Spatial analysis of metabolic syndrome among healthcare workers in a suburban area

Apriningsih Apriningsih[1*], *Firlia* Ayu Arini[2], and *Eflita* Meiyetriani[3,4]

[1]Department of Public Health, Faculty of Health Sciences, Universitas Pembangunan Nasional Veteran Jakarta, 16415 Depok, Indonesia
[2]Department of Nutrition, Faculty of Health Sciences, Universitas Pembangunan Nasional Veteran Jakarta, 16415 Depok, Indonesia
[3]Faculty of Public Health, Universitas Indonesia, 16415 Depok, Indonesia
[4]SEAMEO-RECFON, 13120 East Jakarta, Indonesia

Abstract. This study aims to investigate the prevalence and spatial distribution of metabolic syndrome (MetS), obesity, hypertension, and high cholesterol levels among health workers in Depok City. 614 respondents were surveyed, with most female (75.1%) and aged 25-34 (44.3%). The study found high rates of high blood pressure (33.2%), high cholesterol levels (30.3%), and metabolic syndrome (40.7%), with 47.6% classified as obese. Spatial analysis revealed significant correlations between metabolic syndrome and obesity ($p<0.05$). Obesity plays a substantial effect in metabolic syndrome prevalence. More study is needed to investigate obesity-targeted interventions to reduce metabolic syndrome prevalence.

1 Introduction

Metabolic syndrome (MetS) is a complex condition marked by a cluster of interconnected factors including obesity, high cholesterol levels, and high blood pressure. In addition, MetS refers to a set of metabolic abnormalities including abdominal obesity, hypertension, elevated triglyceride levels, low HDL cholesterol, and high fasting blood glucose. Collectively, these elements increase the risk of cardiovascular disease and type 2 diabetes [1–2]. The prevalence of MetS among various occupational groups has garnered significant interest in recent years.

The World Health Organization (WHO) has identified MetS as a significant public health concern, primarily due to its increasing prevalence worldwide, which mirrors trends in lifestyle-related factors such as unhealthy dietary choices, physical inactivity, and stress [3]. Healthcare workers—who often endure long and erratic hours (along with considerable job demands)—are especially vulnerable to these risk factors. This scenario may heighten their chances of developing MetS [4]. However, although they recognize these risks, many still find it challenging to adopt a healthy lifestyle.

Numerous studies have documented the prevalence of MetS across various occupational groups. Nevertheless, healthcare workers demonstrate particularly high rates [4]. Research conducted on healthcare professionals in Taiwan indicated a MetS prevalence of

* Corresponding author: apriningsih@upnvj.ac.id

approximately 14% [5]. In Indonesia, where the health worker population is continually expanding, similar concerns have emerged regarding the heightened prevalence of MetS among medical professionals. One study, for instance, revealed a significant presence of hypertension, obesity, and dyslipidemia among healthcare workers [6]. Such findings underscore the necessity for targeted health interventions in healthcare settings as they could mitigate MetS risk factors within this essential workforce. This highlights the importance of addressing these health issues.

Obesity is recognized as a major factor contributing to Metabolic Syndrome (MetS), particularly because it correlates with poor dietary habits, inadequate physical activity, and the increased psychological stress endured by many healthcare workers. Previous studies have shown that obesity can worsen the various elements of MetS—such as insulin resistance and heightened blood pressure—by promoting chronic inflammation and dyslipidemia. These issues are especially pronounced in urban areas (such as Depok City), where environmental stressors, elevated pollution levels, and sedentary lifestyles exacerbate the overall health crisis. However, comprehending the connection between obesity and MetS among health workers, particularly in urban areas, is vital for crafting effective interventions. This insight can initiate the development of targeted strategies designed to alleviate these health challenges.

Research has shown that the prevalence of MetS is higher among certain occupational groups, including health workers, with one study reporting a prevalence of 13% among this population [7]. Furthermore, research on workers identified obesity as a dominant factor contributing to metabolic syndrome, emphasizing the relevance of lifestyle and environmental factors in the development of this condition [8].

