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MAPPING THE DISTRIBUTION OF DIARRHEA CASES AMONG CHILDREN UNDER FIVE AND THEIR RISK FACTORS IN CIREBON CITY USING A GEOGRAPHIC INFORMATION SYSTEM IN 2024

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Abstract

Background: Diarrhea is an environmentally-based disease that remains a global and national health threat. West Java is the province with the highest prevalence, reaching 11.0%, while in Cirebon City, the prevalence of diarrhea among toddlers is 20.99%. These high figures indicate a significant public health problem in Cirebon City. Therefore, this study aims to map diarrhea cases and their influencing factors in Cirebon City in 2024. Research Methodology: This type of research uses descriptive quantitative with a cross-sectional design that uses secondary data regarding cases of diarrhea in toddlers and their risk factors. Research Results: The results of the mapping of toddler diarrhea cases indicate that the majority of areas are classified as low to moderate, with 12 community health centers in the low category, 9 in the moderate category, and 1 in the high category. Exclusive breastfeeding coverage is dominated by 14 community health centers in the moderate category and 7 in the good category, PHBS throughout the area is in the good category, and population density is classified as very high. Accumulated weighting shows that most areas are in the moderate classification. Conclusion**:** The distribution of diarrhea in toddlers in Cirebon City is predominantly low to moderate, with a small number of areas in the high category. Risk factors for exclusive breastfeeding, clean and healthy lifestyles (PHBS), and population density vary, but are generally good to moderate. Weighting results indicate that the majority of areas have a moderate risk level.

Keywords: Diarrhea, Toddlers, Risk Factors, GIS, QGIS

Introduction

The occurrence of diseases from an epidemiological perspective is influenced by the interaction between the agent, host, and environment. An imbalance in this epidemiological triad can trigger various health problems, one of which is diarrhea [1]. Diarrhea (diarrheal disease) is a condition characterized by a frequency of bowel movements more than three times a day with liquid or abnormal stool consistency, which may be accompanied by blood or mucus [2]. This disease is generally caused by infections of the digestive tract due to microorganisms such as bacteria, viruses, and parasites [3]. Diarrhea is classified as an environment-based disease that is actually preventable; however, it remains a major cause of morbidity and mortality, particularly among children under five who are vulnerable to dehydration and growth and developmental disorders [4]. Globally, diarrhea continues to be a significant health burden, with approximately 1.7 billion cases annually among children under five and 443,832 deaths among children aged 1–59 months, making it one of the leading causes of death in this group [3]. This indicates that diarrhea remains a priority issue in public health, especially in developing countries.

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In Indonesia, diarrhea remains a serious health problem and has the potential to cause outbreaks (KLB) [5]. Data show an increase in the number of diarrhea cases from 2,604,952 cases in 2022 to 3,105,152 cases in 2023. Among children under five, cases increased from 974,268 to 1,168,393 during the same period. Based on the 2023 Indonesia Health Survey (SKI), the prevalence of diarrhea among children under five was 7.4%, while it was 2% for all age groups and 3.9% among infants [6]. These data indicate that diarrhea remains a significant health threat, particularly for vulnerable age groups. At the regional level, West Java Province is among the areas with a high burden of diarrhea cases, with 213,663 cases reported among children under five, followed by East Java and Central Java [7]. The prevalence of diarrhea among children under five in West Java is recorded at 11.0% with service coverage of 34.56%, indicating a gap between incidence and case management [6],[7]. Meanwhile, in Cirebon City, the number of diarrhea cases among children under five reached 4,853 cases with a prevalence of 20.99% and ranked among the top 10 diseases in 2024 [8]. This condition confirms that diarrhea among children under five remains a priority health issue at the local level.

The incidence of diarrhea in children under five is influenced by various multidimensional risk factors. Previous studies have shown that environmental factors such as access to clean water, latrine conditions, wastewater disposal systems, and waste management play a role in increasing the risk of diarrhea [9]. In addition, factors such as population density, water sanitation, and clean and healthy living behavior (PHBS) also contribute to disease transmission [10]. Behavioral factors and maternal characteristics, such as exclusive breastfeeding and level of knowledge, are also significantly associated with diarrhea incidence among children under five [11]. Furthermore, nutritional aspects such as vitamin A supplementation as well as zinc and oral rehydration therapy have been shown to influence both the occurrence and management of diarrhea [12]. These findings indicate that diarrhea is a complex disease with interrelated determinants. In the context of public health analysis, a spatial approach using Geographic Information Systems (GIS) is increasingly relevant. GIS enables location-based analysis by processing spatial and attribute data simultaneously, thereby producing more informative visualizations of disease distribution [13],[14]. The use of GIS in the health sector can help identify high-risk areas, support decision-making, and improve the effectiveness of health interventions [15],[16],[17]. Through spatial mapping, disease distribution can be analyzed more comprehensively, facilitating the determination of intervention priorities [18].

