.92; 95% CI= 0.82 to 1.03; p < 0.001). Female sex (b= 0.21; p < 0.001), urban residence (b= 0.06; p= 0.021), and high Gini Ratio (b = 0.17; p < 0.001) increased the risk of hypertension, whereas high physical activity and higher provincial minimum wage reduced the risk. The ICC of 0.37% indicated low variation across districts/cities.

Conclusion: Hypertension risk among Indonesian adults is mainly driven by individual factors, while income inequality is the only contextual factor with a significant effect. These results emphasize the need for interventions targeting both personal health behaviors and socioeconomic disparities.

Keywords: hypertension, systolic blood pressure, multilevel analysis, Indonesian Health Survey

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BACKGROUND

Hypertension, often termed a "silent killer," is a condition that frequently manifests without clear clinical symptoms, resulting in many individuals remaining unaware of their hypertensive status (Ministry of Health, 2023). Globally, hypertension accounts for an estimated 8 million deaths annually, with approximately half a million of these occurring in Southeast Asia, a region where one-third of the population is affected (Lukito, 2023). Data from the Institute for Health Metrics and Evaluation (IHME) indicate that 61.6% of total mortality may be attributable to hypertension. According to the World Health Organization (WHO, 2023), the global prevalence of hypertension is estimated at 33%, whereas the prevalence in Southeast Asia is reported at 32%. Despite the high burden, approximately 30% of individuals with hypertension in the region have not received adequate or appropriate treatment (WHO, 2023).

Multiple determinants contribute to the development of hypertension, including increasing age, unhealthy dietary patterns, elevated Body Mass Index (BMI), and insufficient physical activity. Low awareness regarding healthy food consumption often results in weight gain and increased BMI. Individuals with central obesity are reported to have a 3.4-fold higher likelihood of developing hypertension compared with those with a normal BMI (Ministry of Health, 2023).

Physical activity is also an important factor that helps reduce blood pressure. Several studies have shown that physical activity is an effective non-pharmacological strategy for lowering blood pressure and is widely recommended for the prevention and management of hypertension, partly through its role in reducing oxidative stress (Larsen & Matchkov, 2016). To address the rising prevalence of hypertension, the Ministry of Health of the Republic of Indonesia launched the Healthy Living Community Movement (GERMAS), which encourages people to engage in regular physical activity as part of efforts to reduce the risk of various diseases, including hypertension (Ministry of Health, 2017).

The area of residence is another important factor in understanding the characteristics of populations affected by hypertension. A study by Venkatesh et al. (2022) reported that the prevalence of hypertension is higher among individuals living in urban areas than among those in rural areas, even though lifestyle-related risk factors are generally more common in urban settings.

The increasing prevalence of hypertension in Indonesia is influenced by several factors, one of which is the country's vast geographical landscape and archipelagic structure, resulting in diverse regional characteristics. A study by Safitri et al. (2024) reported that the high prevalence of hypertension in Java Island is associated with unhealthy lifestyle behaviors, including poor dietary patterns and insufficient physical activity.

Using a multilevel analytical approach provides a more substantive method for examining data that consist of hierarchical structures. Hox et al. (2017) emphasized that multilevel modeling is highly appropriate when data are organized into nested levels, where individuals may be clustered within larger groups. Research by Raudenbush and Bryk (2002) further demonstrated that multilevel models are valuable for exploring the relationship between individual factors and contextual influences, ultimately offering deeper insights into existing social dynamics.

The 2023 Survei Kesehatan Indonesia (SKI) provides nationally representative

data aimed at assessing disease patterns and health trends among the population. In addition to identifying disease prevalence, the SKI includes a series of questions designed to capture various risk factors associated with major health conditions. The 2023 SKI was conducted in collaboration with Statistics Indonesia (BPS), particularly in relation to sampling methodology. Data collection was carried out through interviews, physical measurements, and clinical examinations (Ministry of Health, 2023).

