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RESEARCH ARTICLE

The Needs of Public Health Mitigation as The Impact of Earthquake Disasters in North Sulawesi Region, Indonesia

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Abstract

North Sulawesi is located on a megathrust system and is very vulnerable to destructive earthquake events. Therefore, disaster mitigation from a health perspective must be carried out. Good knowledge will shape a positive attitude as a response that will determine actions in providing effective and optimal health services during a disaster. However, so far, the level of knowledge, attitudes, and actions of doctors in community health centers in North Sulawesi in facing disasters has never been evaluated, so the readiness of doctors in community health centers in facing disasters is still not well understood. One of the effects after a disaster is kidney failure (CKD) due to the lack of fluids needed by the body, making it one of the unavoidable effects of a disaster. Chronic Kidney Disease (CKD) is one of the diseases whose number and prevalence are significant both globally, nationally, and locally in North Sulawesi. The purpose of this research is to: 1) explore the perceptions and experiences of the community regarding the risk factors for CKD, 2) develop and test the effectiveness of a disaster-based education program in increasing community knowledge about CKD prevention. The design used is a multistage mixed method. The research began with the collection of qualitative data through in-depth interviews, followed by the development of an educational program and the experimental testing of the educational program. This research was conducted in Kuwil Village, North Minahasa Regency. A total of 15 participants were involved in the interviews and 38 participants in the experimental phase. Qualitative data is analyzed thematically, while quantitative data is analyzed descriptively through comparison. The results of the qualitative analysis yielded 2 themes. The first theme is the disparity in public knowledge about CKD, and the second theme is the public's efficacy regarding the prevention and impact of CKD. The analysis results using the paired t-test obtained a p-value of 0.000, which means that the disaster-based education program is effective in increasing public knowledge about CKD and its prevention. Having sufficient knowledge and adequate sources of information can help the community in making healthy lifestyle choices, especially in preventing the occurrence of CKD. Disaster-based education programs can be one of the approaches that community health centers can take to improve public literacy.

Keywords: Chronic Kidney Disease, Public Health, Diabetic, Community Health, Disaster, Earthquake

1. Introduction

Indonesia is situated on a complex tectonic system at the convergence of four tectonic plates and possesses a tropical climate characterized by significant fluctuations in weather, temperature, and wind direction, rendering it one of the nations with elevated disaster risk. The National Disaster Management Agency (BNPB) reported that in 2020, there were 4,650 disaster incidents, primarily consisting of floods, which accounted for 1,518 incidents. Severe weather, including intense rainfall, strong winds, and elevated waves in various aquatic regions, has resulted in flooding in Indonesia, particularly in North Sulawesi Province, which contains 30 running rivers. The frequency of disasters in North Sulawesi has been escalating annually, with 21 incidents recorded in 2020 and 45 in 2021.

North Sulawesi is situated between 0° - 5° N and 123° - 127° E as an archipelagic region characterized by significant environmental deterioration and encircled by numerous volcanoes, rendering this province susceptible to natural calamities. The likelihood of a significant catastrophe signifies a substantial need for adept and ready physicians in emergency scenarios. The insufficiency and inadequacy of healthcare human resources, shaped by elements such as knowledge, attitudes, and behaviors, frequently impede disaster management. The expertise of the family physician will influence the efficiency and precision of employing medical help and rescue apparatus in emergencies.

Disasters can affect structural integrity, material condition, and general health. The impact of disasters can arise due to social reactions, infectious diseases, population displacement, weather influences, food and nutrition, water supply and sanitation, mental health, and damage to health infrastructure. Physical injuries during a disaster can affect all ages and those who are vulnerable, such as children, the elderly, and those weakened by illness. Good knowledge will shape a positive attitude as a response that will determine actions in providing effective and optimal health services during a disaster. However, so far, the level of knowledge, attitudes, and actions of doctors in community health centers in North Sulawesi in facing disasters has never been evaluated, so the readiness of doctors in community health centers in facing disasters is still not well understood. One of the effects after a disaster is kidney failure (CKD) due to the lack of fluids needed by the body, making it one of the unavoidable effects of a disaster. Chronic Kidney Disease (CKD) is a disease that has a significant impact on a person's life, such as a lack of control over daily and social activities, loss of freedom, early retirement, financial pressure, disruption of family life, changes in self-image, and decreased

self-esteem, leading to psychological and social problems such as anxiety, social isolation, loneliness, helplessness, despair, and depression (Zhang et al., 2023)

