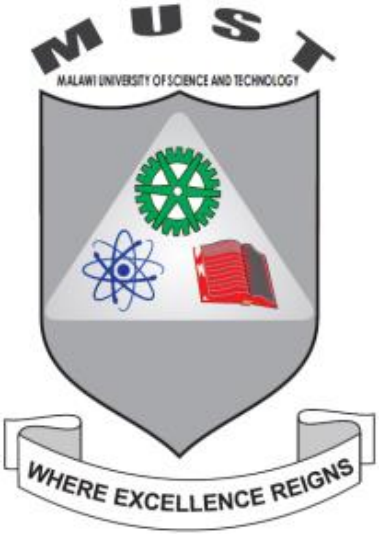


INVESTIGATING THE RELATIONSHIP BETWEEN FLOODING AND DIARRHEA DISEASE, THE CASE OF LILONGWE CITY (BIWI & KAWALE)

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JULY, 2021

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DECLARATION

I Colleta Chadewa declare that this research project represents my workand that it has never been submitted to this institution or any other institution for any academic purpose. All sources of information have been appropriately acknowledged.

Signature: 

19 July 2021

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Abstract

Floods have significant implications for the well-being and health of the communities. Floods can be dangerous to people and can damage homes, as well as water and sanitation systems. Flooding can be caused by a variety of factors: deforestation, development in flood-prone areas, obstruction of drainage channels, urbanization, and poor waste management are all examples of human activities that can lead to extreme flooding (Government of Malawi, 2013), its frequency and magnitude can be increased due to climate change impacts. Malawi's capital city has been hit by floods in recent years. However, each flooding incident poses unique challenges, which is why one of the priorities of the Sendai Framework of Action for Disaster Risk Reduction (SFDRR 2015-2030) is to better understand disaster risk to respond to each situation individually. This study was intended to investigate the relationship between flooding and the transmission of diarrhea diseases in two informal settlements of Lilongwe city in particular Kawale and Biwi communities.

The key hypothesis of this study was that "there is a positive association between flooding event and the transmission of diarrhea diseases in Lilongwe city," which was followed by another hypothesis that "there is no significant difference in the relationship between flooding event and the transmission of diarrhea diseases among communities in Lilongwe. Questionnaires, key informant interviews, and focus group discussions were used to collect primary data, and secondary data were obtained from the city's department of disaster management affairs (DODMA) on flood data. Recorded diarrhea cases in the post-flood and pre-flood periods were obtained from hospitals to provide evidence to support the hypothesis. The collected data was used to determine the most vulnerable groups to diarrhea associated with flooding, to determine the trends in diarrhea disease prevalence in post-flood and pre-flood situations, to assess the communities' susceptibility to the transmission of diarrhea diseases in the post and pre-flood period and to identify the coping mechanisms the community can use to alleviate the impact of flooding on diarrhea. The results of the analysis of quantitative data from the household questionnaire and secondary data have been analyzed using descriptive statistics and they have

been presented in the form of graphs, charts, and tables using Excel and SPSS. Focus groups and main informant interviews were used to gather qualitative data, which was then analyzed using thematic analysis. To come up with conclusions, the findings from the two methods were triangulated. MUSTREC guidelines were observed on all ethical considerations.

The findings of this study have shown that there's a positive association between the flooding event and the transmission of diarrhea diseases in two informal settlements of Lilongwe city and that there's no difference in the association between one community to the other. The results in both post and pre-flood periods from the year 2016 to 2020 have shown that there is an increased prevalence of diarrhea cases in the post-flood period. Children have been identified as the most vulnerable to flood-related diarrhea. The study's findings indicate that the two informal settlements are already susceptible to the spread of diarrhea diseases due to the type of housing used, sanitation practices, and environmental conditions, with flooding exacerbating the problem. Households devise various measures to avoid the adverse consequences of diarrhea as a result of flooding, such as piling sand around houses to keep filthy floodwater away. The researcher has found that the communities desire to cope up with the situation in the aftermath of flooding only that they lack resources, knowledge, and empowerment.