Given the availability of the 2023 SKI dataset and the high prevalence of hypertension in Indonesia, the present study utilizes this dataset to investigate the issue.

SUBJECTS AND METHOD

1. Study Design

This study is an analytical observational study with a cross-sectional design, using data from the 2023 Indonesia Health Survey (SKI). The research was conducted across all regions of Indonesia. Data analysis was carried out from July to August 2025.

2. Population and Sample

The study population consisted of all respondents in the 2023 Indonesia Health Survey (SKI) who were aged 15 to 50 years and had their blood pressure measured directly by SKI enumerators. A random sampling technique was applied, resulting in a total sample of 48,878 study participants. For the level-2 variables, the number of contextual variables examined exceeded 25.

3. Study Variables

The independent variables in this study included age, education, Body Mass Index (BMI), sex, physical activity, urban–rural residence, income inequality, and provincial minimum wage. The dependent variable in this study was hypertension.

4. Operational Definition of Variables

Hypertension was classified based on the respondent's hypertension category and was not derived from systolic blood pressure measurements collected directly by SKI enumerators in 2023.

Age referred to the respondent's age in years at the time of the 2023 SKI interview.

Sex referred to the respondent's gender, as reported in the family registration document and confirmed during the data collection interview.

Education referred to the highest level of formal education completed by the respondent at the time of the 2023 SKI interview.

Place of residence (village/city) referred to the respondent's residential location as identified by the village or city code recorded during the 2023 SKI data collection.

Income inequality (Gini Ratio) represented a statistical measure used to describe the degree of income distribution imbalance, calculated using the Gini coefficient as reported by Statistics Indonesia (BPS) in 2023.

Provincial Minimum Wage referred to the minimum monthly wage set by each provincial government as a safety net for workers to ensure a decent standard of living.

Body Mass Index (BMI) referred to the respondent's weight classification, calculated as body weight (kg) divided by height squared (m^2).

Physical activity referred to the respondent's daily activities that require energy expenditure.

Place of residence (district/city) referred to the respondent's administrative location at the time of data collection, as identified through questionnaire responses indicating the district or city of residence.

5. Study Instruments

The research instrument used in this study was the questionnaire developed by the household questionnaire and a three-block individual questionnaire.

6. Data analysis

Univariate analysis was used to describe the distribution of each variable included in the study. Bivariate analysis using simple linear regression. Multivariate analysis using multilevel linear regression. All analyses were conducted using STATA version 13.

7. Research Ethics

Data ethics included anonymity, and confidentiality throughout the research process. A Data Confidentiality Agreement was obtained from the Center for Data and Information Technology (PUSDATIN), Ministry of Health of Indonesia, under document number FRM/SMKI-PUSDATIN/70, dated 16 May 2025.

RESULTS

1. Sample Characteristics

Based on Table 1, the majority of respondents in this study were aged 40 to 59 years, totaling 20,641 individuals (42.23%), while the smallest proportion was respondents aged <20 years, with 2,354 individuals (4.82%). The sample consisted of 26,784 women (54%) and 22,094 men (45.2%). Regarding Body Mass Index (BMI), 26,588 respondents (54.4%) had a normal BMI ranging from 18.5 to 25 kg/m². Most respondents had completed senior high school or higher education, totaling 21,767 individuals (44.53%). Based on urban–rural residence, the majority lived in urban areas, with 26,445 respondents (54.1%). In this study, 15,006 respondents (30.7%) were found to have high blood pressure. With respect to island of residence, most respondents lived on Sumatra Island, accounting for 15,556 individuals (31.83%). As for blood pressure classification, 15,006 respondents (30.70%) were categorized as having high blood pressure.

