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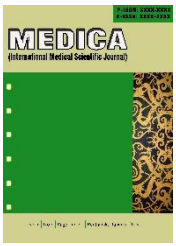

Geographical Analysis of Hypertension Distribution in Bengkulu City using a Geographic Information System Approach

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Abstract

Hypertension is one of the most prevalent non-communicable disease and remains a major public health challenge worldwide. Understanding its spatial distribution is important for describing geographical variations in disease burden and supporting evidence based public health planning. This study aimed to describe the spatial and temporal distribution of reported hypertension cases in Bengkulu City, Indonesia during the period 2020-2024. A quantitative approach with a descriptive ecological desgin was employed using secondary data on hypertension cases among individuals aged ≥15 years obtained from 20 public health centers. Spatial analysis was conducted using Geographic Information System (GIS) and hypertension case distribution was classified into low, moderate, and high categories using the Equal Interval method. The findings revealed substantial spatial and temporal variation in reported hypertension cases throughout the study period. Most areas of Bengkulu City were consistently classified in the high category, with complete spatial coverage observed in 2021, 2022, and 2024, whereas limited moderate category areas emerged in 2023. Districts including Selebar, Gading Cempaka, Ratu Agung, Singgaran Pati, Muara Bangka Hulu, and Kampung Melayu repeatedly exhibited higher reported case burdens than other areas. However, considerable fluctuations in the annual number of reported cases were observed and should be interpreted cautiously, as variations in surveillance systems, reporting pratices, and health service utilization may have influenced the reported patterns. Overall, hypertension remained widely distributed across Bengkulu City during the study period. GIS based mapping provides useful baseline information for public health surveillance and may support the development of geographically targeted prevention and control strategies.

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1. INTRODUCTION

Non-communicable diseases (NCDs) remain the leading cause of death globally and represent a major public health challenge (Colozza et al, 2023). Among the various NCDs, hypertension is one of the most prevalent conditions and contributes substantially to cardiovascular morbidity and mortality worldwide (Naghavi et al., 2024). Globally, hypertension affects approximately 1.28 billion adults aged 30-79 years. However, nearly half of individuals with hypertension remain unaware of their condition, indicating persistent challenges in early detection and disease control (World Health Organization, 2024).

In Indonesia, hypertension continues to be a significant public health problem. According to the Basic Health Research (Health Research and Development Agency, 2019), the prevalence of hypertension among individuals aged ≥15 years increased from 25,8% in 2013 to 34,1% in 2018. In Bengkulu Province, the estimated number of individuals with hypertension aged ≥15 years reached 438,116 with Bengkulu City recording the highest number of cases in the province (Ministry of Health of the Republic of Indonesia, 2024). These findings indicate that hypertension remains a considerable health burden and requires continuous monitoring to support effective prevention and control efforts.

Geographical factors may contribute to variations in the distribution of hypertension across regions. Spatial analysis in Indonesia demonstrated that hypertension cases were not distributed evenly across provinces and districts, indicating the presence of geographical variation in disease burden (Oktamianti et al, 2023). Simillary, Sukarno et al. (2014) reported that residents living in lowland areas tended to have higher blood pressure than those residing in highland areas. This difference was associated with lifestyle related factors, including smoking habits and excessive salt consumption, both of which are recognized risk factors for hypertension. As a coastal lowland area, Bengkulu City has distinct geographical characteristics, making it relevant for spatial analysis of hypertension case distribution.

Understanding the spatial distribution of hypertension is important for describing the geographical variation of cases across regions. Geographic Information Systems (GIS) provide an effective approach for integrating and visualizing epidemiological and spatial data, enabling a clearer representation of disease distribution patterns within a population (Wang, 2020).

Despite Bengkulu City having the highest number of hypertension cases in Bengkulu Province, information regarding the spatial distribution and temporal trends of hypertension at the local level remains limited. Detailed information describing the geographical distribution of hypertension cases across Bengkulu City is still needed to support local health planning. Therefore, this study aims to describe the spatial distribution of hypertension cases in Bengkulu City from 2020 to 2024 using Geographic Infromation Systems (GIS). The findings are expected to provide an overview of the geographical distribution of hypertension cases and severe as baseline information for future public health planning and research.

