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GEOSPATIAL AND ENVIRONMENTAL ANALYSIS OF STUNTING PREVALENCE IN PEKANBARU CITY, INDONESIA

Riska Epina Hayu[1]✉, Eva Mayasari[2], Nur Hadziqoh[3]
[1,2]Public Health Study Program, Al Insyirah Institute of Health and Technology
[3]Electro-medical Engineering Technology Study Program,
Al Insyirah Institute of Health and Technology

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ABSTRACT

Stunting is a chronic nutritional problem that remains a major public health challenge in Indonesia. In 2022, the national stunting prevalence was recorded at 21.6%, exceeding the WHO threshold of below 20%. In Pekanbaru, the prevalence reached 23%, contributing significantly to the total number of stunting cases in Riau Province. Stunting reflects the socio-economic conditions of a community, as it can be influenced by various factors, including population density and environmental conditions. This study aimed to analyze the spatial distribution of stunting in Pekanbaru and examine its correlation with environmental and geographic factors, including population density, access to clean water, and sanitation facilities. An observational analytical design was used, incorporating spatial analysis and correlation tests. The study was conducted in 2023 by confirming reported stunting cases. Results showed that stunting was distributed across 15 districts in Pekanbaru, with the highest prevalence found in the sub-districts of Lima Puluh. Notably, Lima Puluh also ranked third in population density. The average percentage of clean drinking water quality was 91.8%, and access to healthy latrines averaged 99.8%. Correlation analysis revealed no significant relationship between population density (p 0.112, r 0.417), drinking water quality (p 0.568, r 0.160), or access to healthy latrines (p 0.995, r 0.002) and the prevalence of stunting. These findings suggest that the three examined variables were not significantly associated with stunting incidence. However, the variable of population density showed a potential correlation, indicating a need for further research.

Kata Kunci:

Spasial;
Stunting;
Kepadatan penduduk;
Sumber air minum;
Akses jamban sehat

ABSTRAK

Stunting merupakan masalah gizi kronis yang masih menjadi tantangan besar di Indonesia. Pada tahun 2022, prevalensi stunting di Indonesia tercatat sebesar 21,6%, masih berada di atas ambang batas yang ditetapkan oleh WHO, yaitu di bawah 20%. Sementara itu, di Kota Pekanbaru, prevalensi stunting mencapai 23%, yang menyumbang bagian signifikan dari total kasus stunting di Provinsi Riau. Masalah stunting merupakan salah satu cerminan dari keadaan sosial ekonomi masyarakat karena terjadinya stunting dapat dipengaruhi oleh berbagai faktor termasuk faktor kepadatan penduduk dan kondisi lingkungan. Penelitian ini bertujuan untuk mengetahui distribusi spasial prevalensi stunting dan korelasi kondisi lingkungan serta geografis pada balita stunting. Penelitian ini merupakan penelitian observasional analitik untuk mengetahui sebaran stunting menggunakan analisis spasial dan uji korelasi kondisi geografis dan lingkungan dengan prevalensi stunting. Penelitian ini dilakukan pada tahun 2023 dengan melakukan konfirmasi kasus stunting di seluruh Puskesmas di Kota Pekanbaru. Hasil penelitian menunjukkan bahwa prevalensi stunting tersebar di 15 Kecamatan di Kota Pekanbaru, dengan prevalensi tertinggi terdapat pada Kecamatan Lima Puluh, kecamatan Lima Puluh juga merupakan wilayah dengan kepadatan tertinggi ketiga. Persentase rata-rata kualitas air minum 91,8% dan persentase rata-rata akses terhadap jamban sehat yaitu 99,8%. Hasil Uji korelasi menunjukkan bahwa tidak terdapat hubungan yang signifikan antaran variabel kepadatan penduduk (p 0,112, r 0,417), kualitas air minum (p 0,568, r 0,160) dan akses jamban sehat (p 0,995, r 0,002) terhadap prevalensi stunting. Penelitian ini menunjukkan adanya ketidakmerataan distribusi kasus stunting di 15 kecamatan di Kota Pekanbaru. Secara keseluruhan penelitian ini menunjukkan bahwa ketiga variabel yang diteliti belum menunjukkan hubungan yang signifikan terhadap kejadian stunting. Namun, variabel kepadatan penduduk menunjukkan potensi hubungan yang perlu ditindaklanjuti dengan penelitian lebih lanjut.

