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The impact of climate variability on diarrhea incidence in Surakarta City, Indonesia 2021-2022

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Abstract. Diarrhea is still a serious public health problem and an endemic disease in Indonesia, with the potential for outbreaks that frequently result in mortality. According to 2018 Primary Health Research data, the incidence of diarrhea in Indonesia was 6.8% for all ages and 11% for toddlers. Diarrhea is one of the diseases associated with climate variability. The goals of this study is to analyze the impact of climate variability (air temperature and humidity) on the incidence of diarrhea cases in Surakarta City from 2021 to 2022. This study use a cross-sectional method. The data used is secondary data from Surakarta City Statistics Center. The Pearson statistical test was used to analyze the differences between variable. The results of this study showed that air temperature ($p = 0.01$ and $r = 1,000$) and humidity ($p = 0.01$ and $r = 1,000$) have an impact on the incidence of diarrhea. In conclusion, temperature and humidity had a positive correlation with diarrhea cases.

1 Introduction

The consequences of climate change have been felt globally for a long time and have influenced many aspects of human existence, including health [1-2]. Everyone may be impacted by the growing global health crisis of climate change [3]. This is increasingly felt and has become one of the major challenges in the health sector [4]. Climate change causes parasites, viruses, and disease vectors to multiply more quickly in contaminated environments.[1]. Several studies report that there are four diseases closely related to climate change: acute respiratory infections (ARI), diarrhea, malnutrition, and malaria [5]. Climate change is expected to cause approximately 250,000 more deaths each year between 2030 and 2050 due to malnutrition, malaria, diarrhea, and heat stress. [4]. The World Health Organization (WHO) also stated that one of the health concerns directly connected with climate change is the increasing incidence of diarrheal illnesses. Several studies have shown a significant relationship between the prevalence of diarrhea and climate change [2]. A study mentioned that air temperature, rainfall, and humidity can be related to the occurrence of diarrhea [6]. During the change from the dry season, when rainfall is still minimal and temperatures are changing, to the start of the rainy season, diarrheal illness peaks.

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Diarrhea is a major health issue and remains one of the leading causes of global morbidity and mortality [7]. A medical illness known as diarrhea is characterized by more frequent bowel movements than usual, which results in feces that are more watery in consistency [8]. Diarrhea is caused by the inflammation of the digestive system by various bacteria, viruses, and parasites. Pathogens transfer from person to person by contaminated food, drinking water, or equipment as a result of poor hygiene [9]. Hygiene behavior, environmental factors, economic status, and climate all play a role in the prevalence of diarrhea [10].

Diarrhea is a major cause of illness and death in children under the age of five. Between 2015 and 2017, the global incidence of diarrhea among children under the age of five increased. Diarrhea killed 499,000 children in 2015, and the disease affected 688 million. [11]. Every year, 1.7 billion cases of diarrhea in children are reported [8]. More than 2.5 million deaths caused by this disease are recorded worldwide each year [7]. According to data from the Centers for Disease Control and Prevention (2015), diarrhea takes the lives of 2,195 children every day. Across the world, diarrheal illness leads to 1 in 9 toddler deaths. Based on data from WHO and UNICEF, diarrhea is the second largest cause of death. worldwide for children under five, accounting for as much as 16 percent of deaths. [11]. Diarrhea is one of the sources of health problems in developing countries, including Indonesia. The incidence of diarrheal illnesses is thought to be increasing in Indonesia due to climate-related variables. Diarrhea, an endemic disease in Indonesia, has the potential to become an extraordinary outbreak (KLB) [9]. There were 18 diarrhea outbreaks in 2015, affecting 18 municipals/cities and 11 provinces. A total of 1213 patients and 30 deaths were reported. According to the 2013 Basic Health Survey (BHS), Indonesia's rates of diarrhea incidence and prevalence across all age groups were 3.5% and 7%, respectively. The provinces of Papua, South Sulawesi, Aceh, West Sulawesi, and Central Sulawesi have the greates incidence and prevalence of diarrhea. [12].