Although several studies have examined diarrhea mapping using GIS, most remain descriptive and are limited to certain variables, broader locations (provincial level), or have not integrated key risk factors such as exclusive breastfeeding, PHBS, and population density simultaneously. In addition, studies at the city level, particularly in Cirebon City using a spatial approach based on recent data, are still limited. Therefore, there is a research gap in the integration of spatial analysis and key risk factors of diarrhea comprehensively at a more specific regional level. Based on this, this study aims to map the distribution of diarrhea cases among children under five and analyze their risk factors, including exclusive breastfeeding, clean and healthy living behavior (PHBS), and population density in Cirebon City in 2024 using Geographic Information Systems (GIS). This study is expected to provide more accurate spatial-based information to support the planning of targeted health interventions.

Methods

This research is a quantitative study with a descriptive analysis approach. The research design used is cross-sectional. This study was conducted at the Cirebon City Health Office from November 2025 to March 2026. The study population consisted of all toddlers with diarrhea cases based on secondary data from routine reports of the Cirebon City Health Office in 2024. The sample included the entire population using a total sampling technique. The research variables consisted of the dependent variable, namely the incidence of diarrhea in toddlers in Cirebon City in 2024, and independent variables including exclusive breastfeeding, Clean and Healthy Living Behavior (PHBS), and population density. Operational definitions were used to clarify the variables so that they could be measured, where diarrhea in toddlers was defined as defecating more than three times a day in toddlers (<5 years), categorized as low (<20%), moderate (21–31%), and high (>32%) (ordinal); Exclusive breastfeeding is defined as breastfeeding for up to six months without additional intake, categorized as good (>80%), moderate (40–80%), and low (<40%) [31] (ordinal); PHBS refers to the implementation of 10 household PHBS indicators, categorized as good (>70%), moderate (35–70%), and low (<35%) [25] (ordinal); and population density is defined as the number of people per km², categorized as low (<50), moderate (50–150), high (150–400), and very high (>400) [7] (ordinal). The research instrument is a checklist sheet. Data analysis uses descriptive analysis. Distribution classification is carried out using the class interval method with the formula Interval = (Maximum value – Minimum value) / (Number of classes) to support spatial visualization in GIS. The results of the analysis are presented in the form of visualization maps for dependent and independent variables using color symbols based on the distribution level, namely diarrhea cases using green (low), yellow (moderate), and red (high); Exclusive breastfeeding and PHBS are colored green (good), yellow (moderate), and red (low); and population density is colored green (low), yellow (moderate), blue (high), and red (very high). The distribution of diarrhea in toddlers and risk factors were visualized using QGIS version 3.10.0.

Results

1. Profile of the Cirebon City Health Office

Cirebon City is part of West Java Province and is located on the northern coast of Java Island at coordinates 108°33′26″ E and 6°42′22″ S, with an elevation of approximately 5 meters above sea level and a total area of approximately 37.358 km². The city has a tropical climate with temperatures ranging from 23.4°C to 33.6°C and an average annual rainfall of 2,751 mm, which influences environmental health conditions.

The administrative boundaries are as follows:

1. North: Kedung Pane River
2. West: Flood Canal/Cirebon Regency
3. East: Java Sea
4. South: Kalijaga River

Administratively, Cirebon City consists of 5 sub-districts, 22 urban villages, and 22 community health centers (Puskesmas) serving as primary healthcare facilities. The Cirebon City Health Office is located on Kesambi Raya Street, Kesambi District, with jurisdiction covering the entire city. This administrative division serves as the basis for the spatial analysis to identify the distribution of diarrhea cases among children under five and their associated risk factors at the community health center service area level.