In addition, the difficulty of performing hemodialysis treatment increases the economic burden on the patient's family and the country, as well as exacerbating mental health issues and generally reducing the patient's quality of life. Therefore, this kidney failure disease is one that needs to be watched out for due to its significant impact. The prevalence of kidney failure disease after earthquake disasters worldwide has rapidly increased by 95% in the last decade. Chronic kidney disease is a progressive condition that affects more than 10% of the general population worldwide, totaling over 800 million people (Santulli et al., 2024). In Indonesia, the prevalence of chronic kidney disease increased from 0.2% in 2013 to 0.38% in 2018 (Wang et al., 2024, Peng et al., 2024). As many as 89% of CKD patients are on hemodialysis, and the majority are in the elderly age group of 65-74 years, male, and with low/no education (Wang et al., 2024). North Sulawesi Province ranked 3rd in Indonesia for the highest prevalence of kidney disease in 2018, with 18,890 cases or a prevalence of 0.53%. CKD patients in North Sulawesi are predominantly elderly aged 65-74 years, female, and with low/no education (Thahir et al., 2023). As many as 13.68% of CKD patients receive hemodialysis therapy (Lamoge et al., 2021, 2023; Thahir et al., 2023).

North Sulawesi is located on a megathrust system and is very vulnerable to destructive earthquake events. Therefore, disaster mitigation from a health perspective must be carried out. One of the health-related disaster mitigations has been implemented in several places such as Palu, Lombok, and Aceh. In this study, the seismicity of earthquakes and the impact of hazards are described, and the results are linked to the health condition of kidney failure. The obtained results are very important to support disaster management programs related to kidney failure in the North Sulawesi region.

2. Data and Methods

Literature study and earthquake data collection in North Sulawesi were conducted during the period 2020 – 2022 from the Indonesian Agency for Meteorology, Climatology and Geophysics BMKG catalog. The catalog area is from 121° E - 126° E and -1° S - 3° N as shown in Figure 1. The minimum magnitude scale used is Mw≥5 with a maximum depth of 100km. Mainshock sorting is the process of separating the mainshock from foreshocks and aftershocks using time and distance criteria.