Table 1. Characteristics of the categorical sample data

Characteristic	Frequency (n)	Persentase (%)
Age group		
< 20 years	2,354	4.82
20 - 39 years	18,350	37.54
40 - 59 years	20,641	42.23
≥ 60 years	7,533	15.41
Sex		
Male	22,094	45.2
Female	26,784	54.8
Body Mass Index (BMI)		
< 18.5 kg/m2	3,570	7.3
18.5 - 25 kg/m2	26,588	54.4
≥ 25 kg/m2	18,720	38.3
Education		
No Formal Education	5,383	11.01
Junior High School	21,728	44.45
Senior High School & Higher	21,767	44.53
Physical Activity		
Low	34,054	69.67
High	14,824	30.33

Characteristic	Frequency (n)	Persentase (%)
Place of Residence		
Rural	22,433	45.9
Urban	26,445	54.1
Blood Pressure		
Normal	33,872	69.3
High	15,006	30.70
Provincial Minimum Wage		
Low (< Rp 2,923,309)	30,538	62.48
High (≥ Rp 2,923,309)	18,304	37.52
Island of Residence		
Sumatera	15,556	31.83
Jawa	14,081	28.81
Kalimantan	4,738	9.69
Sulawesi	7,600	15.55
Bali dan Nusa Tenggara	4,210	8.61
Maluku	1,726	3.53
Papua	967	1.98

2. Bivariate Analysis

Age show a positive and statistically significant association with the risk of hypertension. Respondents aged 20 to 39 years had 5.29 times higher odds of hypertension compared to those aged < 20 years (OR = 5.29; 95% CI= 3.67 to 7.62; p <0.001). Respondents aged 40 to 59 years had 26.77 times higher odds of hypertension compared to those aged < 20 years (OR = 26.77; 95% CI = 18.65 to 38.43; p < 0.001). Meanwhile, respondents aged ≥ 60 years had 71.39 times higher odds of hypertension compared to those aged < 20 years (OR = 71.39; 95% CI = 49.66 to 102.64; p < 0.001). Thus, increasing age is associated with a higher risk of hypertension.

Education level shows a negative and statistically significant association with hypertension risk. Respondents with junior high school education had 0.68 times the odds of hypertension compared to those with no formal education (OR = 0.68; 95% CI= 0.64 to 0.73; p < 0.001). Meanwhile, respondents with senior high school education or higher had 0.39 times the odds of hypertension compared to those with no formal education (OR = 0.39; 95% CI = 0.36 to 0.41; p < 0.001). This indicates that higher education levels are associated with a lower risk of hypertension.

Body mass index (BMI), respondents with BMI 18.5 to 25 kg/m² were not significantly associated with hypertension compared to those with BMI < 18.5 kg/m² (OR= 1.05; 95% CI= 0.96 to 1.16; p= 0.249). However, respondents with BMI ≥ 25 kg/m² had 2.02 times higher odds of hypertension compared to those with BMI < 18.5 kg/m² (OR = 2.02; 95% CI = 1.83 to 2.22; p < 0.001). This finding suggests that obesity is associated with an increased risk of hypertension. Gender shows a positive and statistically significant association with hypertension. Female respondents had 1.27 times higher odds of hypertension compared to male respondents (OR = 1.27; 95% CI = 1.21 to 1.32; p < 0.001).

Physical activity shows a negative and statistically significant association with hypertension. Respondents with high physical activity had 0.79 times the odds of hypertension compared to those with low physical activity (OR= 0.79; 95% CI = 0.75 to 0.83; p < 0.001). This indicates that higher physical activity has a protective effect against hypertension. Place of residence shows a positive and statistically

significant association with hypertension. Respondents living in urban areas had 1.08 times higher odds of hypertension compared to those living in rural areas (OR= 1.08; 95% CI = 1.04 to 1.13; p < 0.001).

Provincial minimum wage shows a negative and statistically significant association with hypertension. Respondents living in provinces with higher minimum wages had 0.85 times the odds of hypertension compared to those in provinces with lower minimum wages (OR= 0.85; 95% CI= 0.81 to 0.89; p < 0.001). Income inequality (Gini Ratio) shows a positive and statistically significant association with hypertension. Respondents living in areas with higher income inequality had 1.24 times higher odds of hypertension compared to those in areas with lower inequality (OR = 1.24; 95% CI = 1.17 to 1.31; p < 0.001). Overall, these findings indicate that demographic, socioeconomic, and behavioral factors play an important role in influencing the risk of hypertension in Indonesia.