2. Distribution of Diarrhea Cases and Risk Factors Among Children Under Five at Each Public Health Center in Cirebon City

Table 4.1 Percentage of Cases and Risk Factors

No	Public Health Center	Diarrhea	Exclusive Breastfeeding	PHBS	Population Density
1	Astanagarib	28.88	52.94	91.80	15.883
2	Cangkol	25.63	56.25	91.86	16.487
3	Drajat	11.03	80.85	93.90	17.270
4	Gunung Sari	22.42	76.74	96.70	9.934
5	Jagasatru	24.97	76.00	93.06	30.766
6	Jalan Kembang	18.92	83.05	94.12	12.231
7	Kalijaga Permai	25.55	86.58	96.24	7.605
8	Kalitanjung	17.39	85.14	90.99	9.563
9	Kejaksan	17.95	67.95	93.09	11.287
10	Kesambi	24.76	77.42	95.19	10.091
11	Kesunean	18.11	63.00	91.75	8.157
12	Larangan	16.07	94.90	94.69	11.524
13	Majasem	13.35	80.25	95.15	11.400
14	Nelayan	23.63	66.67	92.15	11.589
15	Pamitran	21.08	53.33	88.97	15.349
16	Pengambiran	19.76	63.39	91.90	9.961
17	Pekalangan	18.97	35.71	91.59	8.325
18	Perumnas Utara	10.08	73.97	94.85	8.225
19	Pesisir	12.31	68.29	92.23	8.148
20	Pulasaren	23.86	68.42	73.80	30.455
21	Sitopeng	42.68	66.12	89.99	3.671
22	Sunyaragi	16.11	81.43	92.44	5.320

3. Results of Mapping Analysis of Prevalence Distribution and Risk Factors of Diarrhea Among Children Under Five

a. Results of Mapping the Distribution of Diarrhea Cases Among Children Under Five at Each Public



Gambar 1Peta Sebaran Kasus Diare pada Balita Kota Cirebon Tahun 2024

Health Centers in Cirebon City in 2024

Based on data from 2024, a total of 4,853 diarrhea cases among children under five were recorded in Cirebon City. The data were obtained from the annual report of the Health Office, which is a recapitulation of 22 public health centers, and were then processed and integrated into a Geographic Information System (GIS) using QGIS to produce a comprehensive distribution map of cases. The results of the processing show that the classification of areas was carried out automatically through

QGIS into three categories, namely low (green), moderate (yellow), and high (red). This classification aims to group the distribution of cases proportionally, making it easier to identify areas with different prevalence levels as a basis for determining health intervention priorities.

Based on Map 1, there is variation in the distribution of cases across regions. Sitopeng Public Health Center has the highest prevalence at 42.68% (high category). A total of 9 public health centers fall into the moderate category, while the remaining 12 public health centers are in the low category with relatively controlled cases. In addition, this study also analyzes the relationship between diarrhea incidence and risk factors through score-weighted mapping, which is presented in the following map.



Gambar [ ] Peta Sebaran Kasus Diare pada Balita Berdasarkan Faktor-Faktor Risiko Kota Cirebon Tahun 2024

The classification in Map 2 is based on the weighting of research variables, namely the incidence of diarrhea among children under five and its risk factors. Each variable is assigned a score in three categories: score 1 (low), score 2 (moderate), and score 3 (high). Furthermore, all scores are summed to obtain a total score used to classify areas into three distribution classes. The analysis results indicate variations in scores across the working areas of public health centers in Cirebon City. There is 1 public health center classified in the high-score category (red), namely Jagasatru Public Health Center, 14 public health centers in the moderate category (yellow), and 7 public health centers in the low category (green). These differences reflect variations in the level of diarrhea risk among children under five, influenced by the accumulation of risk factors in each area.

b. Mapping of Exclusive Breastfeeding Distribution at Each Public Health Center in Cirebon City in 2024



The data for this study were obtained from the 2024 coverage report of infant and under-five interventions from the Cirebon City Health Office, which is a recapitulation of monthly reports from 22 public health centers. The data were then processed using QGIS to produce a distribution map of exclusive breastfeeding coverage. The map classification is divided into three categories: green (high >80%), yellow (moderate 40%–80%), and red (low <40%).

Based on Map 3, there are 7 public health centers in the high category (green), namely Jalan Kembang (83.05%), Sunyaragi (81.43%), Majasem (80.25%), Drajat (80.85%), Kalitanjung (85.14%), Perumnas Utara (94.90%), and Kalijaga Permai (86.58%). A total of 14 public health centers fall into

the moderate category (yellow), while 1 public health center is in the low category (red) with a coverage of 37.71%.

In addition, this study also analyzes the relationship between diarrhea incidence among children under five and exclusive breastfeeding practices, which is visualized through score-weighted mapping in the following map.



The classification in Map 4 was developed using a weighting method for the variables of diarrhea among children under five and exclusive breastfeeding coverage. Each variable was assigned a score: 1 (high/good), 2 (moderate), and 3 (low/poor). The scores for each variable were then summed to obtain a total score, which was used to classify the distribution of diarrhea cases based on the exclusive breastfeeding factor.

