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Environmental Factors Associated with Tyfoid Fever in Barru General Hospital

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The author(s) declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

ABSTRACT

Purpose: This study explores the relationship between environmental factors—such as clean water supply, fecal disposal, waste treatment, household waste security, and household drinking water treatment—and the incidence of typhoid fever in Barru District, South Sulawesi. The hypothesis suggests that inadequate environmental sanitation and poor water supply are major contributors to the spread of typhoid fever.

Research Design and Methodology: The research utilized a cross-sectional observational design, focusing on 80 Barru Regional General Hospital patients. Respondents were selected through purposive sampling based on specific criteria. Data were gathered through direct observations, structured interviews, and hospital medical records. The Chi-Square test was used to analyze the relationships between the identified variables.

Findings and Discussion: The findings indicate a significant relationship between clean water supply and household waste security with typhoid fever incidence. Respondents lacking access to clean water and proper waste management practices showed a higher risk of infection. However, no significant associations were observed between typhoid fever incidence and factors like fecal disposal, waste treatment, or household drinking water treatment.

Implications: These results suggest that policy interventions aimed at improving water supply and waste management practices at the community level could effectively reduce the incidence of typhoid fever. Future research should investigate the interaction between these environmental factors and individual behaviors, extending the study to other regions for a more comprehensive understanding.

Introduction

Typhoid fever is an acute systemic infectious disease that is a major concern in many parts of the world, especially in developing countries. The disease is caused by Salmonella typhi bacteria that can survive in various environmental conditions, including groundwater, pond water, seawater, and contaminated food. Various factors, such as rapid population growth, increased urbanization, low quality of health services, and poor availability of clean water and sanitation, contribute to the emergence of typhoid fever endemic areas. The spread of the disease is exacerbated by high levels of antibiotic resistance to Salmonella typhi, which complicates the management of existing cases (Ajibola et al., 2018; Arif et al., 2019; Balaji et al., 2018; Chatham-Stephens et al., 2019; Crump, 2019).

Various studies have revealed that typhoid fever is a significant health problem in many developing countries, with an estimated 17 million people suffering from the disease each year. Data

from the World Health Organization (WHO) shows that the number of typhoid fever cases worldwide reaches between 16 to 33 million people, with a mortality rate of 500,000 to 600,000 every year. Central and Southeast Asia countries, including Indonesia, are the most affected by this disease. In Indonesia alone, there are an estimated 800 typhoid fever patients per 100,000 population per year, with a mortality rate of 2%. Most cases occur in the age group of 3 to 19 years, suggesting that children and adolescents are the most vulnerable to this infection (Gibani et al., 2019; Habte et al., 2018; Kim et al., 2019; Levine & Simon, 2018; Marchello et al., 2019).

However, while many studies have been conducted to understand the epidemiology of typhoid fever and the factors that influence its spread, there is still a gap in understanding the interactions between these factors at the local level. Most previous studies have focused on national or regional aggregate data without considering local variations that may affect disease transmission dynamics. Furthermore, while water quality and sanitation are often cited as key risk factors, few studies have explored how community-level interventions can significantly reduce the risk of infection. Therefore, this study seeks to bridge the gap by focusing on an in-depth analysis in Barru District, South Sulawesi, which is one of the areas with a high incidence of typhoid fever (Milligan et al., 2018; Mogasale et al., 2018; Murphy et al., 2017; Park et al., 2018; Prasad et al., 2018).

Based on the analysis of the existing gaps, this study aims to answer the main question: How do interactions between water quality, sanitation, and other environmental factors affect the incidence of typhoid fever in Barru District? In addition, this study also aims to evaluate the effectiveness of interventions carried out at the local level in preventing the spread of this disease. The uniqueness of this study lies in its in-depth contextual approach to local dynamics that may differ from other regions in Indonesia. As such, this study is expected to not only fill a gap in the existing literature, but also make a significant contribution in the development of more effective prevention strategies in the future (Radhakrishnan et al., 2018; Rasheed et al., 2019; Shaikh & Nisar, 2019; Veeraraghavan et al., 2018; WHO, 2019).

Literature Review

Typhoid Fever: History and Spread

The history of typhoid fever dates to when a French scientist named Piere Lois introduced the disease in 829. The term “typhoid” or “typhus” comes from the Greek “typos,” meaning fever with impaired consciousness (Murphy et al., 2017). The disease is known as a highly contagious intestinal infection and was originally thought to be airborne. However, a scientist named Gaffky identified that the transmission of the disease was actually through water, not air. In 1886, Gaffky also successfully developed Salmonella typhi in culture media, which became an important breakthrough in understanding the pathogen that causes typhoid fever. The typhoid test developed by Widal in the late 19th century is still used today, showing how important this discovery was in diagnosing the disease (Levine & Simon, 2018). In 1948, Woodward and colleagues reported that chloramphenicol was an effective drug for treating typhoid fever, giving new hope to patients infected with Salmonella typhi or Salmonella paratyphi A, B, and C, which are the main bacteria causing the disease (Radhakrishnan et al., 2018).