Table 2. Results of the simple linear regression analysis for variables influencing hypertension risk in Indonesia

Variable	OR	95% CI		p
		Lower Limit	Upper Limit	
Age				
< 20 years	*Ref.*			
20 - 39 years	5.29	3.67	7.62	< 0.001
40 - 59 years	26.77	18.65	38.43	< 0.001
≥ 60 years	71.39	49.66	102.64	< 0.001
Education				
No Formal Education	*Ref.*			
Junior High School	0.68	0.64	0.73	< 0.001
Senior High School & Higher	0.39	0.36	0.41	< 0.001
BMI				
< 18.5 kg/m²	*Ref.*			
18.5 - 25 kg/m²	1.05	0.96	1.16	0.249
≥ 25 kg/m²	2.02	1.83	2.22	< 0.001
Sex				
Male	*Ref.*			
Female	1.27	1.21	1.32	< 0.001
Physical Activity				
Low	*Ref.*			
High	0.79	0.75	0.83	< 0.001
Place of Residence				
Rural	*Ref.*			
Urban	1.08	1.04	1.13	< 0.001
Provincial Minimum Wage				
Low (< Rp 2.923.309)	*Ref.*			
High (≥ Rp 2.923.309)	0.85	0.81	0.89	< 0.001
Gini Ratio 2023				
Low (< 0.400)	*Ref.*			
High (≥ 0.400)	1.24	1.17	1.31	< 0.001

3. Multilevel analysis

Table 3 shows the results of the multilevel multivariate analysis examining factors associated with hypertension risk in Indonesia based on the 2023 SKI data. After controlling for all variables in the model,

several factors remained significantly associated with hypertension. Age shows a positive and statistically significant association with hypertension risk. Respondents aged 20 to 39 years had 4.39 times higher odds of hypertension compared to those aged < 20 years (OR = 4.39; 95% CI = 3.04 to 6.34; p < 0.001). Respondents aged 40 to 59 years had 20.77 times higher odds of hypertension (OR = 20.77; 95% CI = 14.45 to 29.85; p<0.001), while respondents aged ≥60 years had 61.52 times higher odds compared to those aged < 20 years (OR = 61.52; 95% CI = 42.75 to 88.51; p < 0.001). This indicates that age remains the strongest determinant of hypertension after adjustment.

Education level shows a negative and statistically significant association with hypertension. Respondents with junior high school education had 0.88 times the odds of hypertension compared to those with no formal education (OR = 0.88; 95% CI= 0.82 to 0.95; p = 0.001). Meanwhile, respondents with senior high school education or higher had 0.67 times the odds of hypertension compared to those with no formal education (OR = 0.67; 95% CI = 0.62 to 0.73; p < 0.001). This suggests that higher education remains a protective factor against hypertension.

Body mass index (BMI) shows a significant association with hypertension. Respondents with BMI ≥ 25 kg/m² had 2.52 times higher odds of hypertension compared to those with BMI < 18.5 kg/m² (OR = 2.52; 95% CI = 2.26 to 2.81; p < 0.001). Although the estimate for BMI 18.5–25 kg/m² had 1.21 times higher odds of hypertension compared to those with BMI < 18.5 kg/m is reported as significant (OR= 1.21; CI 95%= 1.09 hingga 1.35; p < 0.001). Overall, higher BMI is associated with increased hypertension risk.

Gender shows a significant association with hypertension. Female respondents had 1.23 times higher odds of hypertension compared to male respondents (OR= 1.23; 95% CI= 1.16 to 1.29; p < 0.001). Physical activity shows a negative and statistically significant association. Respondents with high physical activity had 0.88 times the odds of hypertension compared to those with low physical activity (OR = 0.88; 95% CI= 0.83 to 0.93; p <0.001), indicating a protective effect.