Studies have indicated that MetS is associated with an increased risk of cardiovascular disease, with dyslipidemia being a key component of this syndrome [9]. Spatial investigation of MetS among primary health providers can shed light on the syndrome's regional spread and associated risk factors. Such analysis can uncover trends likely driven by environmental, socioeconomic, and occupational factors. For instance, research has revealed that the prevalence of MetS varies greatly depending on geographic area, age, and gender [10]. Therefore, this study aims to investigate the prevalence and spatial distribution of metabolic syndrome, obesity, hypertension, and high cholesterol levels among health workers in Depok City.

2 Materials and methods

This study employs a cross-sectional design to assess the prevalence and spatial distribution of MetS, obesity, hypertension, and high cholesterol levels among healthcare workers in Depok City, Indonesia. A total of 614 health workers, selected using a purposive sampling method, participated in this study. Data on demographic characteristics were collected using a structured interview questionnaire. Additionally, data on blood pressure, cholesterol levels, metabolic syndrome, and obesity status were collected through doctor's medical examinations conducted between March and April 2023. Ethical approval for this study was obtained from KEP UPNVJ.

Descriptive statistics, including frequencies and percentages, were used to summarize the participants' demographic characteristics and health parameters. Spatial analysis was conducted to evaluate the spatial autocorrelation between metabolic syndrome, obesity, hypertension, and high cholesterol levels using Moran's I index. Bivariate analysis was performed to explore the relationships between these health conditions. Spatial analysis was conducted using Quantum GIS 3.28.14 and Geoda 1.20.036.

3 Results and discussion

In this study, most respondents were female aged 25-34 years. There were 30.3% of respondents had high cholesterol levels, 40.7% of respondents indicated MetS, and 47.6% of respondents classified as obese [Table I]. These findings align with the research conducted among Depok City government health employees in 2023, which reported that 62.9% of the employees were obese [8]. Similar results were observed in studies from 2009 [12] and 2016 [13], which reported that many civil employees of Depok City were obese and hyperglycemic. Metabolic syndrome is characterized by 5 components: central obesity, hypertension, hyperglycemia, hypertriglyceridemia, and low HDL levels. Obesity and hypertension were the most prevalent components of metabolic syndrome among healthcare workers in this study. A study conducted among healthcare workers in North Jakarta in 2021 [8] also showed the prevalence of Mets was 38,7%, similar to our finding that the prevalence of Mets was 40.7%. Depok is located near Jakarta, the capital city of Indonesia. The geospatial analysis study in Indonesia in 2022 showed that living in more built-up areas was associated with greater BMI and risk of becoming overweight or obese. As Depok was categorized as an urban area, it showed a similar result that the prevalence of obesity was above 40% [14]. Another study from China indicated that the risk of obesity increased in built-up areas, commonly found in urban and suburban municipalities. This might be attributed to the unhealthy environment lacking adequate exercise facilities, sub-optimal public transport reducing physical activity, and unrestricted access to unhealthy diet [20]. A study conducted in the United States in 2010 [16] identified workers characteristics associated with greater risk of suffering from metabolic syndrome, including older age (1.03 [1.03-1.04]) and being overweight (5.63 [3.80-8.35]) or obese (25.94 [18.08-37.23]) compared to those with underweight or normal weight.

Table 1. Respondent characteristics

Characteristics	Frequency	Percentage
Gender		
Male	153	24.9
Female	461	75.1
Age		
15-24	53	8.6
25-34	272	44.3
35-44	165	26.9
45-54	102	16.6
55-64	21	3.4
>65	1	0.2
Hypertension		
Normal	410	66.8
Hypertension	20	33.2
Cholesterol		
Normal	428	69.7
High	186	30.3
Have metabolic syndrome		
No	364	59.3
Yes	250	40.7
Obesity		
No	322	52.4
Yes	292	47.6
Total	614	100