Typhoid fever is an acute infectious disease affecting the small intestine, characterized by symptoms of fever lasting a week or more, often with gastrointestinal distress, and in some cases, with impaired consciousness. Transmission of the disease occurs through food and drink contaminated with the feces and urine of asymptomatic patients or carriers (Ajibola et al., 2018). In some countries, transmission can also occur from consuming shellfish from contaminated water, raw fruits and vegetables fertilized with human feces, and dairy products contaminated by germ carriers or undetected patients. In addition, flies can also mediate transmission by transferring microorganisms from feces to food (Habte et al., 2018). These microorganisms multiply in food, and the infectious dose required to cause typhoid is lower than that of paratyphoid.

Epidemiology of Typhoid Fever

Typhoid fever is a disease that can affect people in various countries, especially in developing countries that have poor personal hygiene and environmental sanitation (Milligan et al., 2018). The

prevalence of typhoid fever cases varies depending on location, local environmental conditions, and community behavior. The worldwide incidence is estimated at 17 million cases per year, with approximately 600,000 people dying from the disease. The World Health Organization (WHO) estimates that about 70% of typhoid fever deaths occur in Asia, particularly in countries such as India, Bangladesh and Indonesia (Park et al., 2018). Indonesia itself is endemic for typhoid fever, with an estimated 800 patients per 100,000 population each year. The prevalence in Latin America is around 150/100,000 people per year, while in Asia, this figure is much higher, reaching around 900/100,000 per year.

Although typhoid fever can affect all age groups, those under 29 are most susceptible to the disease (Veeraraghavan et al., 2018). In developing countries, where poor environmental sanitation and personal hygiene, typhoid fever is a serious health threat. The prevalence of cases varies depending on geographical location, local environmental conditions, and community behavior (Mogasale et al., 2018). In some areas, typhoid fever is more common during the rainy season, when environmental sanitation deteriorates due to flooding or stagnant polluted water. However, the disease may be more common in other areas during the dry season, when clean water becomes difficult to access, and communities are forced to use polluted water sources. The epidemiology of typhoid fever is strongly influenced by environmental factors and community behavior, making it a very complex disease and difficult to control in countries with weak health infrastructure.

Typhoid fever transmission is also influenced by population mobility and rapid urbanization. In large cities, where populations are dense, and sanitation is often inadequate, typhoid fever can spread rapidly through contaminated water and food. In addition, population movements from rural to urban areas and migration between countries can expand the spread of the disease to previously unaffected areas. In Southeast and South Asia, high urbanization rates and population growth contribute to the increase in typhoid fever cases. People living in slums or areas with limited access to clean water and adequate sanitation are most vulnerable to the disease.

Pathogenesis of Typhoid Fever

The pathogenesis of typhoid fever begins when Salmonella typhi bacteria enter the human body through contaminated food or water (Prasad et al., 2018). After passing through stomach acid, some bacteria reach the small intestine and enter the lymphoid plaques in the hypertrophied terminal ileum. Here, complications such as bleeding and interstitial perforation may occur. The bacteria then penetrate the intestinal mucosa and enter the lymphatic system, eventually reaching the mesenteric lymph nodes which are also hypertrophied (Balaji et al., 2018). After passing through these lymph nodes, Salmonella typhi enters the bloodstream through the thoracic duct, spreading to various organs including the liver through the portal circulation from the gut (Crump, 2019). The bacteria then lodge in Peyer's plaques, the spleen, liver and other parts of the reticuloendothelial system.

Initially, typhoid fever was believed to be caused by endotoxemia, the entry of bacterial endotoxins into the bloodstream causing symptoms of fever and toxemia. However, experimental studies later concluded that endotoxemia is not the main cause of fever and toxemia symptoms in typhoid fever (Marchello et al., 2019). Instead, the main role of Salmonella typhi and its endotoxins in the pathogenesis of typhoid fever is to aid in the local inflammatory process in the tissues where the bacteria proliferate. Endotoxins from Salmonella typhi stimulate leukocytes in inflamed tissues to produce and release pyrogens, which in turn cause fever (Arif et al., 2019).