Place of residence shows a positive and statistically significant association. Respondents living in urban areas had 1.06 times higher odds of hypertension compared to those living in rural areas (OR= 1.06; 95% CI= 1.01 to 1.13; p = 0.021). Income inequality (Gini Ratio) shows a statistically significant association. Respondents living in areas with high income inequality had 1.19 times higher odds of hypertension compared to those in areas with low inequality (OR= 1.19; 95% CI= 1.11 to 1.27; p < 0.001). Provincial minimum wage shows a statistically significant association. Respondents living in provinces with higher minimum wages had 0.92 times the odds of hypertension compared to those in lower-wage provinces (OR = 0.92; 95% CI = 0.88 to 0.97; p = 0.004).

At the contextual level, the random effect at the district/city level was statistically significant, as indicated by the likelihood ratio test (Chi²= 23.8; p <0.001), suggesting that the multilevel model is more appropriate than a standard logistic regression model. The intraclass correlation coefficient (ICC) of 0.37% indicates that a small proportion of the variance in hypertension risk is attributable to differences between districts/cities. Overall, the multivariate analysis confirms that demographic, socioeconomic, behavioral, and contextual factors jointly influence hypertension risk

in Indonesia, with age remaining the most dominant factor.

Tabel 3. Results of multilevel multiple linear regression analysis on the contextual effects of districts/cities on the risk of hypertension among adults

Independent Variables	OR	95% CI		p
		Lower Limit	Upper Limit	
Fixed Effect				
Age				
< 20 years	Ref.			
20 - 39 years	4.39	3.04	6.34	< 0.001
40 - 59 years	20.77	14.45	29.85	< 0.001
≥ 60 years	61.52	42.75	88.51	< 0.001
Education				
No Formal Education	Ref.			
Junior High School	0.88	0.82	0.95	0.001
Senior High School & Higher	0.67	0.62	0.73	< 0.001
BMI				
< 18.5 kg/m²	Ref.			
18.5 - 25 kg/m²	1.21	1.09	1.35	< 0.001
≥ 25 kg/m²	2.52	2.26	2.81	< 0.001
Sex				
Male	Ref.			
Female	1.23	1.16	1.29	< 0.001
Physical Activity				
Low	Ref.			
High	0.88	0.83	0.93	< 0.001
Place of Residence				
Rural	Ref.			
Urban	1.06	1.01	1.13	0.021
Gini Ratio 2023				
Low (< 0.400)	Ref.			
High (≥ 0.400)	1.19	1.11	1.27	< 0.001
Provincial Minimum Wage				
Low (< Rp 2.923.309)	Ref.			
High (≥ Rp 2.923.309)	0.92	0.88	0.97	0.004
Random Effect				
Districts/Cities	0.12	0.01	0.02	
N observation	44,878			
LR test vs. Logistic Regression: chi² = 23.8				
Likelihood Ratio Test p < 0.001				
Intraclass Correlation (ICC)= 0.37 %				

DISCUSSION

1. Age and Hypertension Risk Factors

Increasing age is strongly linked to a higher risk of hypertension. This can be seen in respondents aged ≥60 years, who had 61.52 times higher odds of having hypertension compared to those aged < 20 years. This result is statistically significant, meaning that older age greatly increases the likelihood of hypertension. This age-related rise in blood pressure may be caused by physiological changes in the body, such as increased peripheral resistance and elevated sympathetic activity in older adults. Additionally, cardiac output and vascular compliance tend to decline with

age. Aging also affects the function of several organs; for instance, arteries gradually lose elasticity, making blood vessels stiffer and narrower. Moreover, the sensitivity of blood pressure regulatory mechanisms, including the baroreceptor reflex, decreases in older age (Marhabatsar and Sijid, 2021).