According to the findings of a household health survey, the number of diarrhea in Indonesia has increased from 7% in 2013 to 8% in 2018.[13]. On the other hand, in 2018 the prevalence of diarrhea in Indonesia was 11% for toddlers and 6.8% for all ages [13]. In 2020, the Ministry of Health of the Republic of Indonesia (MOH RI) (2021) reported 1.140.503 cases with a morbidity rate of 843 per 1,000 population among children under the age of five in various health care facilities [14]. Data from the Central Java Provincial Health Profile (2016) show that the percentage of cases of diarrhea in 2016 was 68.9%, increasing from the percentage in 2015 of 67.7% [15]. In 2021, the province of Surakarta had 6,542 cases of diarrhea, which increased to 7,113 in 2022. [16].

Based on climate variation data and diarrhea incidence data in the city of Surakarta, it is important to start a study on the correlation between climate variation and the occurrence of diarrhea. This study's findings are expected to be used as a reference for diarrhea prevention and control.

2 Material and Methods

This research used a quantitative analytical technique with a cross-sectional design. This research. aims to investigate the effect of changes in climate variability (air temperature, and humidity) on diarrheal disease in the city of Surakarta, Central Java, Indonesia. This research was conducted in July 2024. This study used secondary data from the Surakarta City Central Statistics Agency. Data on diarrhea cases, air temperature and humidity from 2020 to 2021. This study's population was from Surakarta, Central Java, Indonesia. The sampling method is complete sampling.

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3 Result

3.1 Univariate Analysis

Figure 1 shows that the incidence of diarrhea increased between 2021 and 2022. The average air temperature in 2021 also increased in 2022, from 22.0°C to 23.7°C.

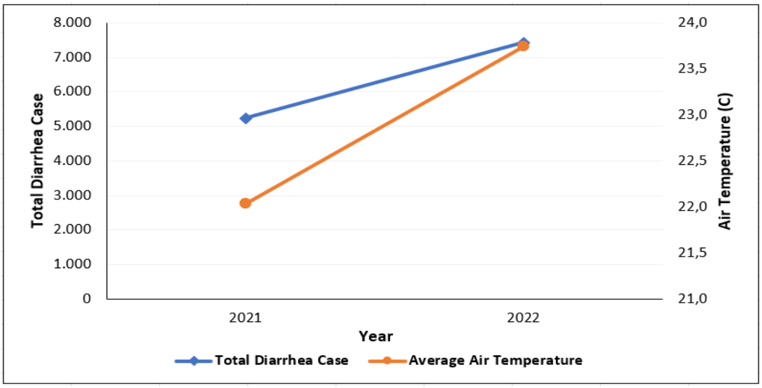

Figure.1. Trend of diarrhea cases and air temperature in 2021–2022 in Surakarta, Indonesia

Figure 2 shows an increase in diarrhea cases from 2021 to 2022. In 2021, there were 5,238 cases of diarrhea, which increased to 7,422 by 2022. Humidity levels also increased, from 69.4 in 2021 to 70.4 in 2022.

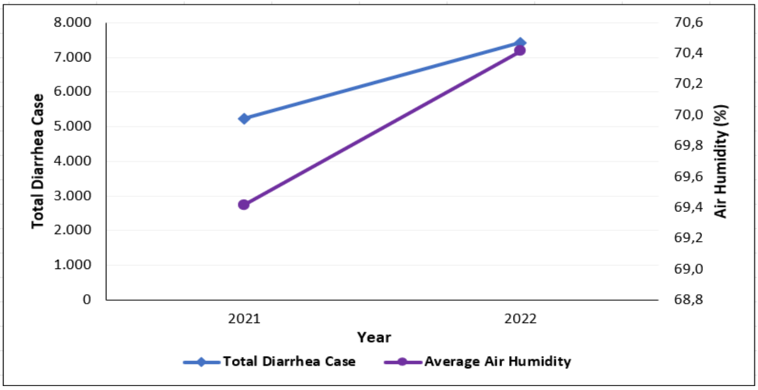

Figure.2. Trend of diarrhea cases and humidity in 2021–2022 in Surakarta, Indonesia

3.2 Bivariate Analysis

The correlation test between air temperature and humidity and the incidence of diarrhea in Surakarta showed a r value of 1.000, suggesting a positive influence, suggesting that the number of diarrhea cases increases as air temperature and humidity rise. The significant value obtained is p=0.01, which means the p value is less than (0.05), suggesting that there is a positive correlation and meaningful connection between air temperature, humidity, and diarrhea incidence in Surakarta from 2021 to 2022.