✉ ***Corresponding Author:***

Riska Epina Hayu
Telp. 082322842003
Email: riska.epina@ikta.ac.id

INTRODUCTION

Stunting is a global nutritional problem and remains a priority health issue in Indonesia. UNICEF data in 2017 showed that Indonesia was still at a high level of stunting prevalence (20 – 29%), indicating that the rate remained above the WHO standard of less than 20% (World Health Organization & United Nations Children's Fund (UNICEF) & International Bank for Reconstruction and Development, 2018). In 2022, the national prevalence of stunting was estimated at 21.6%. Through the Ministry of Health, the President of the Republic of Indonesia set a national target to reduce stunting prevalence to 14% by 2024. This reflects the government's commitment to addressing stunting, which is not merely a matter of physical growth but involves three critical concerns: impaired learning ability, intellectual disability, and increased risk of chronic diseases (Kementerian Kesehatan RI, 2023).

According to the Indonesian Ministry of Health's 2021 profile, the prevalence of stunting in Indonesia was 4.9% of the total number of children aged 0–59 months in that year (Kementerian Kesehatan RI, 2023). Data from a nutritional surveillance conducted at community health centers (posyandu) in Riau Province in 2020 reported that 25,617 toddlers experienced stunting (Dinas Kesehatan Provinsi Riau, 2019). In Pekanbaru City, stunting cases accounted for 23% of the total stunting cases in the province. Although Pekanbaru did not record the highest number of stunting cases, it still requires special attention due to the persistence of new cases every year. Researchers argue that residents in urban areas like Pekanbaru should have easier access to healthcare services, information, and education about stunting compared to rural populations, where such access is still limited. A study by (Purwanti & Nurfita, 2019) found that place of residence (rural vs. urban) significantly affects the likelihood of stunting, with children in rural areas being 1.136 times more likely to experience stunting than those in urban settings. Therefore, the persistence of stunting in an urban setting such as Pekanbaru may be influenced by other factors that merit further investigation.

Various studies have shown that the causes of stunting are multidimensional, ranging from inadequate nutritional intake and infectious diseases to environmental and social factors. An unhealthy environment, including limited access to clean water sources and sanitation facilities such as healthy latrines, has been shown to contribute significantly to high stunting rates (UNICEF, 2024). International studies, such as one conducted by Sahiledengle et al., (2022) in Ethiopia, reported that access to sanitation and housing conditions affect children's linear growth indicators, although household drinking water sources were not predictive of wasting or stunting. Other research has suggested that these challenges are often intensified in areas with high population density, which strains environmental infrastructure, increases the risk of contamination, and complicates the provision of basic services (Black et al., 2013; Prendergast & Humphrey, 2014). This illustrates a synergistic effect between physical environmental conditions and socio-demographic factors on the incidence of stunting.

Several studies in Indonesia have examined the relationship between environmental sanitation and stunting. For example, research by Suarayasa et al. (2023) in Palu City found that access to clean water and healthy toilets was significantly associated with the nutritional status of toddlers. Another study by Apriulana & Fikawati (2018) concluded that poor sanitation significantly influences the incidence of stunting. Gaffan et al. (2023) found that children under five living in households with limited sanitation facilities were 1.33 times more likely to be underweight compared to those living in homes with basic sanitation. However, most of these studies have not included population density as an environmental determinant that could either strengthen or weaken the relationship between sanitation and stunting. Therefore, integrative research is needed to examine the combined influence of population density, drinking water sources, and access to healthy toilets on stunting prevalence. By analyzing these variables together, this study aims to provide a more comprehensive understanding of the environmental determinants of stunting and serve as a foundation for developing area-based intervention policies.

METHOD

Type of Research

This study is an analytical observational study with a quantitative approach. Observational research implies that the researchers did not provide direct treatment or intervention to the variables under study but instead observed and analyzed existing data. It is categorized as analytical because it aims to identify correlations between the variables examined, namely geographical conditions (population density) and environmental factors (sources of drinking water and access to healthy toilets). The study aims to

examine the distribution of stunting cases across sub-districts in Pekanbaru City and determine the correlation between geographical and environmental factors and the prevalence of stunting.

Place and Time of Research

This study was conducted across all sub-districts in Pekanbaru City, comprising 15 (fifteen) sub-districts with recorded stunting cases in 2022. These sub-districts include Bina Widya, Tuah Madani, Payung Sekaki, Kulim, Tenayan Raya, Bukit Raya, Marpoyan Damai, Sail, Lima Puluh, Pekanbaru Kota, Rumbai Barat, Rumbai, Rumbai Timur, Senapelan, and Sukajadi. The research was carried out from June 2023 to February 2024, with confirmation of stunting case data conducted at 20 (twenty) Health Centers spread throughout Pekanbaru City.

Population and Sample

The population in this study comprised all toddlers under five years old residing in the 15 sub-districts of Pekanbaru City. The sample consisted of children under five years old with stunting status, spread across these sub-districts in 2022. A total of 318 stunting cases were reported in 2022, distributed across all 15 sub-districts in Pekanbaru City.