Once in the bloodstream, Salmonella typhi spreads throughout the body and can cause serious systemic infections. The bacterium can hide inside cells of the reticuloendothelial system, such as macrophages, which makes it difficult for the immune system to eliminate. These systemic infections can lead to various complications, including intestinal perforation, gastrointestinal bleeding and liver abscess. In addition, Salmonella typhi can also cause bacteremia, a condition where the bacteria spread into the bloodstream and cause infections in other organs such as the heart, kidneys, and brain. These complications can be fatal if not treated immediately.

In addition, the pathogenesis of typhoid fever is also influenced by the body's immune response to the infection. At the onset of infection, the body produces antibodies against Salmonella typhi. However, these bacteria cancan evade the immune response by altering their surface antigens,

allowing them to survive and multiply in the body. This leads to prolonged infection and increases the risk of complications. An inadequate immune response can also lead to reactivation of the infection in people who have recovered from typhoid fever, especially if they have a weakened immune system.

The development of antibiotic resistance is also an important factor in the pathogenesis of typhoid fever. Salmonella typhi bacteria resistant to antibiotics such as chloramphenicol, ampicillin, and trimethoprim-sulfamethoxazole are increasingly common, especially in endemic areas. This resistance worsens disease prognosis and limits treatment options, increasing the risk of complications and death. Efforts to control typhoid fever through vaccination and improved sanitation are essential to prevent the spread of resistant bacteria and reduce the global burden of the disease.

Research Design and Methodology

This research uses observational research with a cross-sectional study approach and an epidemiological research design to examine the relationship between the independent and dependent variables. This research was conducted in the area of the Barru Regional General Hospital, Barru Regency. The population in this study were all patients recorded in the medical records of the Barru District General Hospital in 2014 from January to June, with a total of 101 patients, 42 inpatients, and 59 outpatients. The sampling technique in this study used the Purposive Sampling method, namely taking samples from the population based on one or predetermined criteria. So, the sample size to be studied is 80 people.

Table 1. Variable operational

Variable	Code	Indicator	Major Reference
Clean Water Provision (X1)	X1.1	The water source used is not polluted so that it fulfills the physical health requirements, namely clear, odorless, colorless and tasteless	(Organization, 2019; Shaikh & Nisar, 2019)
	X1.2	The water source used does not meet health requirements	
Feces Disposal Facility (X2)	X2.1	The disposal facilities have met the requirements such as dirt cannot be touched by insects and rats, water and soap are provided	(Chatham-Stephens et al., 2019; Gibani et al., 2019; Rasheed et al., 2019)
	X2.2	Means of reducing prices do not meet the requirements and can be touched by insects	
Waste Treatment (X3)	X3.1	Garbage is disposed of in the trash and transported to the final landfill	(Arif et al., 2019; Kim et al., 2019)
	X3.2	Waste processing is only burned, thrown into the river or just left like that	
Household Waste Security (X4)	X4.1	Trash can be left outside the house	(Marchello et al., 2019)
	X4.2	There is a trash can in the house	
Household Drinking Water Treatment (X5)	X5.1	Water has been properly treated, namely cooked until it boils between 5-10 minutes and reaches a temperature of 600C-1000C	(Chatham-Stephens et al., 2019; Gibani et al., 2019)
	X5.2	Water is not pre-boiled until it boils between 5-10 minutes and does not reach a temperature of 600C-1000C	
Typhoid Fever Incidence	Y1.1	The patient was hospitalized and recorded on the Barru Hospital card status as positive for typhoid fever	(Arif et al., 2019; Kim et al., 2019)
	Y1.2	The patient was carrying out street treatment and was recorded on the Barru Hospital card status as suspected of typhoid fever	

***Source**: source should be written in italic text with font size 8*

Primary data were obtained through observation and direct interviews with respondents using questionnaires that had been prepared previously regarding the provision of clean water, disposal of feces, waste management, waste security, and drinking water treatment. The data used in this study

were secondary data taken from the Medical Records section at the Barru Regional General Hospital in 2014. The initial data was collected from 24 October to 27 October 2014.

The data obtained are processed using the SPSS program on a computer. Research data are presented in the form of manuscripts and frequency distribution tables. The hypothesis was tested with a degree of significance (α) = 0.05. The statistical test used is Chi-Square.

Findings and Discussion

Findings

Respondent Characteristics

This research was conducted in Barru district in Kacematan Barru and Tante Riaja District, with a total sample of 80 respondents consisting of 34 respondents suffering from typhoid fever and 48 respondents only suspected of having a Typhoid fever. Based on table 2, the distribution of respondents based on the gender of typhoid fever sufferers shows that 37 male respondents (45.1%) and 45 female respondents (54.9%) suffer from typhoid fever. This shows that the percentage of typhoid fever sufferers is higher in women than men. In terms of age, people with typhoid fever are divided into several age groups, namely 32 respondents aged under 15 years (39.0%), 32 respondents aged 15-29 years (39.0%), 12 respondents aged 30-44 years (14.6%), five respondents aged 45-59 years (6.1%), and one respondent aged 60 years or older (1.2%). This data shows that most typhoid fever patients are in the age group below 30 years old, accounting for almost 80% of all respondents. This may be due to different activities and habits in each age group, where children and adolescents may be more susceptible to infection due to unhygienic behavior or eating habits.