Table 1. Results of Correlation Analysis between Air Temperature and Diarrhea Incidence in Surakarta City from 2021 to 2022

Variable	Diarrhea		
	Pears. Correlation. (r)	Significant (p)	Description
Air temperature – case of diarrhea	1.000	0.01	

Table 2. Results of Correlation Analysis between Humidity and Diarrhea Incidence in Surakarta City from 2021 to 2022

Variable	Diarrhea		
	Pears. Correlation. (r)	Significant (p)	Description
Humidity – case of diarrhea	1.000	0.01	

4 Discussion

4.1 The Impact of Air Temperature on the Incidence of Diarrhea in Surakarta City in 2021–2022

Every disease and mortality are influenced by climate change. Climate change will cause changes in ecosystems, which will affect the patterns of interaction between the environment and humans, affecting the community's health [2]. Rainfall, temperature, humidity, and wind speed are all factors that influence climate variability. According to study, climate change influences the transmission of diarrheal diseases. [11]. The study found a significant correlation between temperature and the incidence of diarrhea in Surakarta City, with a p-value of 0.01 (0.01 < 0.05). The findings of this study are consistent with the previous research, which reported a significant relationship between air temperature and diarrhea cases. The findings suggest a weak and positive pattern, with a 1 °C increase in temperature leading to an increase of 40.944 diarrhea cases, and the R square value (0.128) indicates that 12.8% of the variance in air temperature can explain diarrhea events. [17]. Temperature trends can influence infectious disease transmission by increasing pathogen proliferation and adaptive mechanisms. [18].

According to Johannsson and Kostad's research, it shows that the risk of diarrhea will increase by 8-11% when there is a temperature rise of 4°C in tropical regions [19]. Research findings in Peru indicate that an increase in average temperature of 1 °C leads to a 3.8% rise in clinic visits for children with diarrhea (incidence rate ratio): 1.038, 95% CI: 1.032–1.044) [20]. Meanwhile, a study in Shanghai found that increasing the temperature by 1°C increased the prevalence of diarrhea in outpatient visits by 2.68%. [21]. A recent study in Nepal found that diarrhea in children under the age of five is positively connected with warmer temperatures, with an increase of 8.1% in the number of diarrhea cases per month for every 1°C increase in maximum temperature [22]. Dharmayanti et al found that rainfall and relative humidity decreased over four years (2017-2020), while temperatures in South Kalimantan increased. The multivariate analysis associated climate parameters to the prevalence of diarrhea in children under five years old in this province suggests a strong relationship between temperature with the occurrence of diarrhea [10].

The increase in temperature may stimulate growth of bacteria [23]. Furthermore, rising temperatures accelerate the incubation period of microorganisms resulting in rapid and extensive transmission. Every change in temperature has an impact on the dynamics of vector species as well as harmful organisms including protozoa, bacteria and viruses. Low temperatures during the rainy season can accelerate disease vector development, such as cockroaches, flies, and rodents [11]. Vectors can spread diarrhea-causing microorganisms such as protozoa, parasites, and bacteria. Flies act as mechanical vectors for a variety of illnesses including those that damage the digestive tract. Flies transmit diseases based on their kind. Adult flies can transport intestinal worm eggs, protozoa, and germs. The number of flies will increase at temperatures ranging from 21°C to 26°C. Because of their natural attraction to liquids, an increase in the number of flies will contaminate people' meals and drinks. If humans consume food that has been contaminated by flies, which contain bacteria, parasites, or wo eggs they could get diarrhea [24]. High temperatures can directly affect the growth of organisms in the environment and encourage the development and spread of infectious parasites. Warmer temperatures can promote pathogen proliferation in food and water sources, resulting in a rise in diarrheal illnesses [11]. The continuous fluctuation and climate change could worsen the global burden of diarrheal diseases [23].