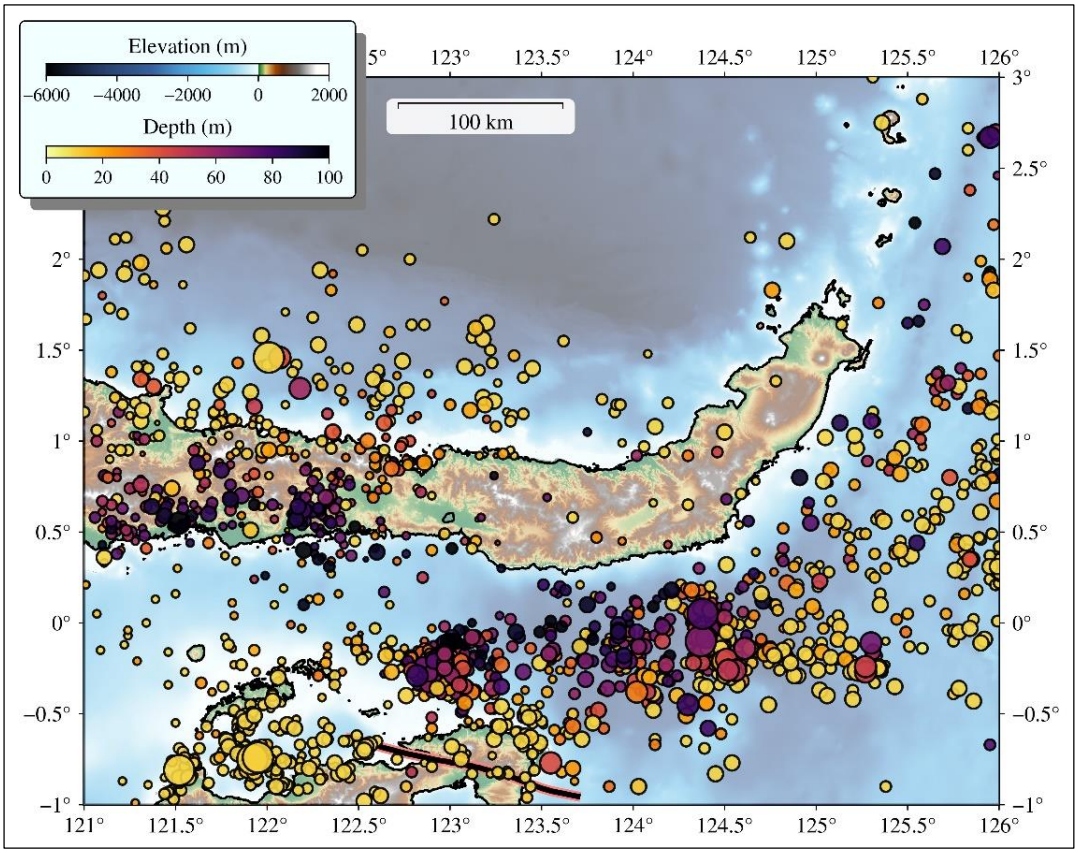

Fig. 1. The tectonic map shows the fault system with topography contour and last five years earthquake activities in the North Sulawesi region and its surrounding.

This separation process uses the empirical criteria method proposed by Gardner and Knopoff (1974), with the separation process assisted by ZMAP software. (Wiemar, 2001). The identification and modeling of earthquake sources and their mechanisms include the location, dimensions, type of earthquake source mechanism, and activity level based on earthquake data from catalogs and previous research. The determination of parameters *a* and *b* is based on the Gutenberg-Richter recurrence relationship using Least Square analysis. The values of *a* and *b* are determined based on data grouped from several areas into a dataset with maximum likelihood statistical model analysis. The estimation of parameters *a* and *b* uses maximum likelihood statistical model analysis because it provides more stable results by modeling the slope of the line rather than fitting the least square for each magnitude. Moreover, the relationship to the health study in this research has a mixed-methods design: multistage. The research design begins with the collection of qualitative data to explore the community's perceptions of kidney failure and its prevention through in-depth interviews. Subsequently, the research continues with the development of an educational program tailored to the local community's conditions and needs, as well

as the collection of quantitative data in the form of disaster-based education on the community's knowledge of CKD and its prevention. In addition, this research is a descriptive study with a cross-sectional design to understand the knowledge, attitudes, and actions of healthcare workers in North Sulawesi in facing disasters.