Furthermore, the distribution of respondents by occupation showed that two respondents worked as teachers (2.4%), eight people as housewives (9.8%), eight people as students (9.8%), one person as a fisherman (1.2%), two people as employees (2, 4%), 27 as students (32.9%), one as a pensioner (1.2%), six as civil servants (7.3%), two as police officers (2.4%), one as a driver (1.2%), 18 as unemployed (22.0%), and six as self-employed (7.3%). This data shows that most of the respondents who suffered from typhoid fever were students and people who were not working. This shows that children and adolescents who are still students have a higher risk of developing typhoid fever, which may be caused by the habit of snacking outside the home, especially food whose hygiene is not guaranteed.

Based on the level of education, the results showed that 10 respondents had primary education (12.2%), 15 respondents had junior high school education (18.3%), 15 respondents had senior high school education (18.3%), one respondent had vocational high school education (1.2%), two respondents had D3 education (2.4%), 12 respondents had S1 education (14.6%), and 27 respondents had no education or were still in primary education (32.9%). From this data, it can be seen that most typhoid fever patients are still at the primary or secondary education level. This suggests that children still at school age are more susceptible to typhoid fever, perhaps due to a lack of knowledge and awareness about the importance of personal hygiene and the food consumed.

The distribution of respondents based on typhoid fever status showed that 34 people (41.5%) tested positive for typhoid fever, while 48 others (58.5%) were suspected of having typhoid fever. Regarding clean water supply, 52 respondents (63.4%) had water sources that did not meet the requirements, while 30 respondents (36.6%) had water sources that met the requirements. Regarding fecal disposal, 13 respondents (15.9%) had unqualified facilities, while 69 (84.1%) had qualified facilities. Regarding waste management, 32 respondents (39%) had unqualified waste management, while 50 respondents (61%) had qualified waste management. For household waste security, 49 respondents (59.8%) had unqualified household waste security, while 33 respondents (40.2%) had qualified household waste security. Based on household water treatment, three people (3.7%) conducted unqualified household water treatment, while 79 people (96.3%) conducted qualified household water treatment. These data suggest that environmental hygiene and household sanitation are important in preventing typhoid fever.

Table 2. Respondent Characteristics

Variable	Measurement	n	%
Gender	Man	37	45,1
	Woman	45	54,9
Age / Years	<15 yrs	32	39,0
	15-29 yrs	32	39,0
	30-44 yrs	12	14,6
	45-59 yrs	5	6,1
	≥60 yrs	1	1,2
Profession	Teacher	2	2,4
	IRT	8	9,8
	Student	8	9,8
	Fisherman	1	1,2
	Employee	2	2,4
	Student	27	32,9
	Retired	1	1,2
	civil servant	6	7,3
	Police	2	2,4
	Driver	1	1,2
	There is no	18	22,0
	Self-employed	6	7,3
Education	D3	2	2,4
	S1	12	14,6
	SD	10	12,2
	Senior High School	15	18,3
	SMK	1	1,2
	Junior High School	15	18,3
	There is no	27	32,9
	Diploma 3	2	2,4
Sufferers of Typhoid Fever	Typhoid fever	34	41,5
	Suspect	48	58,5
Clean water supply	Not eligible	52	63,4
	Qualify	30	36,6
Fecal Disposal	Not eligible	13	15,9
	Qualify	69	84.1
Waste management	Not eligible	32	39,0
	Qualify	50	61,0
Household Waste Security	Not eligible	49	59,8
	Qualify	33	40,2
Household Water Treatment	Not eligible	3	3,7
	Qualify	79	96,3