2. METHOD

This research uses a quantitative approach with a descriptive-ecological design. The combination of these three designs aims to provide a comprehensive and data-based overview of the distribution and trends of a phenomenon at the population and regional levels, without being limited by individual causal analysis. Then, from this research, patterns of hypertension case distribution and incidence trends in Bengkulu City during the period 2020-2024 can be formed.

The research used total sampling, meaning that all available hypertension case data from 20 community health center work areas during the research period were analyzed. To reduce bias due to differences in population size between regions, the analysis was conducted using proportions or incidence rates based on the population aged ≥15 years in each health center working area. Thus, comparisons between regions are made based on the incidence rate of hypertension, not just the absolute number of cases. Before the analysis was conducted, the data underwent a process of completeness, consistency, and validation against the official reports of the Bengkulu City Health Office. Incomplete or inconsistent data is re-verified with the available data sources to ensure the quality and accuracy of the information used in the research by (Ghalavand et al, 2024).

Spatial analysis was conducted using the Quantum Geographic Information System (QGIS) software. Spatial data in the form of administrative boundaries of the community health center work areas in shapefile format was obtained from official sources of the Bengkulu city health department and integrated with hypertension case data thru an attribute join process. Next, thematic mapping was conducted to illustrate the distribution of hypertension cases in each community health center's working area. Quantum GIS is a software commonly used in thematic mapping and spatial analysis in the field of public health as a medium to assist in mapping, particularly in the process of inputting, processing, analyzing, and presenting spatial data in the form of maps (Fahri, 2020).

Map classification is performed using the equal interval method, which divides the classification of hypertension patient levels. The equal interval method is chosen so that the variation in data values can be reached and visualized (Sejati & Setiawan, 2023). The class interval width is calculated by dividing the difference between the maximum and minimum values by the number of classes determined (3 classes), resulting in a class interval width of 3152. Subsequently, the regions are categorized into low class with a range of 0-3125, medium 3152-6304, and high >6304 based on the established intervals.

Spatial analysis was conducted descriptively by comparing the distribution patterns of hypertension cases between regions and observation periods. The visualization results were used to identify areas with a relatively high case burden and changes in the distribution pattern of hypertension over the five-year observation period. This research has obtained a letter of introduction from the Faculty of Medicine and Health Sciences, University of Bengkulu, to conduct data collection at the Bengkulu City Health Office. The data used are secondary data in the form of aggregate reports of hypertension cases and do not contain individual identities. The use of the data is solely for the purposes of research and scientific reporting. The entire process of data management, analysis, and presentation is carried out in accordance with the principles of health research ethics, including maintaining information confidentiality, data security, and preventing data misuse by separating patient identity information from the research data (Abu Attieh et al., 2025).

3. RESULTS AND DISCUSSION

Spatial distribution analysis of hypertension cases in Bengkulu City using Geographic Information System (GIS) with QGIS software has been conducted on data from 20 community health centers spread throughout Bengkulu City during the period 2020-2024. Data visualization used thematic classification methods with three categories of hypertension incidence levels: low (displayed in green), moderate (displayed in yellow), and high (displayed in red). The analysis results show a dynamic spatial distribution pattern with significant temporal variation over the five-year observation period. In 2020, based on data obtained from the Bengkulu City Health Office, the number of hypertension patients aged ≥15 years was 82,320 cases.

The hypertension distribution pattern in Bengkulu City in 2020 showed the highest heterogeneity compared to the following years. Areas with low hypertension incidence were identified in the Sungai Serut District, which is the working area of the Sukamerindu Health Center located in the northeastern part of the city, with 4,841 recorded cases. This category was found in several locations, including Teluk. Kecamatan Segara in the northwest, which falls under the service area of the Kampung Bali and Pasar Ikan health centers with 2,448 and 3,837 cases respectively, and parts of Kecamatan Ratu Samban, which are the responsibility of the Anggut Atas and Turun health centers with 2,619 and 3,480 cases respectively. The highest number of cases is in Kecamatan Selebar, which includes the service area of the Telaga Dewa health center with 8,899 reported cases and the Betungan health center with 2,665 reported cases. Meanwhile, most areas of Bengkulu City show high levels of hypertension, including Gading Cempaka District, Muara Bangka Hulu District, Kampung Melayu District in the southern part, Ratu Agung District, and most of Singaran Pati District. Based on visual map analysis, it is estimated that around 65-70% of the total area of Bengkulu City fell into the high hypertension category in 2020, with the highest concentration in the central to southern parts of the city (Bengkulu City Health Office, 2021).

