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Spatial autocorrelation of stunting prevalence among children under five years in West Bandung Regency in 2022

Minawati[1*], Indang Trihandini[1], Tiopan Sipahutar[1], Syefira Salsabila[2]

Abstract

Purpose: This study aims to determine whether there is spatial autocorrelation based on the prevalence of stunting and their spatial diffusion pattern. It also aims to find areas that will become stunting hotspots and cold spots area in West Bandung Regency in 2022. **Method:** This research employed an ecological study design using spatial analysis to estimate and analyze the distribution pattern of stunting prevalence in the West Bandung Regency in 2022. The data used results from a child monitoring record in *Posyandu* (Integrated Service Post) carried out by the West Bandung Regency Health Office regarding the prevalence of stunting among children under five years. This study used Moran Index and Local Indicators Autocorrelation (LISA) for spatial pattern analysis. **Results:** This study shows that there is negative spatial autocorrelation, or the distribution of stunting prevalence forms a random pattern (I<E). This study also indicates that there is statistically no spatial correlation between sub-district areas based on stunting prevalence in West Bandung Regency in 2022 (p-value > 0,05). There is no hotspot and cold spot area of stunting in West Bandung Regency in 2022. **Conclusion:** The prevalence of stunting in West Bandung Regency in 2022 is not spatially related between sub-district areas, with a random or scattered pattern. The area that is the main priority for intervention is Saguling Subdistrict, the subdistrict with the highest prevalence of stunting. The intervention program implemented in Cililin Subdistrict can be implemented in Saguling Subdistrict to reduce stunting prevalence.

Keywords: autocorrelation; spatial analysis; stunting

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[1]Department of Biostatistics and Population Studies, Faculty of Public Health, Universitas Indonesia, Indonesia

[2]Department of Nutrition, Faculty of Public Health, Halu Oleo University, Indonesia

[*]**Correspondence:**
minawati@ui.ac.id

INTRODUCTION

Malnutrition is still a public health problem worldwide, especially in developing countries [1]. According to WHO, in 2020 globally, approximately 149 million children under five are estimated to be stunting [1]. Stunting is a disruption in the growth and development of children due to chronic malnutrition and recurrent infections, which causes children to be classified as short or very short if categorized based on length or height according to age, which is less than -2 standard deviations (SD) on the WHO growth standard [1,2]. Stunting can have long-term health impacts, such as obstacles to cognitive and physical development, and an increased risk of degenerative diseases. Stunting also affects the economic sector, where stunting has the potential to cause annual losses approximately 2-3% of the Gross Domestic Product (GDP) annually [3].

The Indonesian government has made stunting as a national priority issue in the National Medium-Term Development Planning (*Rencana Pembangunan Jangka Menengah Nasional*/RPJMN) 2020-2024, which targets

decreasing the stunting prevalence to 14% by 2024 [4]. The prevalence of stunting in 2022 nationally is reported to have decreased compared to 2021, which is 24.4% to 21.6% [5,6]. Even though it has reduced, this is still far above the target set before and still above the standard for public health problems set by WHO, which is 20% [7]. Therefore, efforts are needed to accelerate the reduction of stunting, considering the SDGs target point 2, which is realizing a world free from all forms of malnutrition by 2030.

In West Java Province, in 2022, stunting prevalence is still higher than 20% which is 20,2% [5]. With the largest population of children under five in Indonesia, stunting cases in West Java contribute to a large number of stunting nationally. Therefore, West Java has been designated a priority area for reducing stunting in Indonesia and 11 other provinces [8,9]. The targeted intervention programs and follow-up plans to accelerate the stunting reduction in West Java are essential and anticipated. The decrease in stunting cases in West Java is expected to contribute to the reduction of stunting prevalence in Indonesia.

Spatial analysis is a method, statistic, and technique that integrates concepts such as location, area, distance, and interaction to analyze, investigate, and explain in a geographical context [10]. Analyzing data through spatial analysis methods and techniques can provide added value by creating new information and knowledge related to spatial patterns, identifying disease clusters, and indicating where and when a case occurred [10,11]. The recommendation to use data and spatial analysis in the context of stunting is outlined in the Global Nutritional Report 2018, which identifies five critical steps needed to accelerate the reduction of stunting. One of these five steps includes the utilization of region-based data to understand where the burden of malnutrition lies and to identify where action is more needed and [12].