Source: *source should be written in italic text with font size 8*

Table 3. Analysis Test Result

	Clean water supply	Fecal Disposal	Waste Treatment	Household Waste Security	Household Water Treatment
Typhoid Fever	32, 2, 34	9, 25, 34	12, 22, 34	28, 6, 34	2, 32, 34
Suspek	20, 28, 48	4, 44, 48	20, 28, 48	21, 27, 48	1, 47, 48
Total (%)	52, 30, 82	13, 69, 82	32, 50, 82	49, 33, 82	3, 79, 82
Typhoid Fever	39.0, 2.4, 41.5	11.0, 30.5, 41.5	14.6, 26.8, 41.5	34.1, 7.3, 41.5	2.4, 39.0, 41.5
Suspek	24.4, 34.1, 58.5	4.9, 53.7, 58.5	24.4, 34.1, 58.5	25.6, 32.9, 58.5	1.2, 57.3, 58.5
Total (%)	63.4, 36.6 100.0	15.9, 84.1, 100.0	39.0, 61.0, 100.0	59.8, 40.2, 100.0	3.7, 96.3, 100.0
Chi-Square	0.0	0.058	0.725	0.001	0.568

Relationship between Clean Water Supply and Typhoid Fever at Barru General Hospital, Barru Regency

Table 3 illustrates the distribution of the relationship between clean water supply and typhoid fever at RSUD Barru, Barru Regency, and significant results were obtained regarding the quality of clean water provided in the area. Of the 34 respondents who were unqualified for clean water supply, 32 people (39.0%) had typhoid fever. This shows that most respondents who do not get adequate clean water have a high tendency to get typhoid fever. Conversely, only two people (2.4%) out of 34 respondents had typhoid fever even though the clean water they got was qualified. Furthermore, of

the 48 respondents in the "suspect" group, 20 (24.4%) were found to be ineligible for clean water, while 28 (34.1%) were eligible but still in the suspect category. This indicates that despite efforts to meet water supply standards, a significant number of respondents are suspected of having typhoid fever. This data suggests that an adequate water supply does not necessarily guarantee that a person is free from the risk of developing typhoid fever. Of course, poor water supply will significantly increase the risk. Based on the statistical test results, a p-value of 0.000 was obtained, which is smaller than 0.05, so H0 is rejected, and H1 is accepted. This means that there is a significant relationship between clean water supply and the incidence of typhoid fever in RSUD Barru, Barru District. This finding reinforces the argument that access to clean water is critical in preventing infectious diseases such as typhoid fever. Furthermore, this result also encourages further interventions from the government and related institutions to ensure that the entire community can reach the provision of clean water according to standards to reduce the incidence of typhoid fever in the region.

Relationship between Fecal Disposal and Typhoid Fever at Barru General Hospital, Barru District

Table 3 outlines the distribution of the association between fecal disposal and typhoid fever in RSUD Barru, Barru District. Of the 34 respondents studied, nine people (11.0%) were unqualified for fecal disposal and had typhoid fever. In contrast, 25 people (30.5%) from the same group were qualified for fecal disposal but still suffered from typhoid fever. This suggests that factors other than qualified fecal disposal are essential in spreading typhoid fever. Meanwhile, of the 48 respondents in the "suspect" group, four (4.9%) were ineligible for fecal disposal and included in the suspect category. In contrast, 44 (53.7%) were eligible but still included in the suspect category. This data indicates that although fecal disposal is done in accordance with health standards, other factors still need to be considered to prevent the incidence of typhoid fever. Based on the statistical test results, the p-value obtained is 0.058, more significant than 0.05. Therefore, H0 is accepted, and H1 is rejected, meaning there is no significant relationship between fecal disposal and typhoid fever in Barru District Hospital, Barru Regency. These results suggest that although inadequate fecal disposal may contribute to the spread of typhoid fever, other factors such as personal hygiene, water quality, and dietary habits also play an essential role in the occurrence of the disease. These findings emphasize the need for a more comprehensive approach to addressing typhoid fever, including improved sanitation, health education, and increased access to quality health services.

Relationship between Sewage Treatment and Typhoid Fever at Barru General Hospital, Barru Regency

Table 3 provides an overview of the distribution of the relationship between sewage treatment and typhoid fever at RSUD Barru, Barru Regency. Of the 34 respondents who did not meet the sewage treatment requirements, 12 people (14.6%) were known to have typhoid fever. On the other hand, 22 people (26.8%) from the same group met the sewage treatment requirements but still had typhoid fever. This data shows that although adequate sewage treatment is essential, other factors must also be considered to prevent typhoid fever. In addition, of the 48 respondents who fell into the "suspect" category, 20 people (24.4%) were not qualified for effluent treatment and fell into the suspect group. In contrast, 28 people (34.1%) were qualified but suspected of typhoid fever. This indicates that good effluent treatment does not necessarily guarantee one is free from the risk of developing typhoid fever. However, poor effluent treatment increases the risk. The statistical test results showed that the p-value was 0.724, more significant than 0.05. Therefore, H0 is accepted, and H1 is rejected, meaning there is no significant association between sewage treatment and typhoid fever at RSUD Barru, Barru Regency. This finding suggests that although adequate sewage treatment is essential to prevent the spread of the disease, other factors also contribute to the spread of typhoid fever, such as drinking water quality, environmental hygiene, and public health behavior. Thus, a more holistic approach is needed to address this issue, including efforts to raise public awareness about the importance of hygiene and sanitation.