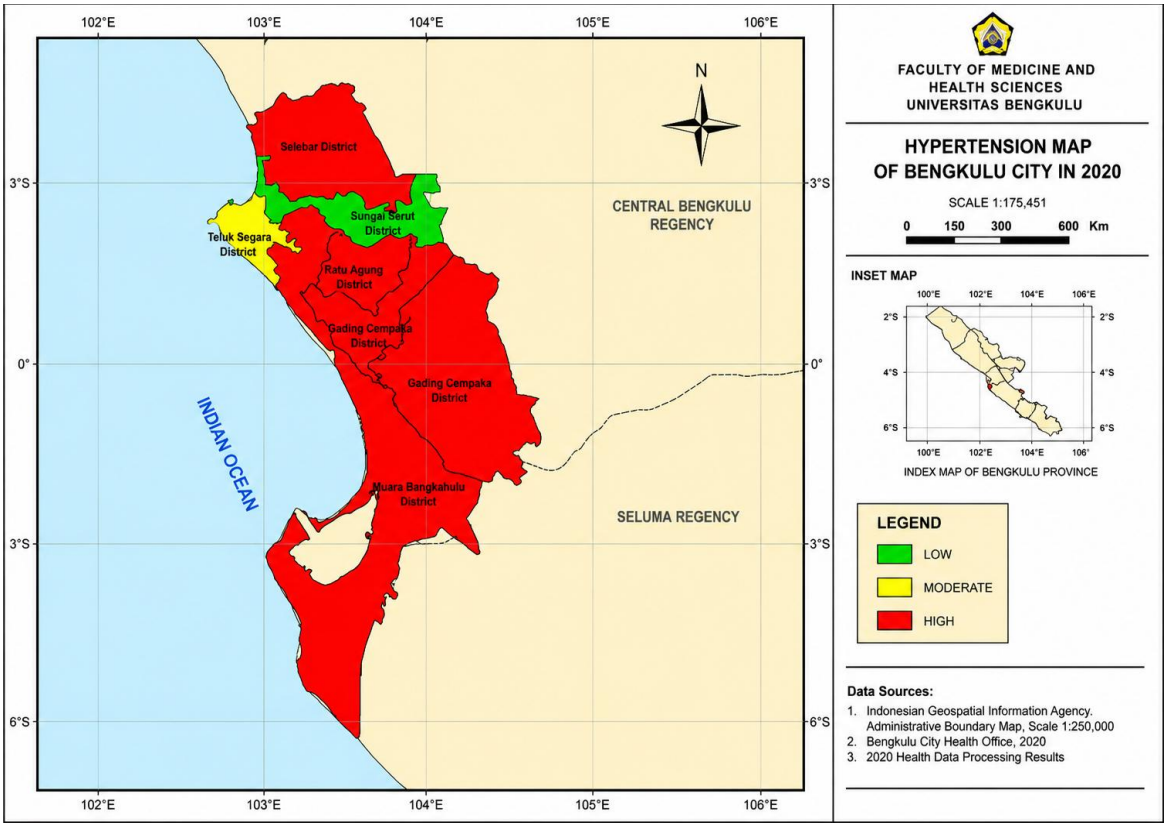

Figure 1. Data on the Distribution of Hypertension Cases in Bengkulu City 2020.

The year 2021 showed a very drastic change in the distribution pattern compared to the previous year. The entire area of Bengkulu City, without exception, showed a high incidence rate of hypertension, reaching 100% coverage with a total of 286,339 cases of hypertension patients aged ≥15 years reported by the Bengkulu City Health Office. No areas were found to fall into the low or medium category. This distribution pattern, which

shows a high level of uniformity, is consistent across all sub-districts in Bengkulu City. The highest number of cases is found in the Selebar district, which falls under the service area of the Telaga Dewa health center, with a total of 30,300 recorded cases, and the Betungan health center, with 10,002 cases. These findings indicate a significant increase in the incidence of hypertension, which is evenly distributed across the city's administrative regions. This substantial change may reflect temporal variation in reported cases and should be interpreted cautiously (Bengkulu City Health Office, 2022).