These results are consistent with findings reported by Nolde et al. (2024), who observed that younger individuals generally have lower blood pressure, whereas blood pressure increases with advancing age. Similarly, Messerli et al. (2018) demonstrated that the risk of hypertension rises significantly with age, particularly among individuals aged 50 years and older. Natural physiological changes associated with aging, such as reduced cardiac function, diminished vascular elasticity, and hormonal alterations, contribute to the increased risk of hypertension in older adults (Triyanto, 2014; Hidayat, 2021).

2. Education and Hypertension Risk Factors

Respondents with senior high school education or higher had 0.67 times the odds of hypertension compared to those with no formal education. This suggests that higher education remains a protective factor against hypertension. The results of this study are supported by the research of Caraballo et al. (2021), which showed that individuals with higher education and older age tend to have lower blood pressure. Individuals with lower education often lack health literacy to prevent hypertension, have limited access to healthcare services, and show lower adherence to antihypertensive treatment, which can hinder interventions aimed at reducing systolic blood pressure (Garfein et al., 2025).

The results of Sun et al. (2022) research also support this finding. Their cohort study, conducted in 2011 with 101,959 participants, found that individuals with lower educational attainment were more likely to engage in unhealthy lifestyles, including poor dietary habits and insufficient physical activity, which contributed to higher blood pressure. In contrast, individuals with higher education were more likely to adopt effective health-promoting behaviors and take appropriate measures to maintain their health (Nugroho and Sari, 2019).

3. Body Mass Index and Hypertension Risk Factors

The results of this study Body mass index (BMI) shows a significant association with hypertension. Respondents with BMI ≥ 25 kg/m² had 2.52 times higher odds of hypertension compared to those with BMI < 18.5 kg/m². Individuals with a BMI >25 kg/m² and larger waist circumference had a 1.75-times higher risk of developing high blood pressure compared to those with normal BMI and normal waist circumference (OR = 1.75; 95% CI = 1.70 to 1.80). Maintaining an optimal body weight to achieve a normal BMI is therefore recommended as an effective strategy to reduce the incidence of hypertension (Zhang et al., 2022).

The results of this study are supported by Wu et al. (2025) who reported that overweight and obesity contribute to increased blood pressure. Similarly, a study conducted among 843 medical students at Southern Medical University found that students with prehypertension and hypertension had significantly higher BMI values ($p < 0.001$) (Song et al., 2023). These findings indicate that BMI is an important modifiable factor in the prevention and management of hypertension.

4. Gender and Hypertension Risk Factors

The results of this study showed that Female respondents had 1.23 times higher odds of hypertension compared to male

respondents. This finding is consistent with the study conducted by Marhabatsar and Sijid (2021), which reported that women tend to have higher blood pressure than men, largely due to menopause. During menopause, women experience a gradual decline in estrogen levels, marking the transition into older age and contributing to an increased risk of hypertension. After menopause, the risk of hypertension and cardiovascular disease increases substantially, in line with the reduction in estrogen levels (Ricardo et al., 2018).

In addition, lifestyle factors such as obesity differ between women and men. Women are more likely to develop obesity after menopause, which is a strong risk factor for both hypertension and cardiovascular disease (Wahabi et al., 2023; Rissanen et al., 2024). A study by Adila and Mustika et al. (2023) also found a significant association between gender and the incidence of hypertension. This may be explained by the decline in estrogen levels in postmenopausal women, as estrogen plays an important role in increasing high-density lipoprotein (HDL) levels.

5. Physical Activity and Hypertension Risk Factors

Physical activity shows a negative and statistically significant association. Respondents with high physical activity had 0.88 times the odds of hypertension compared to those with low physical activity, indicating a protective effect. These findings are consistent with the study of Islam et al. (2023), which reported that physical activity reduces cardiovascular risk. The recommended level of physical activity to lower blood pressure is at least 150 minutes per week.