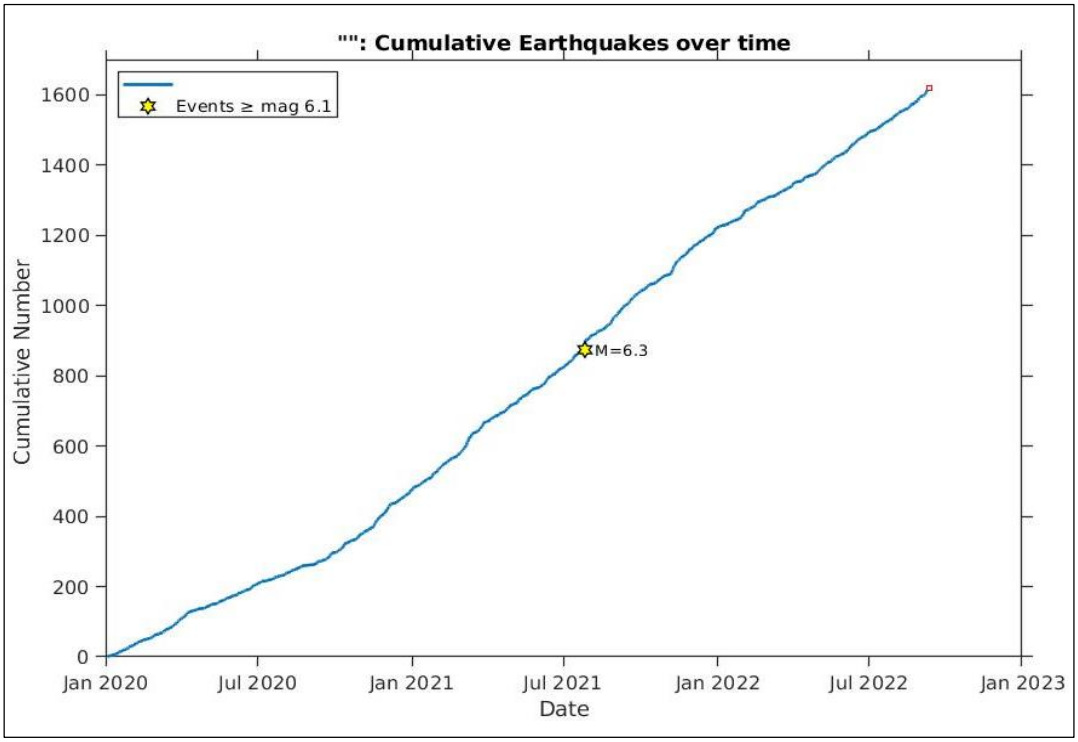

Fig. 2. The graph of spatial-time earthquake occurrence in North Sulawesi province.

The data comes from the results of a questionnaire distributed online to each respondent. The collected data will undergo editing, coding, data entry into the computer, and data re-examination. This research was conducted in Kuwil Village, North Minahasa Regency. A total of 15 participants were involved in the interviews and 38 participants in the experimental phase. The sampling technique used is purposive sampling. The sampling technique employed is purposive sampling. High-risk community (elderly) aged > 55 years. The main instrument for qualitative data is the researcher themselves, assisted by several guiding questions. Meanwhile, the instrument for quantitative data uses a questionnaire on knowledge about CKD and its prevention. Qualitative data collection will be conducted through in-depth interviews. (in depth interview). The results of the qualitative data will be analyzed thematically, while the quantitative data will be analyzed using comparative analysis with a paired t-test.

The results of the field survey conducted in the Working Area of the Kolongan Health Center, North Minahasa Regency, indicate that the number of patients with Kidney Failure Disease visits in January-February 2023 was 28 people. Additionally, during the survey at Sentra Medika Hospital North Minahasa, data was obtained showing that 130 patients were undergoing routine hemodialysis therapy, with an average of 42-55 hemodialysis procedures per day. The results of interviews with several nurses found that, in general, the factors causing CKD are an unhealthy lifestyle and a lack of patient understanding regarding CKD and its prevention.

The results of interviews with several kidney failure patients identified that the causes of their CKD were due to unhealthy lifestyles and the consequences of non-compliance with the treatment of other chronic diseases such as hypertension and diabetes mellitus. Therefore, educational programs that are tailored to the conditions and needs of the community will be important in efforts to improve literacy, lifestyle changes, and CKD prevention for the community. Based on this background, the objectives of this research are to: 1) explore the perceptions and experiences of the community regarding the risk factors for CKD occurrence, 2) develop and test the effectiveness of a disaster-based education program in increasing community knowledge about CKD prevention.

3. Results and Discussion

In the research we focus for Manado City as the purposes of this research. the earthquake dates were obtained from secondary data collected from the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG). over a period of 5 (five) years, or approximately 1,621 events. Based on the obtained values, the values of a and b vary, and the largest earthquake ever recorded on Earth occurred on July 2021, with a magnitude of 6.3. Subsequently, these values are used to determine which areas have a high level of seismicity.