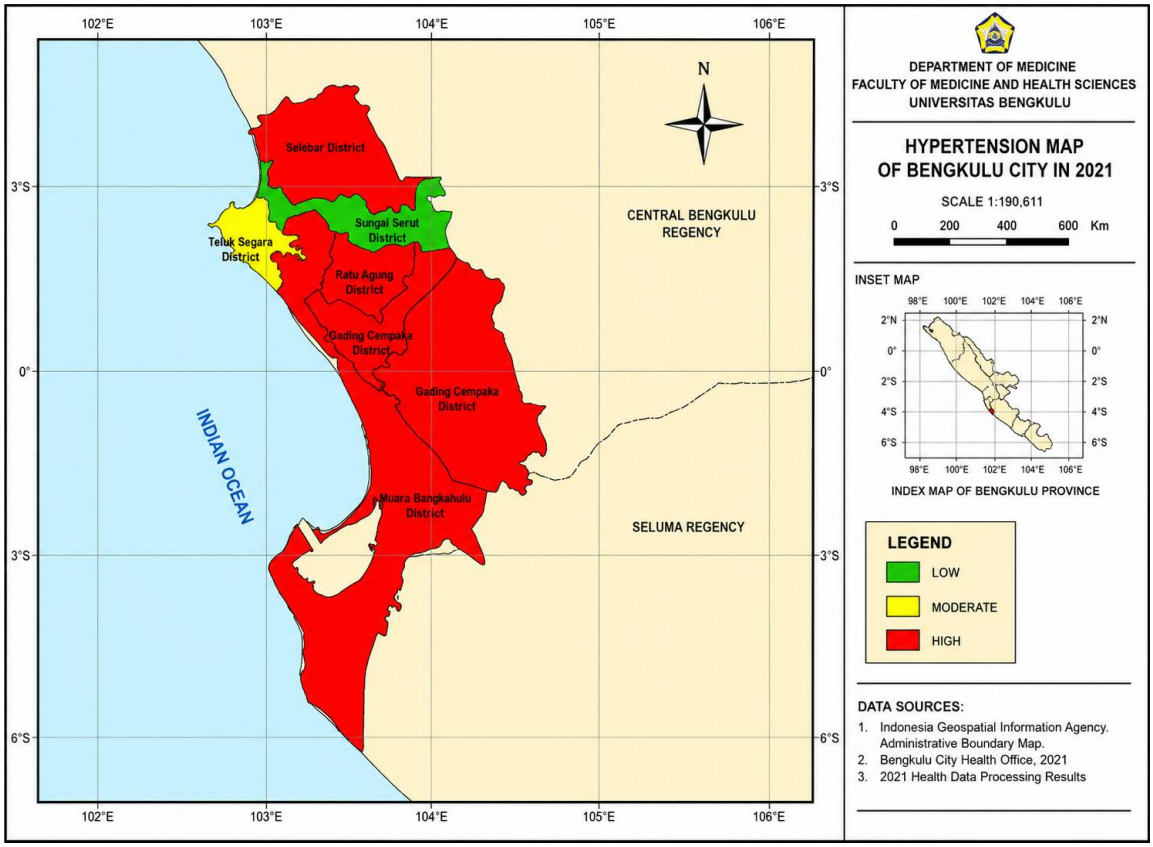

Figure 2. Data on the Distribution of Hypertension Cases in Bengkulu City 2021.

The distribution pattern in 2022 maintained the same characteristics as in 2021. All areas of Bengkulu City remain in the high hypertension category with 100% coverage, with a total of 36,404 cases of hypertension sufferers aged ≥15 years reported by the Bengkulu City Health Office. The even distribution across all sub-districts indicates the persistence of the hypertension problem, which has not shown significant improvement. No region showed a decrease in category to moderate or low during 2022, and Selebar District, which still recorded the highest number of cases, particularly in the service areas of Puskesmas Telaga Dewa, with a total of 3,852 cases, and Puskesmas Betungan with 1,271 cases. This indicates that the high prevalence of hypertension in Bengkulu City is not a temporary phenomenon, but an ongoing issue that requires comprehensive and sustainable intervention (Bengkulu City Health Office, 2023).