The research findings contrast from that reported by Pertiwi et al. in 2021 in terms of climate and diarrhea incidence in Bandar Lampung, Indonesia. According to the Pearson test, the incidence of diarrhea is not impacted by air temperature (p=0.385 and r=0.186) or humidity (p=0.337 and r=0.205) [2]. A similar investigation found no significant link between temperature and diarrhea cases, with a p-value of 0.9 (>α) [25].

4.2 The Impact of Air Humidity on the Incidence of Diarrhea in Surakarta City in 2021–2022

This study found a significant association between humidity and the incidence of diarrhea in Surakarta City, with a p-value of 0.01 (0.01 < 0.05). The results of this study are consistent with previous national and international studies. A study in Banjarmasin reported a strong association (r = -0.665) between humidity and diarrhea prevalence in the city. There was a significant association (r = -0.665) between humidity and diarrhea incidence in the city from 2014 to 2019. The incidence of diarrhea decreased as the humidity increased. According to the linear regression study, humidity was strongly associated with diarrhea incidence (p = 0.000), with a coefficient of -23.978. This means that for every 1% increase in humidity, the incidence of diarrhea decreases by 23.978 cases and vice versa [26]. Based on the research conducted in South Kalimantan for four years (2017-2020), it shows a decrease in rainfall and relative humidity, while temperature has increased. The results of the multivariate analysis showed that relative humidity had a significant link with the incidence of diarrhea in children under five years old in this province. [10]. In Indonesia, the highest humidity occurs in January-February, which is also the month with the highest number of diarrhea cases [17].

Another study in Bangladesh showed that increased humidity was associated with increased incidence of diarrhea (p = 0.0001). Increased humidity also impacts the growth and survival of pathogenic bacteria and protozoa in the environment [27]. The effect of relative humidity on diarrhea incidence is through the spread of diarrhea-causing bacteria and vectors [28]. During the rainy season, humidity increases and places that contain wet waste, such as garbage cans and drainage systems, as well as feces, have high levels of humidity. This can lead to the rapid and effective growth of diarrhea-causing germs [24]. These conditions also allow animals such as rats, cockroaches, or flies that are vectors of diarrhea to breed, thereby increasing their population and strengthening the indirect transmission route of diarrhea [24]. High humidity promotes bacterial growth and development [28].

High humidity and low sunlight intensity can create conditions conducive to the proliferation of diarrhea-causing microorganisms. This situation also accelerates the development of vectors such as rats, cockroaches, and flies [26]. One study reported that bacteria and humidity are positively related. High humidity promotes bacterial growth and development. Changes in humidity affect vector populations that can threaten health. High humidity allows bacteria to survive longer. Poor home ventilation accelerates disease transmission [17]. The survival of diarrhea-causing microorganisms and their vectors is affected by relative humidity, leading to higher incidence. [27].

Humidity is rarely studied compared to rainfall and temperature. According to a systematic review, the association between humidity and diarrheal diseases is inconsistent [28]. This inconsistent association may be due to viral diseases (such as rotavirus diarrhea) that can live in both low and high humidity [18]. Pathogens' biological processes are impacted by humidity. [28]. From 2005 to 2018, research in Singapore found that every 10% increase in relative humidity over one week was positively associated with an increase in the incidence of diarrhea one week later [incidence rate ratio (IRR): 1.030, 95% CI 1.004-1.057] and negatively associated with a decrease in the incidence of diarrhea six weeks later (IRR: 0.979, 95% CI 0.961-0.997). [29]. Results from a study in Tana Toraja Indonesia, conducted between 2011 and 2015, reported that monthly humidity had no significant correlation ($p=0.268$) and a very weak association ($r=0.145$/14.5%) with diarrhea incidence [17].). The association between relative humidity and diarrhea is supported by laboratory data that rotavirus can live at low relative humidity and temperature [10]. The results of the study suggested that an increase in humidity of up to 80% had an impact on reducing the infectivity rate of several rotavirus agents, which may indirectly explain why humidity has a negative linear correlation with the number of diarrhea [1].

5 Conclusion

Temperature and humidity have a correlation with the prevalence of intestinal diseases, but they are not the primary causes of diarrhea. The incidence of diarrhea can also be directly influenced by human immunity, socioeconomic and cultural factors, rainfall, human behavior in cold weather, and inadequate water availability.

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