JEVNAH
Journal of Evidence Based Nursing and Public Health
JEVNAH 1(2):50–58
ISSN 3028 - 2615

Analyzing the Impact of Population Density on Hepatitis A Prevalence Using Geographic Information Systems (GIS) in Sudimoro District, Pacitan Regency

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Received Date: June 29, 2024 Revised Date: July 18, 2024 Accepted Date: August 14, 2024

ABSTRACT
Background: This study examines the relationship between population density and Hepatitis A prevalence in Sudimoro District, Pacitan Regency, using data from 2019. Geographic Information Systems (GIS) technology was employed to analyze spatial patterns and correlations. **Method:** The research applied a quantitative approach, utilizing secondary data on Hepatitis A cases and population density. Simple linear correlation analysis revealed a moderate positive correlation (r = 0.48) between population density and the number of Hepatitis A cases, indicating that higher population density is associated with increased disease prevalence. **Findings:** Villages with high density, such as Gunung Rejo and Sudimoro, generally reported more cases, while those with lower density showed fewer cases. However, anomalies like Sembowo, which has high density but fewer cases, suggest that other local factors, such as sanitation and healthcare access, also play significant roles. The study underscores the importance of targeting high-density areas for public health interventions while considering additional factors influencing disease spread. Further research is recommended to explore these variables in more detail.

KEYWORDS: Geographic Information Systems (GIS); hepatitis A; population density; correlation analysis.

1. Introduction

Geographic Information Systems (GIS) technology has rapidly evolved, extending its applications beyond geography to numerous fields, including healthcare. Health practitioners widely utilize GIS to analyze healthcare access disparities, monitor disease outbreaks, and optimize the allocation of limited resources to improve public health (Rahmanti & Prasetyo, 2012). The ability of GIS to visualize data through mapping serves as an effective tool for guiding policymakers at various administrative levels in identifying health priorities and selecting the most suitable health programs for implementation in healthcare institutions across different regions. Furthermore, GIS can play a key role in evaluating the success of public health programs applied in previous periods, offering insights into areas needing further intervention (Economic Report on Africa 2005: Meeting the Challenges of Unemployment and Poverty in Africa, Economic Commission for Africa, 2005).

Cite This Article:
Nurdiansyah, R. (2024). Analyzing the Impact of Population Density on Hepatitis A Prevalence Using Geographic Information Systems (GIS) in Sudimoro District, Pacitan Regency. *Journal of Evidence Based Nursing and Public Health, 1*(2), 1-15. https://doi.org/10.61511/jevnah.v1i2.2024.1168

In the healthcare field, GIS is particularly valuable for analyzing and mapping various health-related data. According to Cromley and McLafferty (2012), GIS can be used to visualize the geographic distribution of at-risk populations, map the spatial distribution of diseases and health concerns, identify healthcare facility locations, and analyze risk factors for disease occurrence. This technology is also crucial in understanding the relationship between risk factors and their health impacts, particularly in the context of environmental health issues and infectious diseases like Hepatitis A, HIV, and tuberculosis. The outcomes of GIS analyses help target interventions more effectively by pinpointing high-priority populations and geographic areas. Through spatial mapping of disease distribution, GIS enables comparisons between regions, which is consistent with Tobler's First Law of Geography: "Everything is related to everything else, but near things are more related than distant things" (as cited in Anselin, 1993). This principle underscores the interconnectedness of regions and how spatial effects often influence neighboring areas.

A relevant example of GIS in action is its application in understanding the spread of Hepatitis A, an infectious liver disease caused by the Hepatitis A virus (HAV). The virus is primarily transmitted through the fecal-oral route, such as consuming food contaminated with HAV or using injected drugs from an infected individual. The risk factors for Hepatitis A can be categorized into three primary groups: the causative agent (the virus), the host, and the environment. Host factors include age, gender, family medical history, occupation, use of untreated drinking water, hygiene habits, and high-risk sexual behaviors. Environmental factors encompass climate, sanitation conditions, access to clean water and waste management, population density, and the number of street food vendors (Intan et al., 2014). By incorporating GIS, these risk factors can be spatially analyzed, allowing for a clearer understanding of how environmental and social conditions contribute to disease spread.