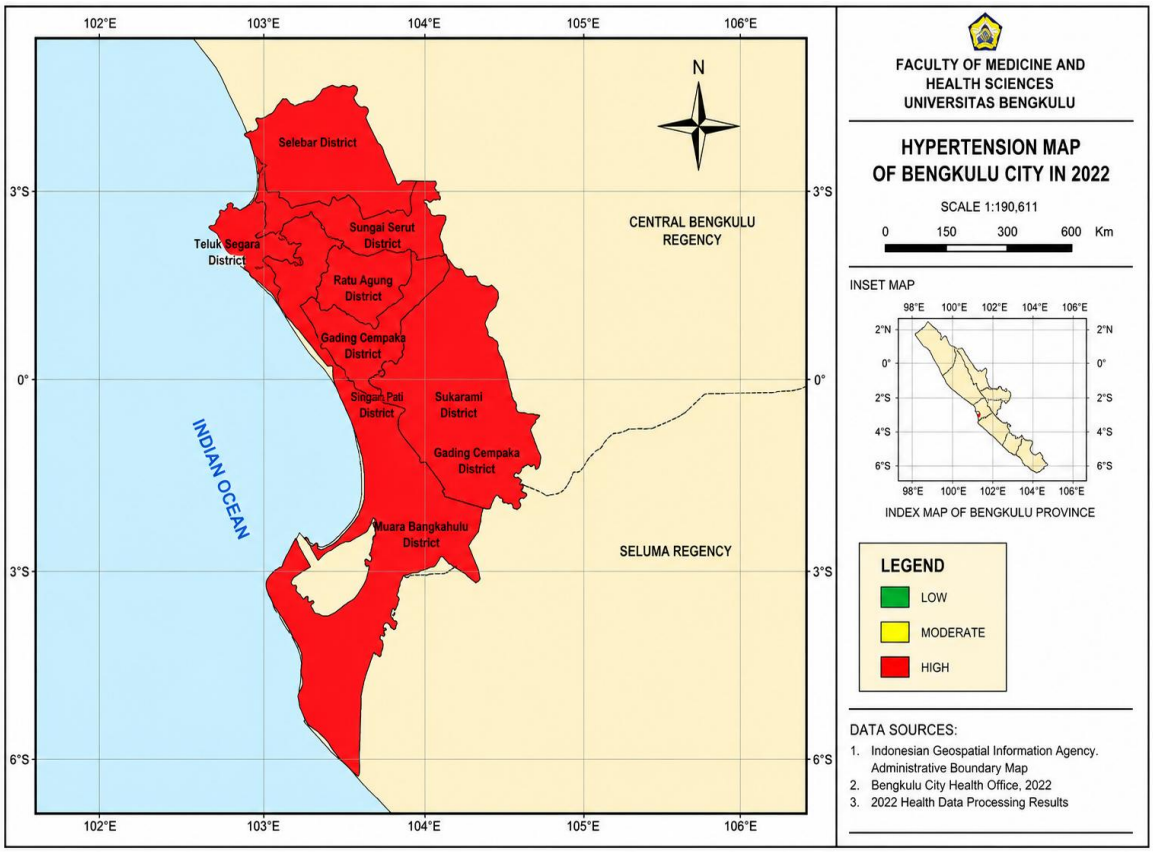

Figure 3. Data on the Distribution of Hypertension Cases in Bengkulu City 2022.

In 2023, the total reported cases of hypertension in individuals aged ≥15 years obtained from the Bengkulu City Health Office was 50,898. In 2023, there was a slight positive change in the pattern of hypertension distribution. Although most areas are still in the high category, areas in the moderate category are starting to re-emerge in the Sungai Serut District, located in the northeastern part of the city, within the working area of Puskesmas Sukamerindu, with a recorded number of 2,903 cases, as well as a small portion of the border area. High-category areas still dominate, with an estimated coverage of around 90-95% of the total area of Bengkulu City. The highest number of cases is still in the Selebar District, within the working area of the Telaga Dewa Health Center with a total of 4,248 cases, and the Betungan Health Center with 2,569 cases. The re-emergence of the moderate category in several areas can be interpreted as an early indication of the effectiveness of the hypertension control program that has been implemented, a possible increase in access to primary healthcare services, or an increase in public awareness in certain areas regarding the importance of managing hypertension (Bengkulu City Health Office, 2024).