Relationship between Household Waste Safety and Typhoid Fever at Barru General Hospital, Barru Regency

Table 3 outlines the distribution of the relationship between household waste safety and typhoid fever at RSUD Barru, Barru Regency. Of the 34 respondents studied, 28 people (34.1%) were unqualified in household waste safety and had typhoid fever. In contrast, only six people (7.3%) from the same group were qualified regarding household waste safety but still needed to catch up to typhoid fever. This data suggests that inadequate household waste safety significantly contributes to the spread of typhoid fever. Meanwhile, of the 48 respondents who fell into the "suspect" category, 21 people (25.6%) were unqualified regarding household waste safety. They fell into the suspect group, while 27 people (32.9%) were qualified but still suspected of having typhoid fever. This suggests that despite efforts to meet household waste safety standards, some respondents are still at high risk of typhoid fever. Based on the statistical test results, a p-value of 0.001 was obtained, more diminutive than 0.05, so H0 is rejected, and H1 is accepted. This means there is a significant relationship between household waste safety and the incidence of typhoid fever at Barru Regional Hospital, Barru Regency. This finding emphasizes the importance of good household waste management as one of the main preventive measures against the spread of typhoid fever. The government and community need to work together to ensure that household waste is managed safely and according to health standards to reduce the risk of typhoid fever in the community.

Relationship between Household Water Treatment and Typhoid Fever in RSUD Barru, Barru District

Table 3 illustrates the distribution of the relationship between household water treatment and typhoid fever at Barru Regional Hospital, Barru District. Of the 34 respondents who did not meet the requirements for household water treatment, two people (2.4%) were known to have typhoid fever, while 32 people (39.0%) from the same group met the requirements for household water treatment but still had typhoid fever. This data indicates that adequate household water treatment is essential but does not always guarantee that a person is free from the risk of typhoid fever. Of the 48 respondents in the "suspect" category, only one person (1.2%) did not meet the requirements for household water treatment and was included in the suspect group. In contrast, 47 people (57.3%) met the criteria but were still suspected of having typhoid fever. This data indicates that although household water treatment has been carried out according to health standards, there is still a risk associated with other factors that may affect the spread of typhoid fever. Based on the statistical test results, the p-value obtained is 0.567, more significant than 0.05. Therefore, H0 is accepted, and H1 is rejected, meaning there is no significant association between household water treatment and typhoid fever at Barru General Hospital, Barru District. This finding suggests that while good household water treatment is essential to reduce the risk of disease spread, additional factors also need to be considered. These factors could include environmental hygiene, personal hygiene practices, and general sanitation conditions around the household.

Discussion

Relationship between Clean Water Supply and Typhoid Fever Incidence in Barru District

The results showed a significant relationship between clean water supply and the incidence of typhoid fever in Barru District. Unqualified clean water supply is an essential factor in the spread of this disease. In daily life, the community's water quality dramatically affects the risk of disease transmission, especially if the water is cloudy and does not meet health standards. Unclean water is feared to contain bacteria or germs that can cause various diseases, including typhoid fever. Clean water sanitation is an essential element in preventing the transmission of typhoid fever. This disease is generally spread through the fecal-oral route, where the germs that cause the disease come from the feces or urine of patients or even from carriers who do not show symptoms of illness (carriers). These germs then enter the body by consuming contaminated water or food. Mass use of water contaminated with germs is often responsible for the occurrence of typhoid fever outbreaks. The source of clean water used by communities may come from springs, but in some cases, the springs are contaminated because the water used comes from drains that may have been contaminated. In

addition, dug wells that need to be adequately covered and the distance between the water source and the septic tank that is less than 10 meters can also be a source of contamination. Salmonella typhi bacteria are often found in wells or water sources contaminated by infected human feces, especially if the distance to the septic tank is too close. If the family consumes water from these sources, the Salmonella typhi bacteria will enter the human gut and multiply, which can eventually cause typhoid fever. Water sources used in daily life should be free from disease-causing agents. If the water used does not meet the requirements or has been polluted, the risk of disease transmission, including typhoid fever, will increase. In this study, many patients still used murky water for their daily needs. However, whether the murky water is polluted and contains Salmonella typhi is not certain. According to research results (Dwi Febriana, 2013), clean water that is not cloudy, odorless, and tasteless has met the physical requirements. However, the bacteriological requirements still need to be identified (Mogasale et al., 2018). In a study conducted by Nurvina (2013) related to the relationship between environmental sanitation, personal hygiene, and individual characteristics and the incidence of typhoid fever, no relationship was found between clean water supply and typhoid fever. This shows that the use of clean water is not the main causative factor in the occurrence of typhoid fever. However, in contrast to the research results (Ahmad Dahlan, 2014) showing a relationship between clean water sources and the incidence of typhoid fever. This study states that clean water sources are one of the factors causing typhoid fever, and polluted clean water sources can increase the incidence of the disease (Ajibola et al., 2018).