Data Collection

Data on stunting cases were collected through the confirmation of reported cases from the year 2022, obtained from 20 (twenty) Health Centers in Pekanbaru City, and grouped by sub-district. Information on population density per sub-district was obtained from the Central Statistics Agency BPS Kota Pekanbaru. Data on environmental conditions per sub-district were collected from the Pekanbaru City Health Profile report.

Processing and Analysis of Data

The prevalence of stunting was calculated by dividing the number of stunting cases in toddlers aged 0–58 months by the total number of toddlers in the same age group in 2022, categorized by sub-district. Data processing and analysis included spatial analysis using the ArcMap 10.8 application to determine the distribution of stunting and population density across sub-districts in Pekanbaru City. Population density was calculated using the formula: number of residents divided by area (km²). Bivariate analysis was conducted using the SPSS application with Pearson's correlation test to determine the degree and direction of the relationship between two numerical variables. Correlation was measured using Karl Pearson's theory, referred to as Pearson's correlation coefficient (r), with values ranging from -1 to +1. The interpretation of correlation strength is presented in the following table:

Table 1. Interpretation of Correlation Coefficient Value Relationships

r value	Interpretation of Relationships
(+1)	Perfect positive relationship
0,70-0,99	Positive Relationships are very strong
0,40-0,69	Positive Relationship is strong enough
0,20-0,39	Positive positive weak relationship
0,00-0,19	Positive relationship is very weak/almost non-existent
0	No relationship
(-0,00- -0,19)	The negative relationship is very weak
(-0,20 – -0,39)	Weak negative relationship
(-0,40 – -0,69)	The negative relationship is moderate strong
(-0,70 – -0,99)	Negative relationship is very strong
(-1,0)	Perfect negative relationship

RESULT

This study aimed to determine the distribution of stunting prevalence and to describe environmental conditions (drinking water quality and access to healthy toilets) and geographical factors (population density) in Pekanbaru City in 2022.

Distribution of Stunting Frequency by Gender

The following is the percentage of stunting cases based on gender in Pekanbaru City in 2022.

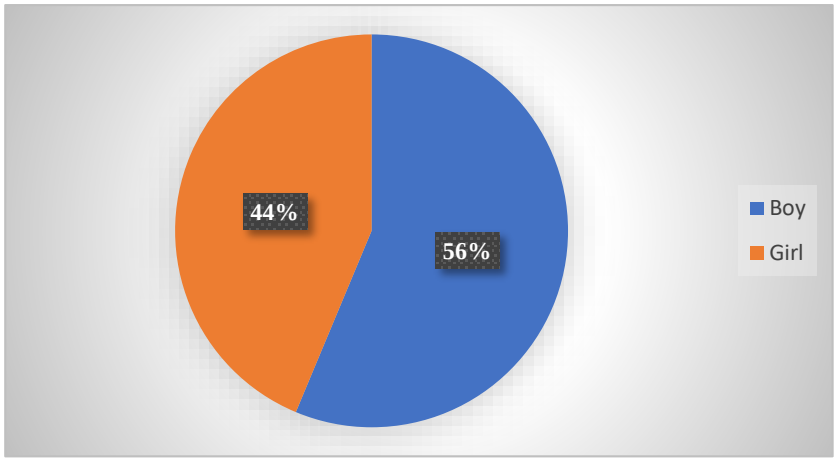

Figure 1. Percentage of Stunting by Gender

Based on the graph above, the majority of stunting cases in Pekanbaru City in 2022 occurred in male toddlers (56%). This finding shows no significant difference in stunting cases between male and female children. Therefore, gender is not considered a suspected risk factor for stunting in this study.

Stunting Prevalence

The following is the prevalence of stunting in Pekanbaru City in 2022.