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Abbreviation's list

SDRR: Sendai framework for disaster risk reduction

ANALP: Learning Accountability Performance in Humanitarian Action

JICA: Japan International Cooperation Agency

GDP: Gross Domestic Product

WHO: World Health Organization

UNISDR: United Nations International Strategy for Disaster Reduction

MGDS: Malawi Growth and Development Strategy

IPCC: Intergovernmental Panel on Climate Change

WASH: Water Sanitation and Hygiene

MICS: Multiple Indicator Cluster Survey

MUSTREC: Malawi University of Science and Technology Research Ethics Committee

DODMA: Department of Disaster Management Affairs

DHO: Department of Health Officer

SPSS: Social Packages for Statistical Sciences

DID: Department for international development

Chapter 1: Introduction

3.15 Background of the study

Flooding patterns have changed around the world in recent decades, becoming more frequent, severe, and unexpected for local populations, particularly as development and poverty have forced more people to live in flood-prone locations (ANALP, 2008). In both rich and developing countries, floods in cities are becoming a growing source of concern. Cities are frequently flooded due to a multitude of factors. Natural forces affect both the natural environment and the urban environment, and the presence of urban settlements exacerbates the problem (Mwaniki, 2009). During the flood and its aftermath, however, there are threats to one's health and safety. Flooding impacts are classified into direct and indirect. Direct impacts are those impacts that result from the direct physical interaction between the floodwater and the elements at risk for example infrastructure damage and loss of life due to drowning. Indirect consequences, on the other hand, are those that develop outside of the flood case, such as a spike in the spread of diarrheal diseases as a result of contaminated water supplies (Kingdom, 2014). Flooding has become a more severe and more common problem in most African towns, having devastating ramifications for the urban poor and vulnerable (Douglas et al, 2008).

Urban floods frequently strike without notice and in regions that aren't normally prone to flooding, making them difficult to control and predict (Susana, 2015). They are especially an issue in Africa, where fast urbanization, climate variability, and change, as well as accompanying changes in urban hydrology, appear to be on the rise (Amoako, 2012). Malawi is classified as one of the 15 countries in Africa with more susceptibility worldwide (World Bank, 2016).

In both rural and urban locations, Malawi is vulnerable to a variety of natural and human-caused risks. Floods, severe storms, droughts, dry spells, epidemics, fires are just a few examples (Cui & Jiang, 2018). Malawi is one of the countries in southern Africa that is flooded almost every year, and it is a nation that is more vulnerable to the effects of extreme weather as a result of its increasingly increasing population, unsustainable urbanization, climate variability and change, and environmental degradation (*Malawi*

2019 Floods Post Disaster Needs Assessment Report, 2019). Flood risk management in Malawi has traditionally focused on river floods, but recent urban flooding has occurred, and its scale and frequency are growing. Malawi's capital city, Lilongwe, has been badly inundated in recent years. The population of Lilongwe is predicted to grow at a pace of 4.3 percent per year (World Bank, 2016). As a result, the majority of the population lives in informal settlements with deplorable living conditions which are fertile grounds for water-borne diseases.

Following a flood, deaths and injuries are influenced not only by the disaster's physical characteristics but also by the social and health conditions of the population, as well as any endemic infectious diseases. Diarrhea (including cholera and dysentery), as well as other ailments, are on the rise as a result of the flooding (Du, FitzGerald, Clark, Yu Hou, 2010, 265-272). According to the World Health Organization (WHO), diarrhea is described as the passing of two or more loose stools each day or more frequently than is usual for a person. It remains a leading cause of morbidity and mortality in developing countries killing nearly two million children every year. Exposure to agents that cause diarrhea is predominately related to the consumption of contaminated water and unhygienic practices in food preparation and excreta disposal (Morse, 2011). There are two types of diarrhea diseases: non-cholera and cholera diarrhea. World Health Organization (WHO) estimates that between 2030 and 2050, climate change will cause an additional 48,000 deaths per year from diarrhea alone (WHO 2018)(Kraay et al., 2020). This study aims to investigate the relationship between flooding and diarrhea diseases.

1.2 Problem statement

In recent years, the severity and frequency of urban flooding in Lilongwe have increased (World Bank, 2016). The effect of floods on the human population is directly related to the area's location and topography, as well as human demographics and built-environment characteristics. The majority of Lilongwe's population lives in informal settlements, where most people use pit latrines for human waste disposal and the waste management is bad. When flooding happens in these informal settlements, many issues arise, such as high levels

of contamination of underground water supplies that many people depend on for domestic use (JICA, 2010). As a result of the semi-urban environment of these areas (Kawale and Biwi), both cholera and non-cholera diarrhea cases are still active (WHO Regional Office for Africa, 2018).