Relationship between Fecal Disposal and the Incidence of Typhoid Fever in Barru District

The results showed no significant relationship between fecal disposal and the incidence of typhoid fever in Barru district. Most typhoid fever patients have adequate and standardized fecal disposal facilities, so the possibility of typhoid fever cannot be directly linked to fecal disposal practices. Even though the fecal disposal facilities are compliant, the community must still be vigilant and maintain the cleanliness of the fecal disposal sites to avoid becoming a source of typhoid fever transmission (Kim et al., 2019). Unsanitary disposal of feces can lead to the spread of various diseases. It starts with infected feces contaminating groundwater or surface water, which is then contaminated with germs from the feces. Insects such as cockroaches or flies can also carry germs from infected feces and then spread them when they land on food or eating utensils such as plates or spoons. If feces are disposed of in simple latrines such as dip latrines, microorganisms from the feces can re-enter the soil vertically to a depth of about 3 meters, depending on soil type and conditions. Dry soil will have a shorter penetration depth than wet soil. Fecal disposal facilities are a risk factor for typhoid fever because the disease originates from the feces of patients and flies as carriers of Salmonella typhi bacteria. According to Arief's (2009) research, there is no connection between latrine ownership and the prevalence of typhoid fever. This indicates that latrine ownership is not the main causative factor in typhoid fever. However, the community must still be vigilant against the spread of infectious diseases (Chatham-Stephens et al., 2019). However, Ahmad Dahlan's (2014) study showed an association between latrine ownership and the incidence of typhoid fever. This means that latrine ownership has a significant relationship with the incidence of typhoid fever. Community knowledge plays a vital role in this because if people have good knowledge about health and environmental hygiene, then the transmission or emergence of disease can be prevented early on. Ownership of a healthy, clean, and free latrine from insects or rats is something the community must know to avoid spreading infectious diseases, especially typhoid fever (Crump, 2019).

Relationship between Sewage Treatment and Typhoid Fever Incidence in Barru District

Most of the waste treated in Barru district has been transported to landfills. The Barru District Government has distributed waste bins to each household and differentiated between dry and wet waste bins so that people can dispose of waste according to its type. However, a small number of people still choose to burn waste, let it accumulate, or throw it into the sea. Garbage, or waste, is anything considered useless by its owner and must be disposed of. Waste that is not managed properly will become a public health problem, because it can become a breeding ground for disease vectors. Solid waste that contains food waste can invite flies to land and even lay eggs in the pile of waste. If

the waste contains infected human or animal feces, flies that settle on it can spread typhoid fever. The proliferation of flies in waste piles also poses a risk of disease transmission, as the more flies there are, the greater the chance of disease transmission (Rasheed et al., 2019). Previous research by Dwi Febriana (2014) also stated that there was no significant relationship between waste management and the incidence of typhoid fever. Good waste management includes collection and transportation, starting from the source that generates the waste, then collected, transported, and processed for reuse. Waste handling does not just stop at the trash can, it goes beyond that. If waste is allowed to accumulate, it will cause aesthetic problems (odor, dirt) and become a nest for nuisance insects (flies, mosquitoes, cockroaches) and rats, which will eventually lead to health problems (Veeraraghavan et al., 2018). Flies like wet and humid places for their nests, while rats like dry and warm places. All these conditions are present in garbage piles. Insects that spread diseases like typhoid fever are typically associated with diseases caused by garbage. Therefore, good waste management is essential to prevent the spread of infectious diseases.