According to Tobler's law of geography that "everything is related to everything else, but near things are more related than distant things", spatial analysis in the context of stunting can be utilized to understand the distribution patterns of cases and whether the prevalence of stunting in an area is influenced by its surrounding regions. The results of spatial analysis, such as the identification of stunting hotspots and other findings, can be utilized in determining priority areas for reducing stunting and can serve as recommendations for policymaking or programs in efforts to reduce stunting.

The spatial analysis results related to stunting in several previous studies have shown significant spatial autocorrelation based on the prevalence of stunting [13–20]. Based on the spatial analysis of stunting conducted in 514 districts/cities in Indonesia, spatial autocorrelation was found based on stunting in the regions of Sumatra, Java, Sulawesi, Bali, Nusa Tenggara Timur (NTT), and Nusa Tenggara Barat (NTB) [20]. Similarly, in West Java Province, spatial autocorrelation based on the prevalence of stunting was identified, and three stunting hotspot areas were found, namely Bandung District, West Bandung District, and Bandung City [21].

In 2022, the prevalence of stunting in West Bandung District was reported at 27.3%, which remains higher than the provincial and national averages [5]. Additionally, West Bandung Regency is identified as a stunting hotspot area in West Java and can be considered a priority area for stunting intervention efforts in the region [21]. While spatial analysis has been applied in regions such as West Java to map out the distribution of stunting, there remains a research void in comprehensively interpreting the dynamic spatial relationships and patterns at localized scales, particularly in areas like West Bandung Regency. Considering these conditions, further research will be conducted on spatial autocorrelation, specifically in West Bandung Regency. This study aims to determine whether there is spatial autocorrelation based on the prevalence of stunting and their spatial diffusion pattern and to find areas that will become stunting hotspots and cold spots area in West Bandung Regency..

This study explores the spatial autocorrelation of stunting in West Bandung Regency, a region with high stunting rates. Using advanced spatial analysis methods, it uncovers local dispersion patterns, identifying specific zones with increased vulnerability. The research enhances our understanding of stunting dispersion, highlighting both high-risk and low-incidence areas in West Bandung Regency.

METHODS

This research uses an ecological study design with spatial analysis to analyze the distribution of stunting prevalence in West Bandung Regency in 2022. The sample for this research is all 16 sub-district units in West Bandung Regency. The data utilized for this research is secondary data sourced from various origins. The stunting prevalence data used in this study are aggregated data collected through surveillance records in 2022 by the West Bandung Regency Health Office. This data was obtained through an official data request process from the West Bandung Regency Health Office. Meanwhile, the digital map of West Bandung Regency used in the study was acquired by accessing the Indonesia Geospatial Portal website. The spatial analysis unit used in this research is at the

sub-district level, encompassing all 16 sub-districts within West Bandung Regency. The spatial analysis units used in this research are all sub-districts in West Bandung Regency, totaling 16 sub-districts.

In autocorrelation statistics, it is crucial to consider a weight matrix, which is used to describe a connection between objects in a particular environment and determine the spatial relationship of regions so that those are close in space are given greater weight than regions that are far away in the calculation [10,22]. This research uses a queen contiguity weighting matrix in determining neighbors, where this weighting matrix is the most recommended if the area's boundaries are irregular. This considers that spatial interaction increases when two polygons share an edge, a node, or both [10,23]. In terms of adding weight matrix and spatial pattern analysis, this research utilizes GeoDa software version 1.22.0.2. Meanwhile, to visualize the distribution of stunting prevalence, QGIS application version 3.22.15 is used.

The spatial pattern analysis used in this research is using the Moran Index to see global autocorrelation and to examine global autocorrelation, followed by the Local Indicators Autocorrelation (LISA) to observe local autocorrelation or the spatial correlation among regions, specifically the sub-district areas. This includes displaying Moran's scatter plot, cluster map, and significance map. Global Moran's Index and LISA values range from -1 to +1, where 0 indicates no autocorrelation. A negative Moran's Index indicates negative autocorrelation, meaning that neighboring regions or clustering of areas have different attribute values. A positive Moran's Index indicates positive autocorrelation, which means that neighboring regions or clustering of areas have similar attribute values and form a cluster [22].