Seismicity Level and Rock Fragility Level in North Sulawesi

The results of processing the b-value and a-value data are presented, which will be used to determine the level of seismicity based on the districts in North Sulawesi. From the data processing, varying values were obtained, the b value is 0.66 (see Fig. 2), indicating that these areas have low stress concentration and high average frequency for small magnitude earthquakes. So, the area indicates that the rock fragility level there is quite high. Seismic waves are movements or vibrations that occur on the Earth's surface as a result of the rapid release of internal energy. North Sulawesi has many fault structures that have the potential to cause earthquakes. In addition, most Neogene structures and some pre-Neogene structures still exist or are still active to this day. The main structures include the Sulu Thrust, Gorontalo Fault, North Sulawesi Subduction (North Sulawesi Trench/Minahasa Trench), and the double collision of the Maluku Sea, which significantly influence the increase in seismic activity in the region. Therefore, conducting research on the fragility of rocks and seismicity in the North

Sulawesi region is very important to determine the potential risks and impacts of earthquakes.

A region is considered to have a relatively high risk of earthquakes if its seismicity level and vulnerability level are high. A high seismicity level indicates that the area has experienced many earthquakes before and may experience them again in the future. Seismicity in an area correlates with rock fragility, which means that the rocks in that area are weaker in withstanding pressure. Based on the value (value b) and (value a), the Manado city has the highest earthquake risk compared to other regions in North Sulawesi. In addition, the tectonic plate processes that may trigger earthquakes are what categorize this area as having the highest vulnerability level in North Sulawesi. This is because the region has fewer earthquakes compared to other regions. due to having only one dominant factor, this area is classified as having type A earthquake vulnerability.

Because it is located on a fault, this area has a lower potential to become an earthquake epicenter. However, even though this area is considered safe, there is still a possibility of being affected by earthquakes ranging from mild to moderate in other places. Post-earthquake, the community has generally started their daily activities as usual, such as gardening. Meanwhile, school activities have not yet returned to normal. However, some members of the community are still at home due to complaints and illness, so they are unaware that there is a health post nearby. This is what causes some people not to go for health check-ups at the nearest post. In addition, families with chronic illnesses also have difficulty getting to the post because their houses are not on flat ground and need to be carried by two or more people. Generally, the complaints are caused by a history of previous illnesses such as hypertension, diabetes, rheumatism, and heart disease. That is certainly different from the complaints that arise when a disaster occurs. The case study conducted during the earthquake in Nepal mostly involved traumatic injuries, so the combination implemented in the earthquake response was disaster preparedness and support from the medical surgical team. (Kanchan et al., 2019). The impact of earthquakes, according to WHO (2023), can lead to an increase in disease rates and the risk of complications from chronic diseases due to interrupted treatment. The complaints found were also obtained from the results of a systematic review on heart and blood vessel diseases during natural disasters, caused by limited access to treatment, inappropriate medications, and the absence of blood pressure measuring devices due to damage from the disaster. This then increases the morbidity rates of cardiovascular diseases such as hypertension, heart failure, myocardial infarction, and pulmonary edema. (Babaie et al., 2021).