In Indonesia, Hepatitis cases have been detected across all provinces, with a prevalence rate of 0.6%, ranging from 0.2% to 1.9%. These cases are typically identified through clinical symptoms, except in East Java, South Sumatra, Central Kalimantan, and North Sulawesi, where healthcare professionals diagnose them. The highest prevalence of clinical hepatitis is seen in individuals aged ≥55 years, with a higher incidence in rural areas than in urban settings, and it tends to be more common among individuals with lower education levels. The prevalence of clinical hepatitis is consistent across all household expenditure levels (Health Research and Development Agency, 2018). Furthermore, Hepatitis A outbreaks (Kejadian Luar Biasa, KLB) occurred in various provinces between 2013 and 2018, highlighting the ongoing public health challenge (Data and Information Center, Ministry of Health, Republic of Indonesia, 2014; Ministry of Health, Republic of Indonesia, 2019).

An outbreak (KLB) is defined as the occurrence or significant increase of illness and mortality within a specific area and timeframe, which may potentially escalate into an epidemic if not addressed (Ministry of Health of the Republic of Indonesia, 2011). By leveraging GIS technology, public health officials can more effectively monitor these outbreaks and take timely action to mitigate their spread.

n 2013, East Java Province accounted for 57% of the 495 Hepatitis A cases in Indonesia, meaning that more than half of the cases were concentrated in East Java. The cases were distributed across five regencies, namely Pasuruan, Ponorogo, Jombang, Lamongan, and Pacitan, with the highest number of cases reported in Pasuruan Regency, totaling 110 cases. In 2018, another Hepatitis A outbreak occurred in East Java, specifically in Bangkalan Regency.

Pacitan Regency, one of the regions in East Java, is endemic to the Hepatitis A virus (HAV). In 2013, Pacitan experienced an outbreak in Ngadirojo District, with 66 reported cases. The Hepatitis A outbreak reoccurred in 2019, with the first case detected on June 13, involving 34 individuals. By June 25, the Pacitan Regency Government had officially declared a state of outbreak. The virus spread rapidly, and within two weeks—by June 30, 2019—the number of cases had surged to 800, affecting eight districts: Sudimoro, Ngadirojo, Tulakan, Arjosari, Tegalombo, Kebonagung, Punung, and Pacitan. The symptoms experienced by the patients included fever, headache, nausea, vomiting, dark urine, and yellowing of the eyes and skin (Pacitan District Health Office, 2019).

The Hepatitis A outbreak in Pacitan Regency lasted for two months, with a total of 1,314 cases reported across the eight affected districts (Pacitan District Health Office, 2020). Sudimoro District had the highest number of cases, with 732 patients, accounting for 55.7% of the total. This was further corroborated by the fact that the first case was identified at the Sudimoro Health Center. Sudimoro also has a relatively high population density compared to other districts in Pacitan Regency. According to data from the Central Bureau of Statistics of Pacitan Regency (2019), Sudimoro had a population density of 431 people per square kilometer in 2019. This figure is notably higher than in other districts of Pacitan Regency.

High population density is a known risk factor for the spread of HAV, the causative agent of Hepatitis A. As McDonald (as cited in Intan et al., 2014) points out, the larger the number of people living in a particular area, the greater the risk of Hepatitis A transmission. This relationship between population density and viral transmission is crucial in understanding the spread of Hepatitis A in Sudimoro District.

The research objective derived from this problem is to examine the relationship between population density and the distribution of Hepatitis A cases in Sudimoro District, Pacitan Regency, in 2019.

2. Methods

This research was conducted in Sudimoro District, which is geographically located between 8.16°-8.28° South Latitude and 111.32°-111.43° East Longitude, covering an area of 7,184.73 hectares. Administratively, Sudimoro District is part of Pacitan Regency, situated approximately 53 kilometers from Pacitan city center.