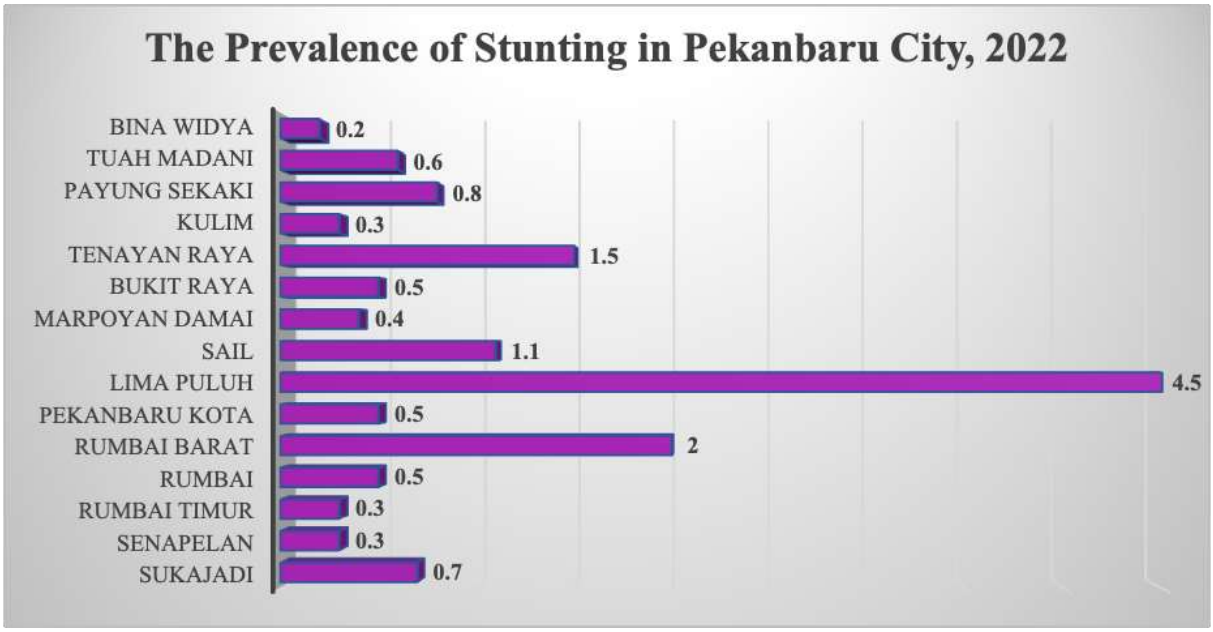

Figure 2. Prevalence of Stunting Cases by Subdistrict in Pekanbaru City, 2022

Stunting prevalence was measured by dividing the number of stunting cases among children aged 0–58 months by the total number of children in the same age group in 2022, categorized by sub-district. The graph shows that the highest prevalence was found in Lima Puluh Sub-district (4.5%). The lowest prevalence was recorded in Bina Widia Sub-district, at 0.2%.

Distribution of Stunting

The following is the spatial distribution of stunting cases and population density by sub-districts in Pekanbaru City.