Moran's Index Scatter Plot is used to visualize spatial autocorrelation statistics. There are four quadrants in the Moran's Index scatter plot, namely High-High (hotspot area) and Low-Low (cold spot area), expressing positive spatial autocorrelation, and High-Low and Low-High, representing negative spatial autocorrelation [10]. The upper-right corner quadrant, High-High (hotspot area), indicates areas with high values surrounded by other areas with high values as well. Meanwhile, the lower-left corner quadrant represents Low-Low (cold spot area), indicates areas with low values surrounded by other areas with common values [10]. Meanwhile, the upper-left corner quadrant represents Low-High, indicates areas with low cases surrounded by other areas with high cases. On the other hand, the lower-right corner quadrant represents High-Low, illustrating areas with high instances surrounded by other areas with low cases [10].

The null hypothesis in this study states that there is no spatial autocorrelation based on the prevalence of stunting in West Bandung Regency (I = E). Meanwhile, the alternative hypothesis states that there is spatial autocorrelation based on the prevalence of stunting in West Bandung Regency (I > E). The statistical test is conducted at a 95% confidence interval, where there is statistical spatial autocorrelation in an area if the test result shows a p-value ≤ 0,05.

RESULTS

Visualization of stunting prevalence among children under 5 years in West Bandung Regency in 2022

Figure 1 shows the visualization of stunting prevalence among children under five years in West Bandung Regency in 2022. Based on Figure 1, the distribution overview of stunting prevalence in West Bandung Regency can be observed. Regarding the severity categories of stunting problems using WHO standards, there are no sub-district areas that have a very high prevalence of stunting.

Out of a total of 16 sub-districts, most of the sub-districts in West Bandung Regency are in the medium and low categories based on stunting. There is only one sub-district categorized as a high problem, which is Saguling Sub-district, and one sub-district categorized as very low, which is Lembang Sub-district. Sub-districts categorized as low problem based on stunting include Cikalong Wetan, Parongpong, Ngamprah, Padalarang, Cihamplas, Batujajar, Cililin, Rongga, and Gunung Halu. Meanwhile, sub-districts categorized as having moderate problem include Cipeundeuy, Cipatat, Cisarua, Cipongkor, and Sindangkerta.

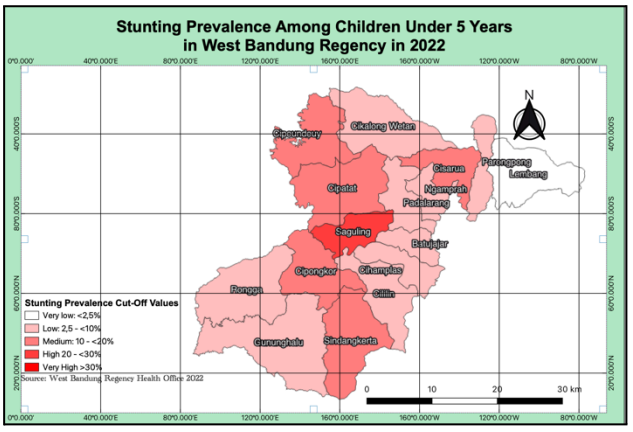

Figure 1. Stunting prevalence among children under 5 years in West Bandung Regency in 2022

The spatial autocorrelation of stunting prevalence in West Bandung Regency in 2022 was measured using the Moran's Index. From **Figure 2**, the analysis shows that the Moran's Index value for stunting prevalence is -0,105, which the value is smaller than the expected value E(I) which is -0,0667. This means that there is negative spatial autocorrelation of stunting prevalence, and the distribution of stunting prevalence forms a random pattern, where neighboring areas tend to have different attribute values. Areas with low values are surrounded by areas with high values, and areas with high values are surrounded by areas with low values. Regarding the statistical aspect, from the significance test results shown in **Figure 3**, the *p*-value is determined as 0,462, which the value is higher than α (0,05). This indicates that statistically there is no spatial correlation among sub-district areas based on the prevalence of stunting in the West Bandung Regency area in 2022.

To find out which the sub-district areas in the high-high quadrant of Moran's Scatterplot as stunting hotspot areas, and to find out which the sub-district areas in the low-low quadrant of Moran's Scatterplot as stunting cold spot areas in West Bandung Regency in 2022, the analysis proceeded with the Local Indicators Autocorrelation (LISA). The output from the LISA Cluster Map presented in **Figure 4** indicates that there are no sub-district areas serving as hotspot areas or areas with high stunting prevalence surrounded by high stunting prevalence areas as well. Similarly, no cold spot areas were identified from the LISA cluster map means there are no areas with low stunting prevalence surrounded by areas with low stunting prevalence as well. Based on the output from the LISA Cluster Map presented in Figure 4, only one sub-district area was found in the Low-High quadrant, namely Cililin Sub-district. Cililin Sub-district has a low stunting prevalence (2,59%) and is surrounded by sub-districts with high stunting prevalence, specifically Saguling, Cipongkor, and Sindangkerta Sub-districts.