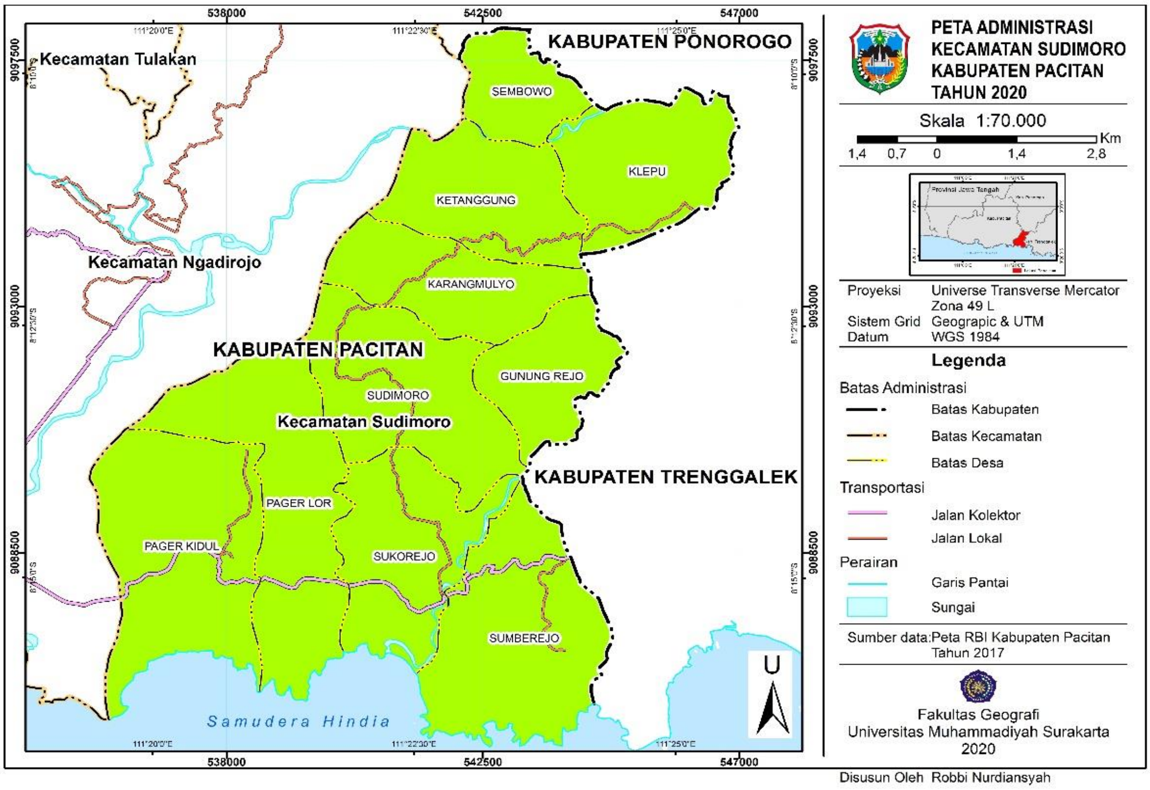

Fig 1. Research location

The method applied in this research is descriptive, utilizing Geographic Information Systems (GIS) and a quantitative approach. This involves presenting the calculated values of simple linear correlation analysis.

2.1 Population

The objective of this research is to analyze the spatial autocorrelation of Hepatitis A cases and examine the relationship between population density and the distribution of Hepatitis A cases in Sudimoro District in 2019. Based on this objective, the population of the study comprises the residents of Sudimoro District, totaling 35,391 individuals, distributed across 10 villages.

2.2 Sampling method

The sampling method in this research is designed to analyze the spatial distribution of Hepatitis A cases using purposive sampling. This means that only the population meeting specific criteria is included as a sample. The criteria for the sample in this study are residents who have been diagnosed with Hepatitis A.

2.3 Data collection

The data collection method employed in this research relies on secondary data obtained from relevant institutions. The secondary data includes the number of Hepatitis A cases recorded in Sudimoro District in 2019, along with the population density data for the same year. These data are crucial for analyzing the spatial distribution of Hepatitis A cases and understanding the relationship between population density and the spread of the disease.

In addition to the secondary data, several key materials were used in the research. These include detailed records on the number of Hepatitis A cases in Sudimoro District for the year 2019, the population density figures for the district during that period, and the administrative map of Sudimoro District from 2019. These materials are essential for conducting a thorough spatial analysis and for visualizing the geographic distribution of the disease across the district. Through the integration of these data and materials, the study aims to provide insights into how population density impacts the transmission of Hepatitis A in the region.

By integrating both spatial and statistical data, this research aims to understand how population density influences the spread of Hepatitis A within Sudimoro District, and how these patterns can be visualized and analyzed through GIS.

2.4 Data analysis with simple linear correlation

Correlation is used to measure the strength of the relationship between predictor variables (X) and response variables (Y). The analysis results are expressed by a numerical value known as the correlation coefficient (Budiyono, 2009). In this research, the predictor variable (X) represents population density, while the response variable (Y) represents the number of Hepatitis A cases. Regression analysis is often conducted alongside correlation analysis to better understand the relationship between variables. The correlation coefficient (r) is calculated using the following equation:

$$r = \frac{n\sum_{i=1}^{n} X_i Y_i - \left(\sum_{i=1}^{n} X_i\right)\left(\sum_{i=1}^{n} Y_i\right)}{\sqrt{\left[n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2\right]\left[n\sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i\right)^2\right]}}$$

(Eq. 1)

Where:

- n represents the number of cases,
- X_i is the number of events for X_i
- Y_i is the number of events for Y_i

The correlation coefficient reflects the strength of the relationship between two variables. It ranges from -1 to 1, where values closer to 1 indicate a strong positive correlation, and values closer to 0 suggest a weaker or no correlation. A negative correlation coefficient indicates an inverse relationship between the variables (Budiyono, 2009).