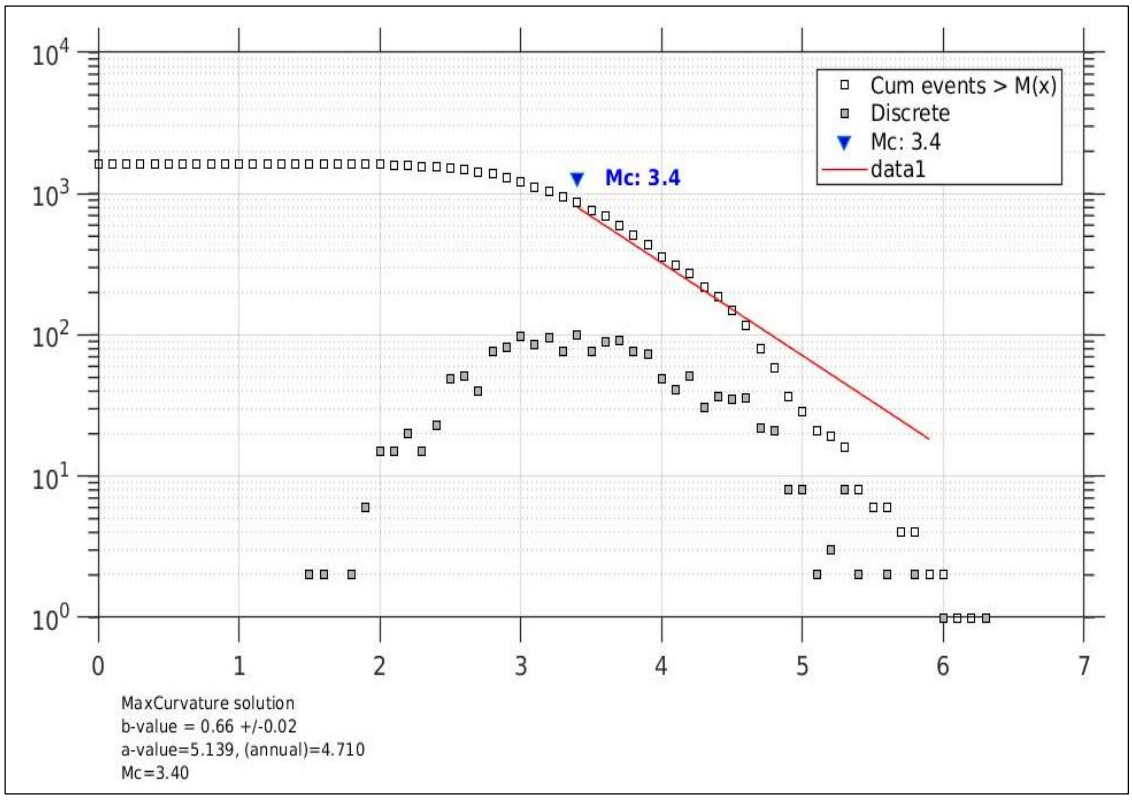

Fig. 3. The graph of earthquake statistics shows the results of b-value with 0.66 and magnitude completeness (Mc) 3.44 in the tectonic system in North Sulawesi province.

The results are divided into 4 parts: characteristics of informants in qualitative data, characteristics of respondents in quantitative data, results of thematic analysis of qualitative data, and results of bivariate analysis for quantitative data. Based on the analysis results in Table 2, it shows that the majority of respondents' characteristics based on age are in the 46-55 years range with 24 respondents (63.2%), followed by the majority of respondents' characteristics based on gender, which are male with 21 respondents (55.3%), while the majority of respondents' characteristics based on the highest education level are at the junior high school level with 14 respondents (36.8%). The research results show that the lack of knowledge among several informants regarding kidney failure disease, with some informants not knowing what kidney failure disease is, its causes, and prevention methods.

Table 1. Characteristics of Respondents in Qualitative Data (n=15).

No	Characteristic	Frequency (n=15)	Percentage (%)
1	**Age**		
	45 – 60 years	9	60
	>60 years	6	40
2.	**Gender**		
	Male	7	46
	Female	8	54
3.	**Occupation**		
	Housewife	6	40
	Private employee	7	46
	Civil Servant	2	14
4	**Education**		
	Elementary school (SD)	5	33
	Junior high school (SMP)	5	33
	Senior high school (SMA)	2	14
	Bachelor degree (S-I)	3	20