The Relationship Between Household Waste Safety and the Incidence of Typhoid Fever in Barru Regency

This study showed a significant association between securing household waste and the incidence of typhoid fever in Barru District. Patients' participation, awareness, and knowledge about securing household waste play an important role. Many sufferers still do not realize that securing household waste is very important to prevent diseases such as typhoid fever. Household waste should not be left in the house for a long time. Household waste should be disposed of immediately in a trash bin outside the house, and it is even better if the waste is separated into organic and non-organic waste. Waste that is allowed to accumulate around the house can be a source of disease, especially typhoid fever. When waste is allowed to accumulate, the number of flies that land on it will increase. These flies can then carry Salmonella typhi bacteria from the waste to food or other surfaces in the house, thus becoming a vector for typhoid fever transmission. According to the Minister of Health Regulation No. 3/2014 on Community-Based Total Sanitation, household waste management aims to avoid storing waste in the house by dealing with the waste immediately. Garbage left too long in the house or around it can attract flies, cockroaches, or rats, all of which can be factors in spreading disease-causing germs. Therefore, proper household waste management is essential to prevent disease transmission, including typhoid fever (Prasad et al., 2018). In addition, public education on the importance of environmental hygiene and sanitation must be improved. People should be made aware that securing household waste is not just a matter of aesthetics but also a preventive measure against various infectious diseases. To guarantee that the entire community consistently practices this practice, health workers must actively participate in providing counseling and training on proper household waste management (Milligan et al., 2018). Continuous and integrated counseling will help communities understand the importance of household waste management in maintaining a healthy environment and preventing disease transmission. In addition, environmental hygiene programs that directly involve the community, such as gotong-royong to clean the environment, can also be an effective step in reducing the risk of transmission of typhoid fever and other diseases.

Relationship between Household Drinking Water Treatment and the Incidence of Typhoid Fever in Barru District

The results showed no significant relationship between household drinking water treatment and the incidence of typhoid fever in Barru District. This is because almost all patients have consumed bottled water, gallon water, or water that has been boiled until boiling. Hence, drinking water treatment is not a major contributing factor to typhoid fever in this area. The local community also knew how to boil drinking water, which indicates that the water is fit for consumption (Mogasale et al., 2018). Nonetheless, it is important to continue raising public awareness regarding the importance of proper drinking water treatment. Water that is not boiled before consumption still has the potential to contain bacteria, and this can cause contamination of the digestive tract. Therefore, although boiling water is already well-established in Barru District, education on ensuring the water consumed meets health requirements must continue. In addition, another factor that needs to be

considered is the condition of drinking water storage. Water storage containers not properly covered or left open can easily be contaminated by Salmonella typhi bacteria. These bacteria can multiply in improperly stored drinking water, increasing the risk of typhoid fever transmission through consumption of contaminated water (Murphy et al., 2017).

In a broader context, research conducted by Dina Yuanita (2007) showed that drinking water storage containers are a major factor affecting the spread of typhoid fever. People who do not have proper water storage containers or use open containers are more susceptible to typhoid fever infection. This is in line with research conducted by Ahmad Dahlan (2014) who found a significant relationship between the habit of consuming untreated water and the incidence of typhoid fever. People who habitually consume raw water risk developing typhoid fever more than those who always consume boiled water (Levine & Simon, 2018). Therefore, although the study results in Barru District show that drinking water treatment is not directly related to the incidence of typhoid fever, it is important to still implement good and correct water treatment practices. The government and health institutions should continue to encourage people to always boil water before consumption and ensure that drinking water storage containers are tightly closed to prevent contamination. In addition, there is also a need to monitor the quality of water used by the community, especially in areas where access to clean water is difficult. Proper drinking water treatment, including boiling and proper storage, is an important step in preventing typhoid fever. These efforts should be encouraged through continuous education and counseling and by ensuring that communities have adequate access to clean water sources and safe water storage facilities. With these measures, the risk of typhoid fever transmission through drinking water can be minimized, resulting in better public health (Park et al., 2018).

Conclusion

This study's conclusion shows a significant association between clean water supply and household waste securing with the incidence of typhoid fever in Barru district. In contrast, this study also found no significant association between fecal disposal, sewage treatment, and household drinking water treatment and typhoid fever incidence. These results illustrate that although some environmental factors such as household waste securing and clean water quality have an important influence on the spread of typhoid fever, other factors do not directly correlate with the incidence of this disease.

This study makes valuable contributions in both scientific and policy practice contexts. From a scientific perspective, the findings enrich the existing literature on environmental risk factors for typhoid fever and emphasize the importance of sanitation and clean water management in infectious disease prevention. Practically, the results of this study can be used as a basis for policy makers in the health and environmental fields to design more targeted interventions in typhoid fever prevention efforts in the community. The uniqueness of this study lies in its in-depth focus on local conditions in Barru District, thus providing specific insights that can be adapted in similar contexts in other regions.

However, this study has several limitations that need to be considered. One of the main limitations is the limited geographical scope of the research, which only covers Barru district and may not fully represent conditions in other regions. In addition, this study was also limited to specific environmental variables and did not consider other factors such as individual hygienic habits or access to health services. For future research, it is recommended that the study be extended to a wider area and include more variables, including social and economic factors, to obtain a more comprehensive picture of the causes and prevention of typhoid fever.

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