As obesity becomes increasingly prevalent, employer-sponsored wellness initiatives have also grown more common. Over the past 20 years, employers and researchers have focused on individual-based programs to alter employees' exercise and nutrition habits. However, more recently, attention has shifted toward the workplace environment. Although there is conflicting data regarding the benefits of individual-based worksite programs on other risk factors, long-term health outcomes, and expenditures, there is generally strong evidence that these programs can result in modest weight loss. There is little evidence that environmental-based interventions are beneficial, and more information is required to draw firm judgments about their advantages. The work site is perfect for putting interventions in place to lower risk factors for obesity and cardiometabolic diseases [16].

According to Figure 1, there are 11 sub-district in Depok City, with four sub-districts classified as areas with high prevalence of MetS, including Sawangan, Cinere, Beji, and Sukmajaya (43.7% - 53.7%). Sawangan, Pancoran Mas, Sukmajaya, and Cilodong sub-districts were classified as areas with high prevalence of obesity (68.1% - 88.9%). There were four sub-districts with a high prevalence of hypertension: Cinere, Limo, Beji, and Cimanggis sub-districts (37.1% - 43.5%). There are four sub-districts with prevalence of high cholesterol (33.5 - 44.2%), including Pancoran Mas, Beji, Sukmajaya, and Tapos.

In Figure 1. There were three colours that describe three categories: red colour represents the area with high prevalence, pink color represents the area with medium prevalence, and the white-coloured area represents the area with low prevalence.

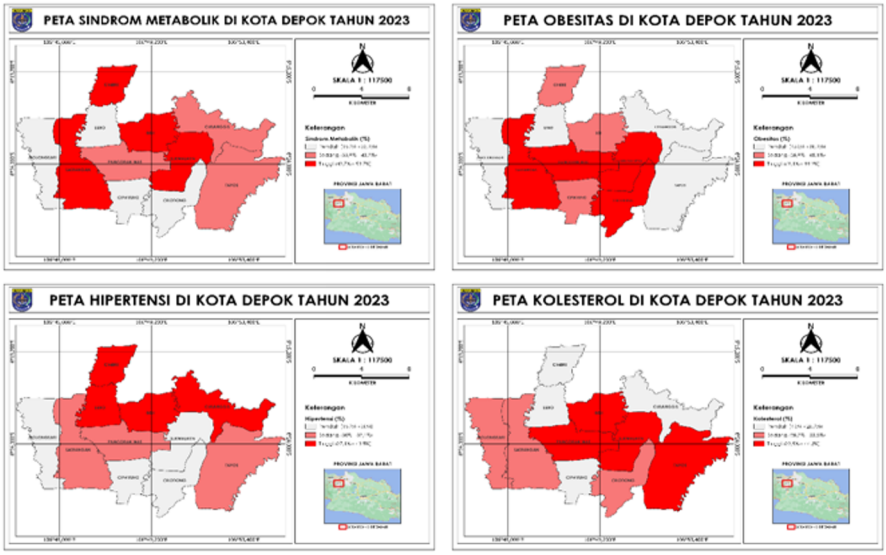

Fig. 1. Mapping of metabolic syndrome, obesity, hypertension, and cholesterol cases among health worker in Depok City in 2023

Table 2. shows the presence of spatial autocorrelation between MetS and obesity in Depok City ($p<0.05$). This indicates that the incidence of obesity influences the incidence of MetS. Spatial autocorrelation between MetS and obesity has a negative direction and shows a spatial pattern in the form of a scatter ($I < E[I]$). The bivariate analysis of MetS and obesity revealed an outlier. Bojongsari ($p=0.001$) and Limo ($p= 0.05$) sub-districts fall into the low-high quadrant, indicating that areas with a high prevalence of MetS surround areas with low prevalence of obesity. Conversely, Sawangan sub-district ($p=0.01$) falls into the high-low quadrant, indicating that areas with low prevalence of MetS surround areas with high prevalence of obesity.