The results are further supported by a meta-analysis conducted in Brazil, which found that physical activity effectively lowers both systolic and diastolic blood pressure. Therefore, physical activity can serve as a consistent protective intervention to reduce blood pressure (Bento et al., 2015). Individuals who engage in regular physical activity have systolic blood pressure that is 7.70 mmHg lower compared to those who are physically inactive (b = -7.70; 95% CI = -9.50 to -5.91; $p < 0.001$) (Monfared et al., 2024).

6. Place of Residence (Urban/Rural) and Hypertension Risk Factors

Place of residence shows a positive and statistically significant association. Respondents living in urban areas had 1.06 times higher odds of hypertension compared to those living in rural areas. Environmental stressors, such as air pollution, also contribute to hypertension risk in urban areas. Bosu et al. (2010) reported that higher levels of air pollution in urban regions are correlated with increased hypertension prevalence and other cardiovascular risk factors (Sani et al., 2022).

In urban areas, psychosocial stress resulting from higher life pressures can lead to lifestyle changes, such as increased alcohol consumption and intake of high-salt foods, which contribute to hypertension (Mohanraj et al., 2022). Differences also exist in access to healthcare services between rural and urban areas, which can influence hypertension management. Although urban residents have more healthcare facilities available, work-related stress and limited time for health monitoring often make it difficult for individuals to obtain the necessary care (Daştan, 2017).

7. Provincial Minimum Wage, Income Inequality, and Hypertension Risk

The results of this study showed that Respondents living in provinces with higher minimum wages had 0.92 times the odds of hypertension compared to those in lower-wage provinces. Income inequality (Gini

Ratio) shows a statistically significant association. Respondents living in areas with high income inequality had 1.19 times higher odds of hypertension compared to those in areas with low inequality. These findings are consistent with the study by Lucumi et al. (2017), which found that women living in areas within the highest income inequality quartile had higher systolic blood pressure than those living in areas with low income inequality, while no such effect was observed in men.

Cardiovascular diseases are more prevalent in populations residing in cities and districts with higher income and education levels (Adisasmito et al., 2020). This trend is partly due to the higher prevalence of obesity in urban areas, which is a major contributing factor to hypertension. These findings suggest that policymakers need to focus on the prevention and control of cardiovascular diseases, particularly in urban and highly educated regions.

Income inequality also influences dietary patterns. Populations with lower income often face challenges in accessing healthy foods due to higher prices and may be forced to choose foods high in salt and calories, whereas individuals with higher income can afford healthier dietary options (Drewnowski et al., 2015). This disparity highlights the importance of addressing socioeconomic factors in hypertension prevention and public health interventions.

8. Contextual Influence of District/ City Residence on Hypertension

The results of this study showed an intraclass correlation (ICC) of 0.36%, indicating that only 0.16% of the variation in hypertension risk was explained by district- or city-level factors, while 99.84% of the variation originated from individual-level differences among respondents. These findings are consistent with the study by Mashuri et al. (2022), which used data from the 2014–2015 Indonesian Family Life Survey (IFLS 5) and found that contextual variables at the district and city levels had an effect on hypertension, although the influence was not dominant, with an ICC of 1.8%. Therefore, despite the presence of contextual effects, interventions targeting individuals and families may be more effective.

Similar findings were reported by Liu et al. (2013), who found that up to 53% of the variation in hypertension prevalence could be explained by differences in physical and social environmental conditions at the neighborhood level in Philadelphia, USA. This indicates that in complex and heterogeneous urban contexts, environmental factors play a significant role in determining health status. Likewise, a study in Brazil by Wagner et al. (2016) reported ICC values for systolic blood pressure ranging from 2.7% to 3.06%, suggesting a moderate contribution of socio-economic neighborhood-level factors (census tract) to hypertension variation among the elderly. Differences in ICC across cities may be attributed to the relatively equitable distribution of healthcare facilities, which have been effectively utilized by the population, resulting in minimal variation at the district or city level.

AUTHOR CONTRIBUTION

All authors have contributed significantly in analyzing existing data, as well as actively participating in preparing the final manuscript of the research results.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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