This lack of knowledge about kidney failure disease is explained by informants, with around 40% of them not knowing about kidney failure disease. The level of ignorance about the causes of kidney failure is mentioned by 33% of informants, and around 33% of informants do not know about the prevention of kidney disease. As many as 46% of respondents know that kidney failure is damage to the kidneys. 40% of respondents explained that kidney failure is caused by insufficient consumption of plain water, frequent and excessive use of strong medications, and hereditary diseases such as diabetes mellitus. 40% of respondents explained that the prevention of kidney failure is by consuming enough plain water and engaging in activities such as exercise. 46% of respondents explained that the source of information was obtained from relatives, acquaintances, and even family members who have kidney failure. About 60% of the informants explained that they had never heard of or received counselling about kidney failure. Furthermore, the community's efficacy regarding the prevention and impact of CKD indicates that around 66% believe that kidney failure complications lead to death, and about 53% of respondents believe that preventing kidney failure involves drinking enough water, avoiding canned beverages, and exercising.

Tabel 4. Tabel results of bivariate analysis.

Variabel	n	Mean	t	df	p value
PreTest	38	38,03	-14,472	37	0,000
Post Test	38	49,79			

Based on the data analysis in Table 4 using the paired t-test, it shows that the mean pre-test value is 38.03 and the post-test value is 49.79, indicating an increase in the community's perception score about kidney failure disease. Based on the results of the paired t-test, a p-value of 0.000 was obtained, where this value < α 0.05, thus Ho is rejected, meaning there is no significant difference in the community's perception before and after the disaster-based education program about kidney failure disease. Therefore, it can be concluded that the disaster-based education program is effective in improving the community's perception of kidney failure disease.

Disparity in Public Knowledge About CKD

The analysis results indicate a significant knowledge gap regarding chronic kidney disease (CKD) among the informants. Most informants have limited knowledge, primarily due to low levels of education and limited access to information. Some even don't know at all what kidney failure is, its causes, or how to prevent it. One of the informants stated, "Hahaha I don't know what kidney failure is, maybe it's a disease" (R12P1), which indicates a low level of awareness about this disease. The informant's knowledge about kidney failure is only superficial. The informant understands the basic concept of this disease, but does not have a comprehensive understanding as expected.

This is suspected to be because the advanced age of the informants is one of the factors affecting their ability to absorb health information. Previous research has shown that the level of education greatly influences a person's level of knowledge. The higher someone's education, the better their mindset and ability to search for and access information, including in terms of health. The results of this study are consistent with previous findings, as the majority of informants have low levels of basic education (elementary and junior high school). This is one of the reasons why their knowledge about CKD is still lacking.

Almost half of the informants understand that kidney failure is damage to the kidneys that causes impaired kidney function. One of the informants explained, "In our opinion, that's a disease because the kidneys are not functioning properly" (R1P3), which means that kidney failure is when the kidneys do not function well. Researchers argue that informants over the age of 45 tend to have better knowledge about kidney failure. This researcher's assumption is also supported by previous studies that state that age affects a person's cognitive abilities and comprehension. People aged 45-60 generally have good comprehension because their senses are still functioning well.
From this first theme, it underscores the importance of broad access to information. This is because as one ages, they usually have a wider perspective and more mature thinking abilities. improve public knowledge about hyperuricemia. The more

sources of information available, the better the individual's understanding of this disease. This shows that health education and public awareness efforts are very important.

People Community Efficacy

The research results show that most participants believe that kidney failure can lead to death, including the need for dialysis. One participant said, "ohh very dangerous, you know, until people have to undergo dialysis and die" (R1P7), which means this disease is very dangerous and can cause death or the need for dialysis. Researchers assume that the study participants believe that kidney failure can lead to death. Therefore, they try to prevent it with simple methods such as drinking enough water, reducing soda consumption, and exercising regularly. This assumption by the researchers is supported by previous studies that show that reducing the risk of kidney failure can be done through simple methods, such as reducing the consumption of sweet drinks and exercising regularly (Wang et al., 2024). Some factors that can cause kidney failure are diabetes, frequent consumption of soda, and insufficient intake of plain water (Lamonge & Ismanto, 2020; Blankestijn, 2024).