2.5 Research flowchart

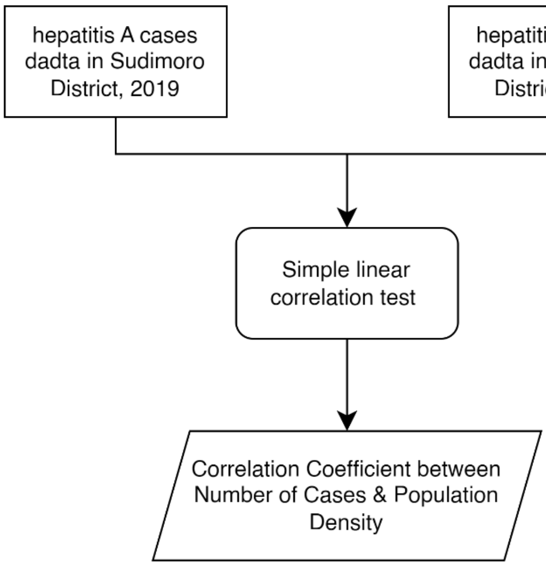

Fig 2. Research flowchart

3. Results and Discussion

3.1 Research result

The relationship between the number of Hepatitis A cases and population density was analyzed using a simple linear correlation. In this analysis, population density served as the independent variable (x), while the number of cases was the dependent variable (y). Table 1 presents the number of cases and population density in each village.

Table 1. Number of hepatitis A cases and population density by village

Village	Population density (X)	Hepatitis A cases (Y)	XY	X^2	Y^2
Gunung Rejo	582	227	132114	338724	51529
Karangmulyo	682	140	95480	465124	19600
Ketanggung	596	28	16688	355216	784
Klepu	511	35	17885	261121	1225
Pager Kidul	279	54	15066	77841	2916
Pager Lor	361	105	37905	130321	11025
Sembowo	602	27	16254	362404	729
Sudimoro	684	209	142956	467856	43681
Sukorejo	349	40	13960	121801	1600
Sumberejo	362	43	15566	131044	1849
Total	5008	908	503874	2711452	134938

 https://doi.org/10.61511/jevnah.v1i2.2024.1168

Based on Table 1, the correlation calculations are as follows:

Table 2. Simple linear correlation calculation

Regression statistics	Population density (X)
R	582
R square	682
Adjusted R square	596
Standard error	511
Observation	279

Based on Table 2, the correlation coefficient is 0.48, indicating a moderate correlation between population density (variable x) and the number of Hepatitis A cases (variable y). This suggests a moderate relationship between the two variables.

3.2 Discusssion

The correlation coefficient measures the strength of the relationship between two variables. It ranges from -1 to 1, where a value closer to 1 or -1 indicates a strong relationship, and a value closer to 0 suggests a weaker relationship or no correlation at all. A negative coefficient indicates a negative correlation, while a positive coefficient indicates a positive correlation (Budiyono, 2009). The simple linear correlation calculation for population density as variable x and the number of cases as variable y yielded a correlation coefficient of 0.48. This result demonstrates the strength and nature of the correlation between the two variables. With a correlation coefficient of 0.48, the relationship between population density and the number of Hepatitis A cases is a positive correlation, meaning that higher population density is associated with a higher number of Hepatitis A cases. However, this coefficient also indicates that the strength of the correlation is relatively weak.

The impact of population density on the number of Hepatitis A cases can be observed in villages with high population density, which generally experience a higher number of cases. Conversely, villages with lower population densities tend to have fewer cases. Table 3 categorizes population density and the number of cases into intervals:

Table 3. Simple linear correlation calculation

Population density class	Interval	Number of cases class	Interval
Low	279-414	Low	27-94
Medium	415-549	Medium	95-161
High	550-684	High	162-228

Based on the classification in Table 3, Table 4 presents the distribution of villages by population density and the number of Hepatitis A cases, along with their classifications:

Table 4. Classification of population density and hepatitis A cases

Village	Population density (X)	Description	Hepatitis A cases	Description
Sembowo	602	High	27	Low
Klepu	511	Medium	35	Low
Ketanggung	596	High	28	Low
Karangmulyo	682	High	140	Medium
Gunung rejo	582	High	227	High
Sudimoro	684	High	209	High
Pager lor	361	Low	105	Medium
Pager kidul	279	Low	54	Low
Sumberejo	362	Low	43	Low
Sukorejo	349	Low	40	Low

Table 4 indicates that villages with higher population densities tend to have a higher number of Hepatitis A cases, whereas villages with lower population densities generally report fewer cases. This finding aligns with the simple linear correlation analysis, which shows a positive correlation with a moderate strength between population density and the number of Hepatitis A cases in each village.