Based on the results of the significance analysis in **Figure 5**, it is known that the CIlilin District area is surrounded by sub-districts that have a stunting prevalence in the medium and high categories, and statistically it is indicated that there is significant spatial autocorrelation in Cililin District. The areas surrounding CiIlilin Su-district influence the prevalence of stunting in the Low-High quadrant.

The distribution of stunting prevalence among children under 5 years in West Bandung Regency in 2022

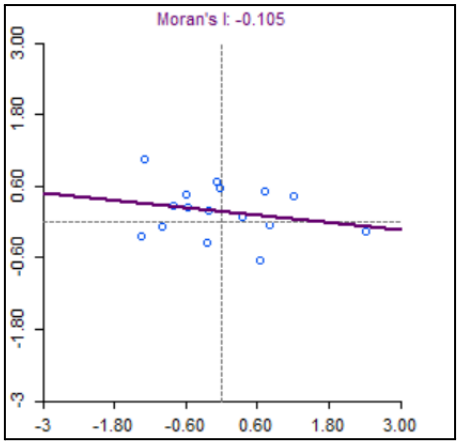

Figure 2. Moran scatter plot of stunting prevalence

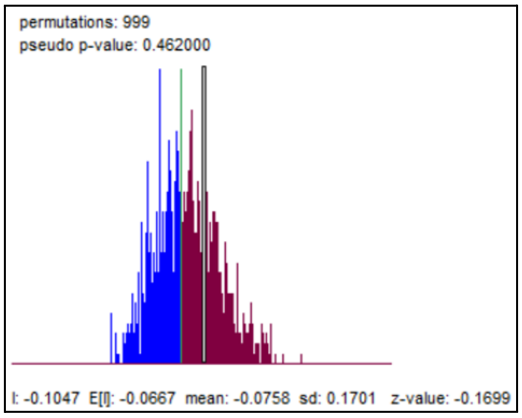

Figure 3. Result of significance test

Cluster map overview of spatial diffusion patterns of stunting prevalence among children under 5 years in West Bandung Regency in 2022

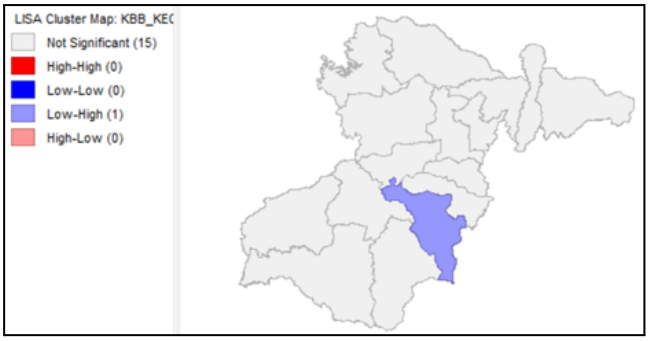

Figure 4. Cluster map of stunting prevalence

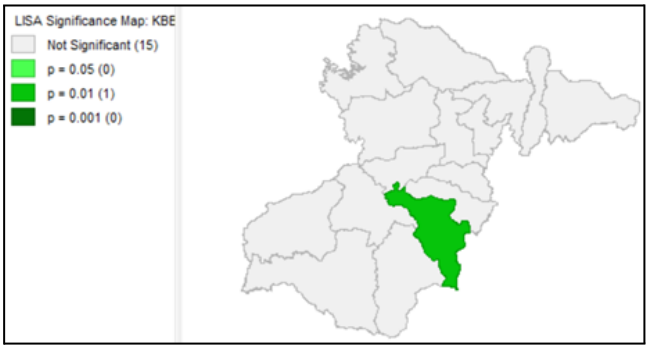

Figure 5. Cluster map for significance test of stunting prevalence

DISCUSSION

The spatial autocorrelation test using the Moran's Index indicates the presence of negative spatial autocorrelation, which means that the prevalence of stunting in West Bandung Regency forms a random or dispersed pattern. This suggests that areas with similar attribute values are not adjacent to each other. The significance test shows that statistically there is no spatial correlation among sub-district areas based on the prevalence of stunting.