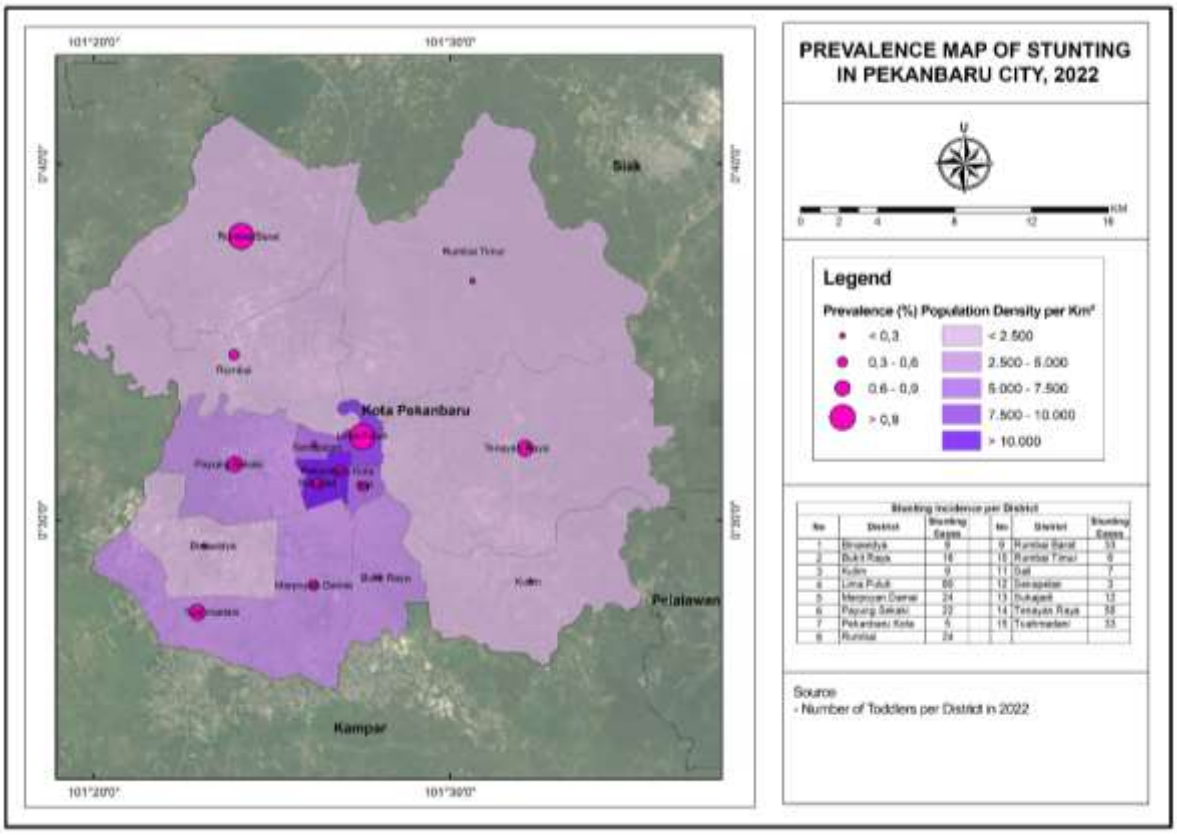

Figure 3. Map of Stunting Prevalence and Population Density by Subdistrict in Pekanbaru City, 2022

Based on the map above, Lima Puluh Sub-district had the highest prevalence of stunting, with >0.9%, or approximately 60 reported cases. Although stunting has multiple risk factors, this study focused on geographic conditions (population density) and environmental conditions (drinking water sources and sanitation) in the sub-districts with the highest number of stunting cases.

Population Density by District

The following is the population density distribution based on sub-districts in Pekanbaru City in 2022.

Table 2. Population Density by District in Pekanbaru City in 2022

No	District	Population Density (Jiwa/Km^2)
1.	Sukajadi	11,434
2.	Senapelan	5,334
3.	Rumbai Timur	247
4.	Rumbai	1,509
5.	Rumbai Barat	300
6.	Pekanbaru Kota	10,035
7.	Lima Puluh	9,589
8.	Sail	6,273
9.	Marpoyan Damai	4,317
10.	Bukit Raya	4,267
11.	Tenayan Raya	930
12.	Kulim	971
13.	Payung Sekaki	2,541
14.	Tuah Madani	4,870
15.	Bina Widya	2,026

Population density varied across sub-districts, with Sukajadi being the most densely populated sub-district, at 11,434 people/km², and Rumbai Timur having the lowest, at 247 people/km². As of 2021, Pekanbaru City covers an area of 632.26 km². The sub-districts of Rumbai Timur, Tenayan Raya, and Rumbai Barat are the three largest in Pekanbaru City, comprising 21.91%, 18.12%, and 13.63% of the total area, respectively. In terms of elevation, Tenayan Raya is the highest sub-district, located at 43 meters above sea level, while Lima Puluh is the lowest, at approximately 4 meters above sea level (BPS Kota Pekanbaru, 2022).

The graph below shows the distribution of stunting cases within the Lima Puluh Sub-district, by village.

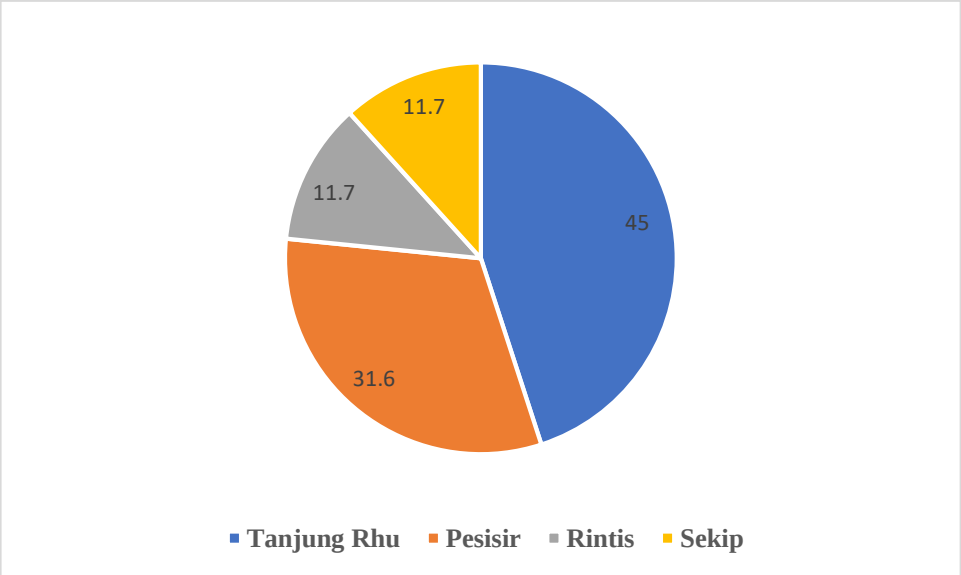

Figure 4. Percentage of Stunting Cases Based on Sub-districts in Lima Puluh District in 2022

The graph indicates that within Lima Puluh Sub-district, Tanjung Rhu Village had the highest proportion of stunting cases, accounting for 45% of the total.