Gunung Rejo, which has the highest number of cases, also has high population density, while Sembowo, despite its high population density, has the lowest number of cases. This anomaly suggests that spatial aspects may influence the correlation. For instance, Sembowo's lower number of cases could be attributed to the lack of neighboring areas with high case numbers. Villages like Pager Kidul, Sumberejo, and Sukorejo, which have both low population density and low numbers of cases, illustrate this relationship further.

4. Conclusions

The study reveals a moderate positive correlation (r = 0.48) between population density and the prevalence of Hepatitis A in Sudimoro District. This indicates that higher population density tends to be associated with a higher number of Hepatitis A cases, although the correlation is not strongly linear. While population density is a significant factor, it is not the sole determinant of Hepatitis A prevalence. Villages with higher population densities, such as Gunung Rejo and Sudimoro, generally report higher numbers of Hepatitis A cases. In contrast, villages with lower population densities, such as Pager Kidul and Sukorejo, tend to have fewer cases. This supports the hypothesis that increased population density may contribute to higher transmission rates of Hepatitis A.

However, anomalies such as Sembowo, which has a high population density but fewer cases, suggest that additional spatial and local factors are at play. This indicates that while population density influences Hepatitis A prevalence, it is not the only factor. Other variables, including local sanitation practices, healthcare access, and community health initiatives, may significantly impact disease prevalence.

To address these issues, public health strategies should prioritize areas with high population density to reduce the risk of outbreaks. Nonetheless, it is crucial to consider other contributing factors and local conditions to create comprehensive and effective interventions. Further research is necessary to explore additional factors affecting Hepatitis A prevalence beyond population density, such as environmental conditions and healthcare infrastructure, to develop targeted public health strategies and improve overall disease management.

Author Contribution

All author contributed fully to the writing of this article.

Ethical Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflicts of Interest

The author declare no conflict of interest.

References

Anselin, L. (1993). *Exploratory spatial data analysis and geographic information systems*. Santa Barbara: National Center for Geographic Information and Analysis.

Badan Pusat Statistik. (2018). *Pacitan Regency in Figures*. Pacitan: Badan Pusat Statistik Kabupaten Pacitan.

Budiyono. (2009). *Statistics for Research*. Solo: UNS Press.

Cromley, E. K. & McLafferty, S. L. (2012). *GIS and Public Health*. New York: The Guilford Press.

Health Research and Development Agency. (2018). *Main Findings of Basic Health Research (RISKESDAS)*. Jakarta: Ministry of Health of the Republic of Indonesia.

Pacitan District Health Office. (2020). *Hepatitis A Infodatin*. Pacitan: Pacitan District Health Office.

Pacitan District Health Office. (2019). *Pacitan Regency Health Profile 2018*. Pacitan: Pacitan District Health Office.

Economic Commission for Africa. (2005). *Economic Report on Africa: Meeting the challenges of unemployment and poverty in Africa*. Africa: Economic Commission for Africa.

Intan, A., Pertiwi, P., Ramani, A., & Ariyanto, Y. (2014). *Hepatitis A risk mapping using geographic information systems (GIS) in Jember Regency, 2013*. *Pustaka Kesehatan*, 2(2), 361–368.

Ministry of Health of the Republic of Indonesia. (2011). *Regulation of the Minister of Health of the Republic of Indonesia No. 2046/MENKES/PER/XII/2011: Specific infectious diseases that can cause outbreaks and efforts to control them*. Jakarta: Ministry of Health of the Republic of Indonesia.

Center for Data and Information of the Ministry of Health of the Republic of Indonesia. (2019). *Data and information: Indonesia health profile*. Jakarta: Ministry of Health of the Republic of Indonesia.

Rahmanti, A. R., & Prasetyo, A. K. N. (2012). *Geographic information systems: Trends in the utilization of information technology for health-related fields*. In *Proceedings of the Third National Seminar on Medical Informatics* (pp. 1-10). Yogyakarta: Master of Informatics Engineering, Universitas Islam Indonesia.

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