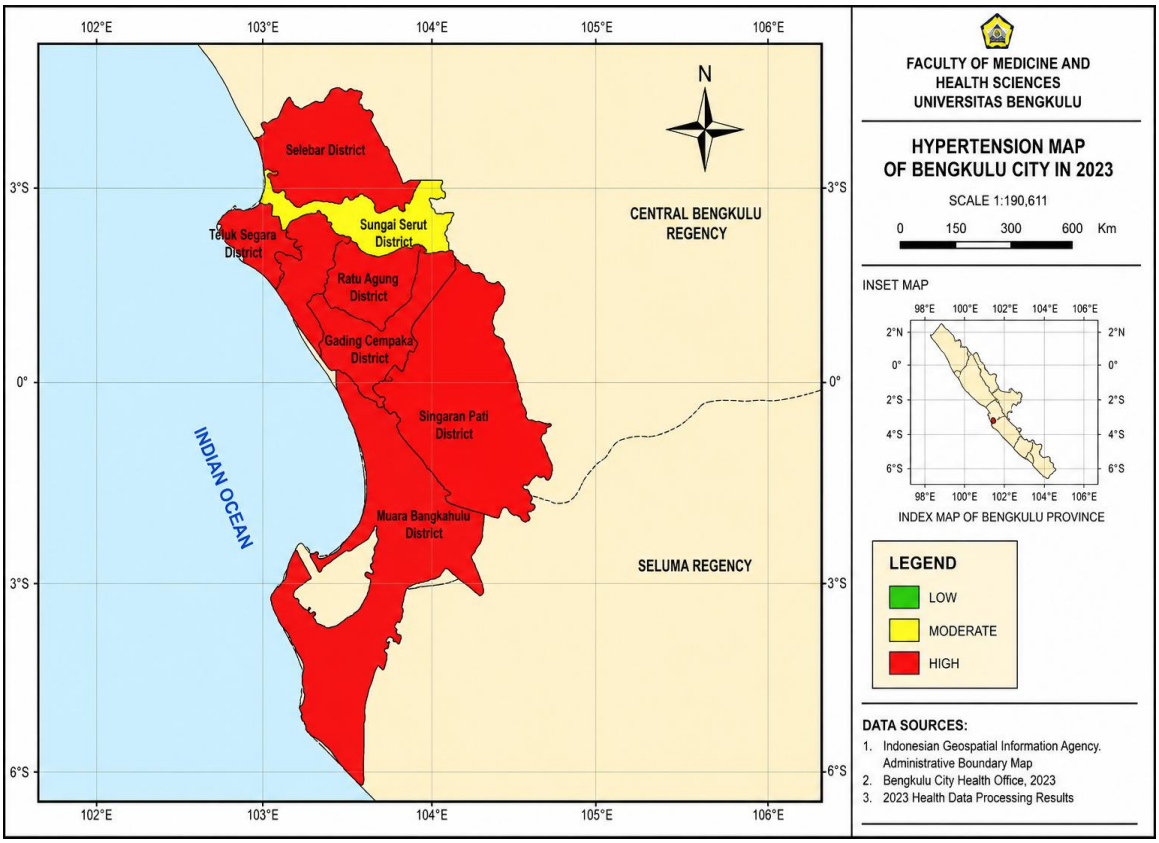

Figure 4. Data on the Distribution of Hypertension Cases in Bengkulu City 2023.

In 2024, the distribution pattern once again showed similar homogeneous characteristics to those seen in 2021 and 2022; however, compared to previous years, the number of hypertension cases in 2024 showed a significant decrease. The recapitalization results from the health department show that the total number of hypertension cases in individuals aged ≥15 years is 9,515 cases. All areas of Bengkulu City are once again categorized as having a high level of hypertension, with a coverage of 100%. No areas with low or moderate categories were found. This uniform distribution is consistent across all existing sub-districts. Then, Selebar District, which previously had the highest number of cases, experienced a decline in 2024. Next, the area with the highest number of hypertension cases shifted to Sungai Serut District, which falls under the jurisdiction of Sukamerindu Health Center, with a total of 744 cases. The return of high territorial coverage after improvements in 2023 indicates that the hypertension control efforts undertaken have not yet achieved a sustainable impact and require evaluation and adjustment of intervention strategies (Bengkulu City Health Office, 2025).