Table 2. Spatial analysis correlation

Variable	I	E(I)	p-value	Z-score
Metabolic Syndrome with Obesity	-0.526	-0.1	0.002	-2.4673
Metabolic Syndrome with Hypertension	-0.226	-0.1	0.139	-1,0314
Metabolic Syndrome with Cholesterol	-0.284	-0.1	0.12	-1.1183

Based on the results of bivariate analysis in Table 2, metabolic syndrome does not have spatial autocorrelation with the incidence of hypertension ($p<0.05$), indicating that the incidence of metabolic syndrome is not influenced by the incidence of hypertension in Depok City. An expected Moran's I value lower than the Moran's I index value (I < E[I]) indicates a diffuse spatial pattern and negative autocorrelation direction. The quadrants obtained between metabolic syndrome and hypertension are hotspots and outliers. The limo sub-district ($p=0.05$) is identified as a hotspot area (high-high quadrant), signifying that the areas with high hypertension prevalence are also surrounded by areas with high metabolic syndrome prevalence. Sawangan sub-district ($p=0.01$) is in the high-low quadrant, indicating that areas with a low prevalence of metabolic syndrome surround areas with high prevalence of hypertension. The Bojongsari Sub-district ($p = 0.001$) falls into the low-high quadrant, indicating that the area with low prevalence of hypertension is surrounded by areas with low prevalence of metabolic syndrome.

The bivariate analysis indicates that the cholesterol incidence does not influence the MetS incidence. The expected Moran's I value lower than the Moran's I index value ($I<E[I]$) indicates a diffuse spatial pattern and negative autocorrelation direction [17][18]. Sawangan Sub-district ($p=0.01$) falls into the high-low quadrant region, indicating that an area with high cholesterol prevalence surrounded by areas with a low prevalence of MetS. The incidence of MetS was not only determined by the case of high cholesterol but also by other components including hypertension, central obesity, and hyperglycemia. However, the high dietary cholesterol intake positively correlated to the MetS incidence. As animal sources contribute the majority of dietary cholesterol, the increase in calorie intake could be attributed to a corresponding increase in fat intake. The elevation of SBP, blood glucose, WC, and serum HDL-C, key components associated with MetS, was significantly influenced by dietary cholesterol [19].

Based on the univariate results, Sawangan is identified as a district with a high prevalence of MetS (43.7%-53.7%), which aligns with the findings that Sawangan also has a high obesity prevalence (68.1%-88.9%). However, the bivariate results showing spatial autocorrelation between MetS and obesity suggest a more complex pattern. The high-low pattern in Sawangan suggests that Sawangan has areas with high obesity prevalence surrounded by areas with low MetS prevalence. This could occur because obesity does not always directly correlate with MetS prevalence. While obesity is a major factor in the development of MetS, other factors such as hypertension and cholesterol levels also contribute, which may explain why Sawangan has a high obesity prevalence but a relatively lower MetS prevalence in surrounding areas. This indicates that in Sawangan, obesity may be more concentrated among individuals who do not have MetS, or other factors (such as genetics or environmental influences) that limit the prevalence of MetS despite high obesity rates in the area.

The spatial analysis results indicate that several sub-districts in Depok have high prevalence rates of both MetS and obesity. Sub-districts like Sawangan and Sukmajaya, classified as high-prevalence areas for MetS and obesity, are key areas for targeted public health interventions. However, the spatial autocorrelation results reveal that Sawangan is in the high-low quadrant for the relationship between MetS and obesity, suggesting that areas with high obesity prevalence are surrounded by areas with low MetS prevalence.This indicates a complex relationship between these two factors. For example, Bojongsari falls into the low-high quadrant, indicating that areas with high MetS prevalence are surrounded by areas with low obesity prevalence. This suggests that other factors (such as hypertension