The findings of this research are contradicted to several spatial studies on stunting prevalence in Indonesia and several other countries that have been conducted previously, which stated that there is spatial autocorrelation related to the prevalence of stunting [13–21]. A study in Ethiopia examining the spatial trends of stunting in children under five using DHS data from 2011, 2016, and 2019 showed that all three had a p-value < 0,001 with respective Moran's Index values of 0.9185, 0.3968, and 0.3530 [16]. This indicates that statistically, there was spatial autocorrelation of stunting in children, and the distribution pattern formed clusters where areas with high prevalence were adjacent to each other [16].

Another study that conducted to analyze the spatial patterns across 7 islands in Indonesia and identify stunting hotspots, also showed results that were inversely proportional to this research. Their study concluded that there was autocorrelation among districts in Sumatra, Java, Sulawesi, Bali, NTT, and NTB regions, and found 133 regency/cities that were stunting hotspot areas [13]. The findings of this research indicate that stunting in Indonesia is clustering and significantly associated with the surrounding area [13].

The same outcome was found in study conducted in Malang Regency, which developed a risk factor model for child stunting in Malang Regency, which stated that there was positive spatial autocorrelation and formed a clustered patterns related to the distribution of stunting prevalence [18]. Similarly, a study that was conducted to analyze the spatial autocorrelation of stunting prevalence specifically in the West Java Province, concluded the presence of spatial autocorrelation. This implies that the prevalence of stunting in a regency or city in West Java is associated with its neighboring areas [21]. The research also revealed that West Bandung Regency is one of the stunting hotspots in West Java. However, this study did not show any spatial autocorrelation at the sub-district level for West Bandung Regency. On the contrary, this study indicates that the prevalence of stunting in West Bandung Regency is not associated with the neighboring sub-district areas; instead, it appears to be dispersed or random pattern.

In this study, there are no areas classified as High-High, Low-Low, or High-Low. Only one area is situated in the Low-High quadrant, namely Cililin Sub-district. Cililin Sub-district exhibits a low prevalence of stunting (2,59%) but is geographically surrounded by neighboring sub-districts with high stunting prevalence, specifically Saguling Sub-district (22,51%), Sindangkerta Sub-district (13,88%), and Cipongkor Sub-district (16,06%).

Geographically, there is only one sub-district with a high prevalence of stunting, which is Saguling sub-district, situated in the center of the Regency. Meanwhile, sub-districts with medium stunting prevalence are dispersed from the northern to the southern parts, including Cipeundeuy, Cipatat, Cipongkor, and Sindangkerta. And there is 1 sub-district in the eastern part which also has a moderate level of stunting prevalence, namely Cisarua sub-district. This shows that the prevalence of stunting in the West Bandung Regency area is spread randomly, and not clustered in a particular region.

The varied geographical landscape in West Bandung poses challenges in accessing and establishing integrated health service facilities. This geographical disparity can lead to unequal access to health services and nutrition education, further exacerbating the stunting problem in remote or less accessible areas, specifically Saguling sub-district. Furthermore, Saguling sub-district has high prevalence of stunting because Saguling sub-district, located near a rapidly developing area, is exposed to various types of ultra-processed foods (UPF) and fast foods, which are high in energy but low in nutrient density. This change in dietary preference, especially among adolescents, may contribute to nutritional imbalances. Moreover, nutritional imbalance in adolescent girls significantly affects anemia and contributes to downstream effects on stunting in future generations.

These findings can be used to consider the stunting mitigation strategies in West Bandung Regency. For researchers, it provides a framework for detailed spatial analysis, revealing unique local stunting patterns in different regions or subdistricts. Health practitioners and nutrition experts can gain practical insights for developing targeted interventions, specifically in Saguling sub-district. Health policymakers can leverage these findings for more efficient resource allocation and the formulation of more adapted stunting reduction initiatives in West Bandung Regency.

CONCLUSION

The prevalence of stunting in West Bandung Regency in 2022 does not show spatial correlation among sub-districts, indicating a random or dispersed pattern. The main priority for stunting intervention should focus on Saguling sub-district, which has the highest prevalence of stunting. To determine intervention strategies, it may be beneficial to consider the approaches implemented in Cililin Sub-district, where despite the surrounding areas having high prevalence, Cililin has managed to reduce stunting prevalence. To identify stunting hotspots, advanced spatial analysis can be conducted using smaller regional units, such as villages. Additionally, to find out the relationship between stunting prevalence and associated risk factors, further research employing spatial exploration or modeling methods like SAR, SEM, SARMA, GWR, among others, could be considered.

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