Drinking Water Quality in Fifteen Districts of Pekanbaru City

The following is the percentage of drinking water quality that meets health standards in Pekanbaru City in 2022.

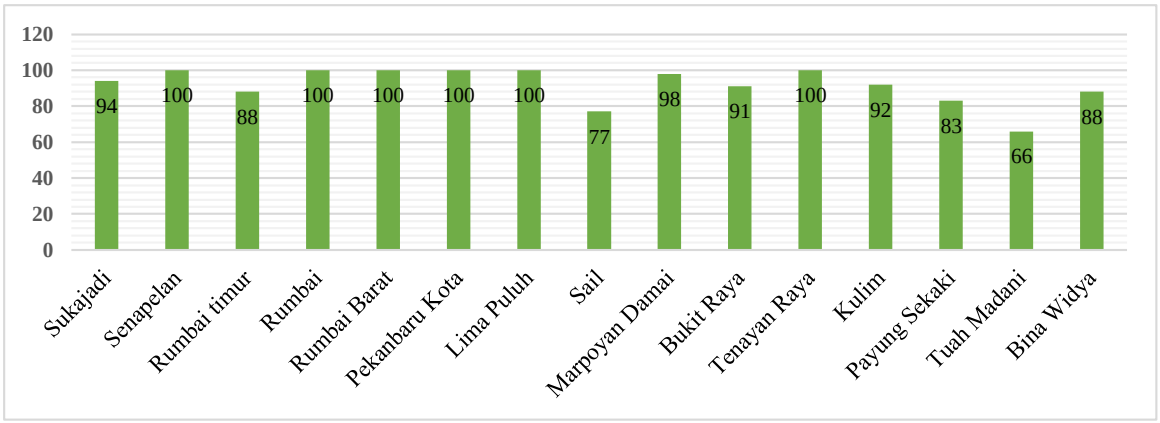

Figure 5. Drinking Water Quality Standards by Subdistrict in Pekanbaru City, 2022

The graph above shows that the percentage of safe (standard-compliant) drinking water varies among sub-districts. Senapelan, Rumbai, Rumbai Barat, Pekanbaru Kota, Lima Puluh, and Tenayan Raya recorded the highest percentages, at 100%. In contrast, Tuah Madani recorded the lowest

percentage, at 66%. These findings reflect an inequality in access to safe drinking water across sub-districts in Pekanbaru City.

Access to Healthy Toilet Facilities in Pekanbaru City

The following is the percentage of access to healthy toilet facilities in Pekanbaru City in 2022, by sub-district.