The mapping results show variations in scores across the working areas of public health centers. There are 5 public health centers in the score 1 category (high/green), namely Gunung Sari, Jagasatru, Kalijaga Permai, Kesambi, and Sitopeng. A total of 9 public health centers fall into the score 2 category (moderate/yellow), while the remaining 8 public health centers are in the score 3 category (low/red). This indicates variations in the level of diarrhea risk among children under five influenced by exclusive breastfeeding coverage in each area.

c. Mapping the Distribution of Diarrhea Cases Among Children Under Five Based on Clean and Healthy Living Behavior (PHBS) in Cirebon City in 2024



The PHBS data in this study represent the percentage of households implementing Clean and Healthy Living Behavior in 2024, obtained from the annual report of the Cirebon City Health Office, which is a recapitulation of data from 22 public health centers. The data were then processed using QGIS software to produce a distribution map of PHBS in Cirebon City. The map classification is divided into three categories based on the standards of the Ministry of Health, namely green (good >70%), yellow (moderate 35%–70%), and red (low <35%). Based on Map 4.5, all public health centers fall into the good category with percentages above 70%, so all areas are visualized in green.

In addition, this study also analyzes the relationship between diarrhea cases among children under five and the PHBS factor through score-weighted mapping, which is presented in the following map.



Gambar 6 Peta Sebaran Kasus Diare pada Balita Berdasarkan Faktor PHBS di Kota Cirebon Tahun 2024

The classification in Map 6 uses a weighting method for the variables of diarrhea among children under five and PHBS. Each variable is assigned a score: 1 (high), 2 (moderate), and 3 (low), which are then summed to obtain a total score as the basis for grouping into three classes. The results are visualized using green (high), yellow (moderate), and red (low) colors. Based on the analysis, the majority of areas fall into the moderate category. There is 1 public health center in the low category (score 3), namely Pulasaren Public Health Center (red), 13 public health centers in the moderate category (yellow), and 8 public health centers in the high category (green). This distribution indicates variations in the risk of diarrhea among children under five influenced by the implementation of PHBS in each area.

d. Results of Population Density Mapping in Cirebon City in 2024



Gambar 7 Peta Kepadatan Penduduk Kota Cirebon Tahun 2024

The population density data in this study were obtained from the 2024 report of the Cirebon City Health Office, which is a recapitulation from each public health center's working area. The data were then processed using QGIS software to produce a population density distribution map of Cirebon City. The map classification is divided into four categories: green (low <50 people/km²), yellow (moderate 50–150 people/km²), orange (high 150–400 people/km²), and red (very high >400 people/km²). Based on the mapping results, all public health center areas in Cirebon City fall into the high to very high population density categories, indicating relatively high and evenly distributed population density conditions.

In addition, this study also analyzes the relationship between diarrhea cases among children under five and population density through score-weighted mapping, which is presented in the following map.



Gambar 8 Peta Sebaran Kasus Diare pada Balita Berdasarkan Faktor Risiko Kepadatan Penduduk di Kota Cirebon Tahun 2024

The classification in Map 8 was developed using a weighting method for the variables of diarrhea among children under five and population density. Each variable was assigned a score: 1 (low), 2 (moderate), and 3 (high). The scores were then summed to obtain a total score used to classify diarrhea incidence based on population density into three categories: green (low), yellow (moderate), and red (high).

The mapping results show variations across the working areas of public health centers in Cirebon City. There are 2 public health centers in the high category (red), namely Jagasatru and Pulasaren. A total of 4 public health centers fall into the moderate category (yellow), namely Astanagarib, Cangkol, Pamitran, and Sitopeng, while the remaining 16 public health centers are in the low category (green). These differences reflect variations in the risk of diarrhea among children under five influenced by population density in each area.

Discussion

1. Mapping the Distribution of Diarrhea Cases Among Children Under Five at Each Community Health Center (Puskesmas) in Cirebon City in 2024

The QGIS mapping results using interval class classification showed that the distribution of diarrhea among children under five in 2024 tended to be under control and was dominated by the low category (green). A total of 12 community health centers had a prevalence of <20%, indicating relatively effective control despite uneven distribution. This finding is consistent with Sari et al. (2023) [12]. However, 9 community health centers were classified as moderate (21%–32%) and 1 as high (>32%), indicating disparities in risk distribution and the presence of a hotspot. This finding is in line with Gea et al. (2023) and Sidqi et al. (2021) [55,56].