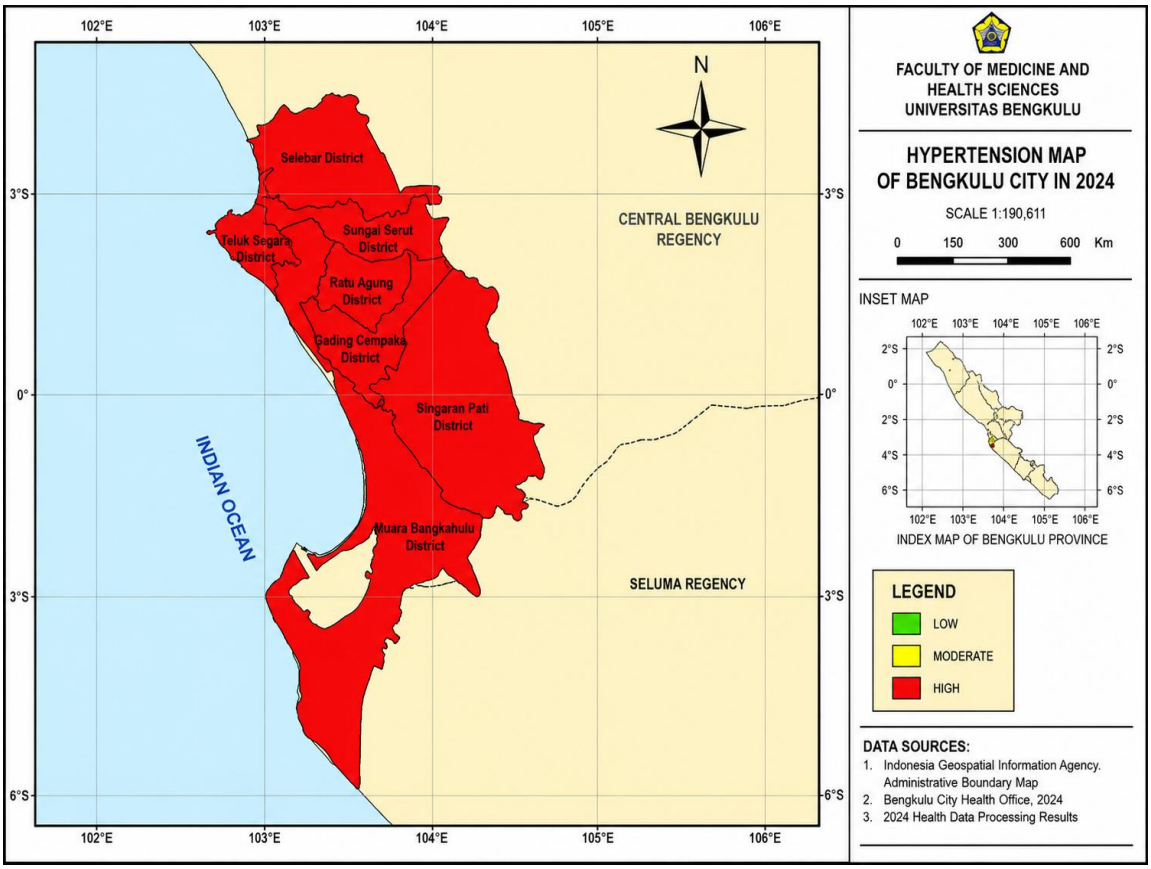

Figure 5. Data on the Distribution of Hypertension Cases in Bengkulu City 2024.

The pattern of hypertension case fluctuations provides insights into the dynamics of hypertension occurrence, influenced by various temporal factors. The identification of vulnerable points or areas with consistently high hypertension levels throughout the study period reveals that five sub-districts consistently fall into the high category: Muara Bangka Hulu sub-district in the northern region, Ratu Agung sub-district, Singaran Pati sub-district in the central region, Gading Cempaka sub-district in the central region, Selebar sub-district in the eastern region, and Kampung Melayu sub-district in the southern region. These six sub-districts show a persistent hypertension problem that requires special attention and more intensive intervention. On the other hand, the Sungai Serut district, located in the northeast, shows a unique fluctuation pattern. In 2020, it was categorized as low, increased to high in 2021-2022, decreased to moderate in 2023, and increased back to high in 2024. These fluctuations indicate that the region is responsive to interventions but requires on going programs to maintain the improvements that have been achieved.