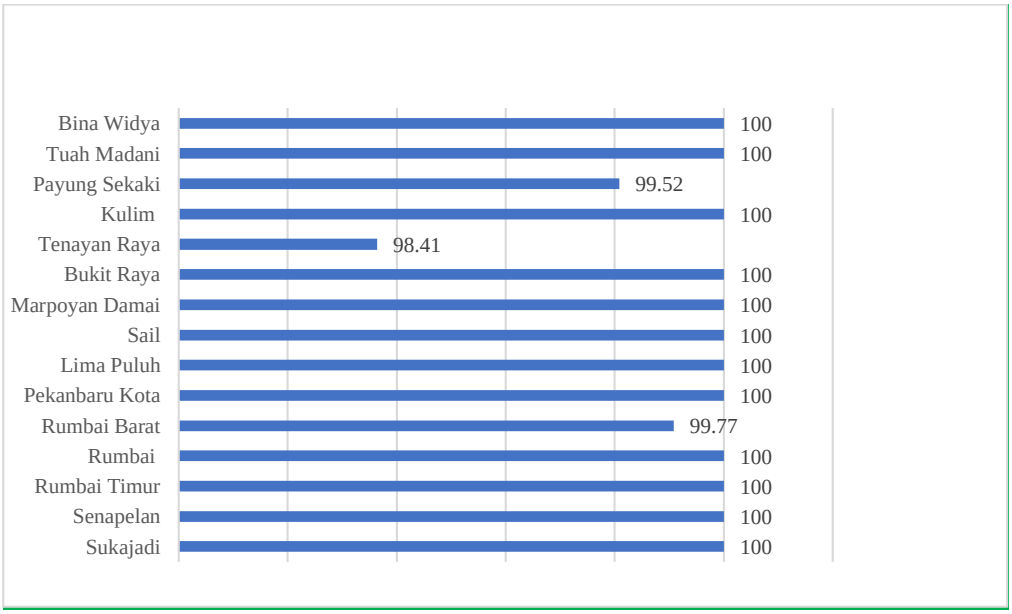

Figure 6. Access to Sanitary Toilets by Subdistrict in Pekanbaru City in 2022

The graph shows that nearly all sub-districts in Pekanbaru City have achieved universal access to sanitary toilet facilities, with an average access rate exceeding 97%. This indicates the success of government programs aimed at improving environmental sanitation. However, continued efforts are required to ensure equal access for all communities, including those in Tenayan Raya Sub-district, which recorded a slightly lower access rate of 98.41%. In comparison, the national average for access to sanitary toilets in Indonesia in 2022 was 80.92% (Kementerian Kesehatan RI, 2023), and the average for Riau Province was 84.06% (Dinas Kesehatan Provinsi Riau, 2022).

Correlation Test of Population Density, Drinking Water Quality and Access to Healthy Toilets on Stunting Incidence

Table 2. Correlation Coefficient Test

Variable X	Variable Y	Koefisies Korelasi ®	P-value
Population Density	Stunting	0.417	0.122
Drinking Water Quality	Stunting	0.160	0.568
Access to Healthy Toilets	Stunting	0.002	0.995

The results of the statistical analysis indicated a moderate positive correlation between population density and stunting prevalence (r = 0.417), with no statistically significant relationship (p = 0.122). The variables of drinking water quality and access to healthy toilets showed a very weak positive correlation with stunting (r = 0.160, p = 0.568; and r = 0.002, p = 0.995, respectively).

DISCUSSION

Population Density and Stunting Prevalence

Population density reflects the level of pressure on natural resources and the intensity of human activity in a particular area (Requia et al., 2018). Population density varies across countries, regions,

and continents; Asia and Europe tend to have higher densities than the United States (Su et al., 2015). Indonesia's population density in 2022 reached 143.86 people per square kilometer. Exposure to environmental contaminants from soil, water, and air—combined with socioeconomic vulnerabilities and high population density—can increase health risks both at the subclinical and clinical levels. Efforts to improve environmental quality can generate significant health and economic benefits, especially in densely populated areas with intense human activity (Silveira et al., 2016). Higher population density is also correlated with the availability of public service facilities, which may improve community quality of life (Irham & Putri, 2023).

Research has shown that population density is one of the factors contributing to stunting (Atalell et al., 2023). While urban areas tend to have better awareness of child nutrition, higher wealth indices, and improved access to healthcare, they also exhibit higher population densities. Conversely, rural areas are more likely to experience poor sanitation, limited nutritional knowledge, and lower socioeconomic status (Mrema et al., 2021).

Based on this study's findings, the three sub-districts with the highest population densities in Pekanbaru City are Sukajadi (11,434 people/km²), Pekanbaru Kota (10,035 people/km²), and Lima Puluh (9,589 people/km²). Lima Puluh has the highest stunting prevalence and the highest number of stunting cases overall. Although population density may not directly cause stunting, it can create conditions that increase the risk, such as limited access to quality healthcare, degraded environmental conditions, insufficient nutritious food, and socioeconomic stress.

The Lima Puluh area is relatively flat and low-lying, situated along the Siak River. The Tanjung Rhu and Pesisir neighborhoods are densely populated, especially near the city center and riverbanks. Houses in these areas are close together, particularly in older residential zones. Many neighborhood roads are narrow, making access for large vehicles and sanitation services difficult. The highest percentages of stunting in Lima Puluh District were found in Tanjung Rhu and Pesisir sub-districts.

Despite these patterns, the Pearson correlation test showed no statistically significant relationship between population density and stunting prevalence in Pekanbaru. This finding indicates that population density may not be the dominant factor contributing to stunting in this context. This aligns with a study by Ahmed et al. (2023), which found that population density was not a significant risk factor for stunting in Sub-Saharan Africa. Nevertheless, population density demonstrated a moderately strong positive correlation with stunting prevalence, suggesting the need for targeted interventions that take population density into account in affected areas.

Water Quality and Stunting Prevalence

According to the Ministry of Health, access to safe drinking water in Indonesia reached 91.05% in 2022 (Kementerian Kesehatan RI, 2023), while water quality compliance monitoring in Riau Province reached 95.3% (Dinas Kesehatan Provinsi Riau, 2019). According to Minister of Health Regulation No. 2 of 2023 on the Implementation of Government Regulation No. 66 of 2014 concerning Environmental Health, drinking water—whether treated or untreated—must meet health standards and be safe for direct consumption. To prevent health risks, drinking water must comply with established quality requirements. Its quality is maintained through internal and external monitoring, with external monitoring conducted by district or city health offices (Kementerian Kesehatan RI, 2023).