Methods that can be implemented according to theory include lifestyle changes such as: reducing excessive salt intake and weight loss, especially for those who are overweight. Drink plenty of water and eat low-protein foods because this can slow the progression of kidney failure. The removal of endogenous metabolic residues or toxins from human blood using dialysis (Peng et al., 2024). Additionally, if you have kidney problems, you must consult a doctor regularly and follow their treatment instructions. For diabetes sufferers, always strive to keep blood sugar levels stable to avoid complications in the kidneys or diabetic nephropathy. Maintaining a healthy lifestyle, such as regular exercise and a balanced diet (Lamonge & Baua, 2023; Santulli et al., 2024). From the second theme, it can be concluded that a person's attitude can influence the process of preventing kidney failure. Hope and motivation are the most important factors to avoid kidney failure, as these two can enhance a person's emotional and psychological state to think broadly about prevention and actions they can take to help them avoid kidney failure.

Effectiveness of Disaster-Based Education Programs on Community Knowledge about Kidney Failure

Based on the research conducted by researchers in Kuwil Village, Kalawat District, North Minahasa, with a total of 38 respondents, it was found that the disaster-based education program is effective in improving the community's perception of kidney failure disease. The results of this study are in line with previous research showing that disaster-based education programs effectively increase knowledge about COVID-19 (Liabeuf et al., 2023). Previous researchers have also stated that disaster-based health education has an impact on Self Care Management of Diabetes Mellitus (Pepin et al., 2024). However, the uniqueness of the disaster-based education method in this study is that it has not been previously applied to the topic of kidney disease, but has been used in different cases such as the COVID-19 Vaccine and Diabetes Mellitus. According to the researchers' argument, the improvement in public perception of kidney failure disease is influenced by four advantages of the disaster-based education program they conducted, namely in terms of methods, educational media, effective communication, and cultural aspects. The first advantage in terms of educational methods is that the method used by the researchers is felt to be more focused on family groups, where each family has different habits, allowing for more optimal intervention delivery.

The researchers' argument is supported by previous studies which state that disaster-based education is one of the efforts to strengthen the role of families as the most influential component on the health status of family members in the community (Liabeuf et al., 2023). The second advantage is in terms of the educational media used by the researchers. In this study, the researchers used educational media in the form of videos and booklets, making the education delivery more engaging because the educational material is presented concisely and clearly in video form and also packaged in a booklet, allowing respondents to reread the material about kidney failure. The researcher's argument is supported by previous studies which state that audiovisual materials are one of the tools for health promotion, where these audiovisuals contribute significantly to changing community behaviour by providing stimuli through hearing and sight, resulting in more optimal outcomes. The more senses present in a medium, the more information a person can obtain (Pepin et al., 2024).

The third advantage in this research is that during the research process, the researcher applies effective communication, starting from the interview process to the provision of education. The researcher uses polite and easily understandable language for the respondents, ensuring that the information provided is well conveyed to them. The researcher's argument is supported by previous studies which state that effective communication is communication that can bring about attitude changes in the individuals involved and that the information provided can be well received, thus preventing misperceptions (Lau et al., 2023; Zhang et al., 2024; Peng et al., 2024).The fourth advantage of this research is from a cultural perspective, where the majority of the community in Kuwil Village shares the same cultural and ethnic background as the researcher, so during visits to each house, the researcher was well-received by the community.

Based on that cultural background, it also facilitates the process of communication and information dissemination. The researcher's argument is supported by previous studies that state that culture has a significant influence on communication, where different cultures mean different ways of conveying ideas, concepts, and different daily behaviours, so if cultures differ, the communication strategies used will also differ (Lamonge et al., 2016; Thahir e al., 2023; Lau et al., 2024). The potential weakness of this educational method is the need for manpower and time from healthcare workers to proactively visit communities/families. The limited number of healthcare workers at community health centres may face difficulties in using this method. However, the community health centre can do this by training health cadres in the village.

4. Conclusion

Having sufficient knowledge and adequate sources of information can help the community in making healthy lifestyle choices, especially in preventing the occurrence of CKD. Disaster-based education programs can be one of the approaches that community health centres can take to improve public literacy regarding CKD prevention.

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