This study shows that hypertension cases are spread almost throughout the city of Bengkulu during the period 2020-2024, with most districts consistently classified in the high category. Spatial visualization shows that Selebar, Gading Cempaka, Ratu Agung, Singaran Pati, Muara Bangka Hulu, and Kampung Melayu repeatedly appear as areas with relatively high hypertension burden. These findings indicate thet hypertension remains a major public health issue thoroughout the city of Bengkulu and is not concentrated in just a few specific locations.

An important finding from this study is the significant fluctuation in the nuber of reported hypertension cases from year to year. The total reported cases increased from 82,320 in 2020 to 286,339 in 2021, then decreased to 36,404 in 2022, increased again to 50,898 in 2023, and decreased to 9,515 in 2024. Such large variations should be interpreted with caution. Because this study relies on secondary surveillance data, these changes may not fully reflect actual epidemiological changes in the incidence of hypertension. Variations in reporting systems, case registration procedures, screening coverage, completeness of health service records, and data management practices may also contribute to the observed fluctuations.

The spatial pattern observed in this study is consistent with previous literature reporting that hypertension tends to be widespread in urban populations. However, this study does not directly assess individual or environmental determinants such as dietary habits, physical activity, smoking behavior, obesity, socioeconomic status, population density, or urbanization levels (Seto & Ramankutty, 2016). Therefore, although these factors have been identified as important contributors to hypertension in previous studies, their specific contribution to the spatial patterns observed in Bengkulu City cannot be determined from the current data.

The re-emergence of moderate category areas in 2023 and the predominance of high category distributions in 2024 suggest temporal variations in reported hypertension case patterns. However, the interpretation of these fluctuations should be approached cautiously, as informantion regarding screening activities, healthcare utilization, survaillence performance, and reporting quality was unavailable. Consequently, the factors contibuting to these spatial changes remain uncertain, and the observed patterns may reflect variations in case detection and reporting rather than true epidemiological changes (Florentino et al., 2025; Kim, 2026).

Since the distribution of hypertension is shaped by the complex interplay of demographic characteristics, behavioral factors, encironmental conditions, and health system factors, further analytical studies integrating these variables are warranted to provide a more comprehensive understanding of the mechanisms underlying hypertension distribution in Bengkulu City (Ghorbany et al., 2025; Hu et al., 2025; Li & Chen, 2026).

These findings highlight the usefulness of Geographic Information Systems (GIS) in identifying spatial patterns of disease distribution and recognizing areas that consistently experience a high burden of hypertension (Kamath et al., 2023). GIS-based mapping can play a role in supporting public health planning as it allows for the identification of geographic variations in health issues, the determination of relevant regional units for health service evaluation, and helps in the more efficient and equitable allocation of health resources according to regional needs (Wang, 2020).

This study has several limitations that need to be considered when interpreting the results. The ecological descriptive design used only allows for the identification of spatial and temporal distribution patterns of hypertension cases, thus it cannot explain causal relationships or directly assess the influence of risk factors (Hu et al., 2025). In addition, the use of secondary data from routine reports by the Health Department causes the research results to depend on the completeness and consistency of the available data. The significant fluctuations in the number of cases from year to year may also be influenced by differences in case detection coverage, recording systems, and reporting quality, making the results of this study more representative of the recorded distribution patterns of hypertension cases rather than actual epidemiological changes (Scharf et al, 2025). Therefore, analytical research is needed, taking into account individual, environmental, and healthcare system factors, to obtain a more comprehensive understanding of the distribution of hypertension in Bengkulu City.

4. CONCLUSION

Hypertension cases in Bengkulu City were predominantly distributed within the high category across most districts during 2020-2024, although temporal variation in category distribution was observed in several areas. Districts including Muara Bangka Hulu, Gading Cempaka, Ratu Agung, Singaran Pati, Selebar, and Kampung Melayu consistently exhibited high reported case counts throughout the study period. Because the present study was based on descriptive ecological data and spatial visualization, the findings should be interpreted as a representation of the geographical distribution of reported hypertension cases rather than evidence of spatial risk, clustering, or causal relationship. Nevertheless, the resulting maps provide useful baseline information for public health surveillance and may support the development of future studies eploying inferential spatial analyses and population based indicators.

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