or hyperglycemia) contribute to the high prevalence of MetS, even though obesity is not as prevalent in these areas. The following table illustrates the negative spatial autocorrelation between MetS and obesity with a $p<0.05$, indicating that obesity prevalence influences MetS prevalence, but this relationship is not always direct. Bojongsari ($p=0.001$) and Limo ($p=0.05$) belong to the low-high quadrant, suggesting that areas with high MetS prevalence surround areas with low obesity prevalence. Sawangan ($p=0.01$) falls into the high-low quadrant, suggesting that areas with high obesity prevalence surround areas with low MetS prevalence, indicating that even though obesity is high, MetS prevalence is lower in this district. This result indicates a complex interaction between obesity and MetS, influenced not only by obesity prevalence but also by other factors such as hypertension and hyperglycemia, which affect MetS prevalence.

The results of this study reveal the significant prevalence of metabolic syndrome (MetS) and its components, such as obesity, hypertension, and high cholesterol, among healthcare workers in Depok City. These findings align with other studies conducted in urban areas, highlighting the increasing burden of non-communicable diseases (NCDs) in Indonesia and other developing nations. The prevalence of MetS in this study (40.7%) is consistent with findings from a study in North Jakarta (38.7%) and reflects the urban lifestyle's impact on metabolic health. Urbanization in Depok and similar areas often results in reduced physical activity and increased access to calorie-dense, nutrient-poor foods, contributing to obesity and MetS prevalence. This trend is also observed internationally; for instance, in China, urban areas have shown higher risks of obesity due to limited exercise facilities, suboptimal public transport, and increased consumption of unhealthy diets [21–22].

In the United States, workplace studies have demonstrated that older age and obesity are significant predictors of MetS, with obesity increasing the risk nearly 26 times compared to normal weight [23]. This underscores the urgent need for targeted interventions in workplace settings to address these risks.

The spatial analysis findings highlight specific sub-districts in Depok City with high prevalence rates of MetS, obesity, and hypertension. Sub-districts like Sawangan and Sukmajaya, categorized as high-prevalence areas for MetS and obesity, could serve as priority areas for targeted public health interventions. Interestingly, spatial autocorrelation patterns such as low-high or high-low quadrants indicate complex interactions between these conditions. For example, Bojongsari exhibits low-high autocorrelation, suggesting that areas with low obesity prevalence may still experience high MetS prevalence due to other factors such as hypertension or hyperglycemia. These spatial relationships emphasize the multifactorial nature of MetS, where components such as central obesity, blood pressure, and glucose levels interact within and across geographic areas. This aligns with studies that show a single component such as high cholesterol does not merely determine MetS but is influenced by dietary patterns and lifestyle [24].

Dietary factors, particularly high cholesterol intake, remain a crucial determinant of MetS. Excessive dietary cholesterol has been linked to elevations in systolic blood pressure, fasting blood glucose, waist circumference, and low HDL-C, all of which are MetS components [24]. Addressing these dietary issues requires a combination of individual-based and environmental interventions. Workplace wellness programs play a significant role in mitigating MetS prevalence. Studies show that employer-sponsored interventions focusing on diet and physical activity can achieve modest weight loss and improve metabolic health. However, there is limited evidence on the long-term effectiveness of environmental-based approaches at workplaces, and further research is required to optimize these strategies [25].

The findings of this study suggest the need for multifaceted public health policies in Depok City. Initiatives should include enhancing urban infrastructure to promote physical activity, such as creating pedestrian-friendly spaces and exercise facilities. Implementing workplace wellness programs tailored to high-risk populations and promote dietary

interventions through community-based education programs aimed at reducing cholesterol and calorie intake.

Further research is required to understand the interplay between urban environmental factors and the spatial distribution of MetS as well as its components. Policymakers must also consider the role of urbanization and socioeconomic disparities in shaping health outcomes to design inclusive and effective health interventions.

4 Conclusion

A high prevalence of metabolic syndrome (MetS) was observed among healthcare workers. Spatial analysis revealed a significant influence of obesity on the prevalence of MetS. These results emphasize the importance of public health interventions focusing on obesity prevention and management strategies to address the high burden of MetS.

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