Globally, inadequate access to safe water, sanitation, and hygiene remains a major risk factor for diarrheal diseases, which are associated with higher morbidity and mortality among children (Forouzanfar et al., 2015). In Ethiopia, where stunting prevalence was estimated at 37%, unsafe drinking water contributed significantly to stunting risk (Ethiopian Public Health Institute (EPHI) and ICF, 2021). WASH interventions could have prevented up to 94% of under-five deaths in the country (Troeger et al., 2020). WASH improvements are also known to reduce environmental enteric dysfunction (EED), which impairs nutrient absorption and contributes to growth retardation (Mbuya & Humphrey, 2016). Research by (Bagu et al., 2024), confirmed a significant link between unsafe water and increased stunting risk due to infection-related malabsorption.

In this study, stunting prevalence in Pekanbaru varied between sub-districts, with the highest prevalence exceeding 0.9% and the lowest below 0.3%. Sub-districts with lower percentages of safe drinking water tended to show higher stunting prevalence. For instance, Tuah Madani, with only 66% safe water coverage, had the third highest prevalence of stunting (0.6%). Despite this apparent trend, the

correlation test revealed no statistically significant relationship between water quality and stunting. This suggests that the relationship between water quality and stunting may be mediated by other factors, such as hygienic behavior and household water handling practices.

The effect of water quality on stunting is complex and long-term. Even water considered safe may still contain contaminants if storage and handling practices are poor. The lack of statistical significance in this study does not negate the theoretical importance of clean water in stunting prevention. These results align with Dearden et al. (2017), who found no significant relationship between improved drinking water access and stunting risk, emphasizing that other factors may play a larger role in determining nutritional outcomes.

Access to Sanitary Toilets and Stunting Prevalence

Sanitation is a critical determinant of public health. According to the WHO, sanitation involves facilities and services for the safe disposal of human excreta. The Ministry of Health defines a healthy toilet as one that meets structural and health requirements, ensuring that waste does not contaminate the environment or expose users to disease vectors (Kementerian Kesehatan RI, 2023).

Infants living in households practicing open defecation are at higher risk of stunting. The GROW project in Ethiopia found a significant association between open defecation and stunting (Ahmed et al., 2023). Poor sanitation increases the risk of various infections and is directly linked to impaired linear growth in children under five (Mudadu Silva et al., 2023). In India, children from households that practiced open defecation were 14% more likely to be stunted than those with access to proper toilets (Rahman et al., 2020).

In Pekanbaru City in 2022, nearly all sub-districts reported over 98% access to healthy toilet facilities. However, three sub-districts—Tenayan Raya (98.41%), Payung Sekaki (99.52%), and Rumbai Barat (99.77%)—had slightly lower access levels and were also among those with the highest stunting prevalence. Statistical analysis revealed no significant relationship between toilet access and stunting, although the p-value approached the significance threshold ($p = 0.075$). This suggests a potential association that warrants further investigation. Lack of access to proper toilets can increase exposure to fecal contamination, elevating the risk of diarrheal infections, malnutrition, and stunting. Even when physical access exists, inconsistent or improper use—especially by children—may compromise effectiveness. Furthermore, the quality of toilet construction and maintenance plays a role in ensuring disease prevention.

Although overall access to healthy latrines in Pekanbaru is high, three sub-districts still show slightly lower coverage. This disparity may contribute to the prevalence of stunting, as inadequate sanitation can lead to open defecation, contaminating water sources and the environment. Such contamination increases the risk of infectious diseases, particularly diarrhea in children, which disrupts nutrient absorption and hampers growth. While most households have latrines, consistent use—especially by children—is not always guaranteed. Furthermore, the quality and cleanliness of these facilities are crucial for effective disease prevention. Although significant progress has been made in improving latrine access, sustained efforts are needed not only to expand infrastructure but also to promote behavior change and enhance overall community well-being to effectively reduce stunting rates.

One limitation of this study is that it only assessed access to infrastructure (drinking water and toilets) without evaluating how these facilities are utilized. The mere presence of a toilet does not ensure consistent or hygienic use by all household members.

CONCLUSION AND SUGGESTION

Based on the research findings, there is an evident inequality in the distribution of stunting cases across sub-districts in Pekanbaru City. Overall, the three variables examined—population density, drinking water quality, and access to healthy toilets—did not show a statistically significant relationship with stunting incidence. However, population density demonstrated a potential association that warrants further investigation. Future studies should also explore other potential contributing factors, such as nutritional intake, maternal education, parenting practices, and family socioeconomic status, which may serve as key determinants of stunting. The findings of this study are expected to enhance local understanding of the environmental and geographic factors influencing stunting, and serve as a

foundation for formulating more targeted and effective policies and interventions to address stunting in Pekanbaru City.

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