The weighting results showed that 7 community health centers remained in the low-score category, indicating the need for targeted interventions. Wulandari & Susanna (2025) emphasized that GIS is effective in determining regional priorities based on risk [1]. Overall, diarrhea is influenced by multiple factors; therefore, area-based interventions are needed in moderate- and high-risk categories through improving exclusive breastfeeding, Clean and Healthy Living Behavior (PHBS), and sanitation.

2. Mapping the Distribution of Exclusive Breastfeeding Coverage at Each Community Health Center (Puskesmas) in Cirebon City in 2024

QGIS mapping based on the Ministry of Health classification showed variations in exclusive breastfeeding coverage: 14 community health centers were in the moderate category (40%–80%), 7 in the good category (>80%), and 1 in the low category (<40%). This condition indicates disparities between regions that may increase the risk of diarrhea. This finding is consistent with Sari et al. (2023) and Hartati et al. (2023) [12,57]. The weighting results showed that 5 community health centers were in the high category (score 1), 9 in the moderate category (score 2), and 8 in the low category (score 3),

indicating variations in risk based on exclusive breastfeeding coverage. Fitriani et al. (2021) emphasized that infants who do not receive exclusive breastfeeding are more susceptible to diarrhea [58], and Ganbold et al. (2025) identified exclusive breastfeeding as an effective global intervention [59]. Therefore, areas with low to moderate coverage should be prioritized for intervention and health education.

3. Mapping the Distribution of Clean and Healthy Living Behavior (PHBS) Implementation at Each Community Health Center (Puskesmas) in Cirebon City in 2024

The QGIS results showed that all community health centers were classified as having good PHBS implementation (>70%). However, the weighting results indicated variations in risk: 1 community health center was in the low category (Pulasaren), 13 in the moderate category, and 8 in the high category, indicating that PHBS has not yet fully contributed to reducing the risk of diarrhea. This finding is consistent with Firenza et al. (2022), who reported a significant relationship between PHBS and diarrhea [60]. Husna & Soviadi (2024) and Darmawan et al. (2021) also emphasized that diarrhea is a multifactorial disease [10,61]. Therefore, diarrhea prevention requires the integration of PHBS with sanitation, access to clean water, and proper waste management.

4. Mapping the Distribution of Population Density at Each Community Health Center (Puskesmas) in Cirebon City in 2024

The QGIS results showed that almost all areas were classified as having very high population density (>400 people/km²), indicated by the red color, suggesting an increased potential risk of environmentally related diseases such as diarrhea. This finding is consistent with Husna & Soviadi (2024) and Wulandari (2025) [10,17]. The weighting results showed that 2 community health centers were in the high category (Jagasatru and Pulasaren), 4 in the moderate category, and 16 in the low category. Fajriyah (2023) stated that population density influences diarrhea incidence [18], whereas Fadhilah (2025) found that its effect may be weakened by other interventions such as sanitation improvement and PHBS implementation [62]. Therefore, population density is an important determinant, but its impact is strongly influenced by environmental conditions and health interventions in each area.

Conclusion

Based on the results of this study on the spatial analysis of diarrhea distribution among children under five and its risk factors in Cirebon City in 2024, it can be concluded that overall, the distribution of diarrhea cases is in the low category with a prevalence below 20% and dominated by green areas, although there is still 1 public health center in the high category, namely Sitopeng (42.62%). The weighting results show 1 public health center in the high category, 14 in the moderate category, and 7 in the low category, indicating variations in risk across regions. In terms of risk factors, exclusive breastfeeding coverage shows variation with 5 public health centers in the high category, 9 in the moderate category, and 8 in the low category. PHBS is dominated by the moderate category (13 public health centers), with 8 in the low category and 1 in the high category, namely Pulasaren. Population density also shows variation, with 16 public health centers in the low category, 4 in the moderate category, and 2 in the high category, namely Jagasatru and Pulasaren. These findings indicate that diarrhea risk is multidimensional and varies across public health center working areas.

Based on these findings, it is recommended that the Health Office strengthen area-based interventions by prioritizing public health centers in moderate and high categories through increasing exclusive breastfeeding coverage, strengthening PHBS, and improving sanitation and access to clean water, as well as utilizing spatial mapping results as a basis for more targeted program planning. Public

health centers are encouraged to strengthen promotive and preventive efforts through continuous education, optimizing the role of health cadres, and routine monitoring of diarrhea cases among children under five. Communities are expected to improve clean and healthy living behaviors, provide exclusive breastfeeding for six months, maintain environmental hygiene, and utilize health facilities. Future researchers are advised to include additional variables such as water quality, sanitation, and socioeconomic factors, and to use more advanced analytical methods to produce more comprehensive results.

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