In the context of climate change, it's important to understand the possible connections between flooding and diarrhea disease. Globally a lot of research has been done on the impacts of urban flooding on diarrhea disease transmission in informal settlements for example although several studies have shown positive relationships between flooding events and infectious diarrhea (WHO 2018), there is a paucity of rigorous evidence regarding the net effect of flooding on diarrhea incidence whereby epidemiological data is needed to cement the evidence. In Malawi, no such investigation has been carried out.

However, little is known about the risk of infectious diarrhea following floods in Malawi, or what factors might influence these effects. Estimates and specific data of diarrhea cases are still scarce, it is always dependent on data from healthcare facilities (Morse, 2011). For example, according to the recorded data from Kawale healthy center after the occurrence of floods on December 18, 2017, just two months later (January and February 2018), there was a huge rise in recorded diarrhea cases of under-five children, which reached 665, whereas in 2020, the same months in the absence of flooding, reported diarrhea cases were twice as low. There's this problem of lack of information that links flooding and the transmission of diarrheal diseases in Malawi, this study aims to fill that gap.

3.15 Significance of the study

Disaster risk reduction is now squarely on the development agenda, as shown by the Sendai Framework (WHO 2013, Yodmani S 2001, UNISDR 2015), which outlines how disasters can be avoided, mitigated, and resolved in the coming decades. The results of this study will assist the government, organizations, and individuals in charge of disaster risk management in addressing issues of diarrhea disease transmission as a means of mitigating the health impacts of floods in urban areas. The results would also aid those in charge of waste management, sanitation, community planning, and disaster risk management in

working together to better manage the risk of diarrhea disease transmission in the post and pre-flood periods in the marginalized regions. Researchers, planners, and politicians will also use the results of this study to better understand how flooding events are related to the spread of diarrhea diseases.

Flooding has an impact on diarrhea disease, which is a major public health issue. Since diarrhea is one of the leading causes of morbidity and mortality, especially among children in low-income countries, this is true (Kolek et al 2003). It is important to analyze the link between flooding and diarrhea to reduce the mortality and morbidity rate for the prevention and reduction of morbidity are among the priority goals outlined in the Millenium Development goals (MGDS). It will also make planning mitigation steps easier, which is critical since one of the four priorities of the Sendai framework for disaster risk reduction (2015-2030) is to improve disaster preparedness for a successful response and to "Build Back Better" in recovery, rehabilitation, and reconstruction.

1.4 Research objectives and research questions

1.4.1 The main objective

The main objective of this study is to investigate the relationship between flooding and the transmission of diarrheal diseases in Lilongwe city in particular Kawale & Biwi.

1.4.2 Specific objectives

- To determine the trends in diarrhea disease prevalence in pre-flood and post-flood situations.
- To determine the most vulnerable groups to diarrhea associated with flooding.
- To assess the communities' susceptibility to the transmission of diarrhea diseases in the pre-and post-flood period
- To identify the community's coping mechanisms for reducing the effects of flooding on diarrhea.

1.4.3 Research questions

- Is there a difference in the number of recorded diarrhea cases in the post and pre-flood periods?
- What are the most vulnerable groups to flood-related diarrhea?
- In the pre-flood and post-flood times, how susceptible is the community to the transmission of diarrheal diseases?
- What coping mechanisms can the populations use to alleviate the effects of flooding on diarrhea?

1.4.4 Study hypothesis

H_0: There is a positive association between flooding and diarrheal diseases in Lilongwe city where flooding causes an increase in the transmission of diarrheal

H_1: There is no slight difference in the increase in the transmission of diarrheal diseases across the villages.

1.5 Thesis structure

This thesis is organized as follows: chapter one discusses the general introduction, followed by the key questions, significance, and objectives of the study. The literature review is discussed in the second chapter. The methodology of the study is discussed in Chapter three, beginning with the research design, data collecting, sample methodologies, study area, data analysis and presentations, research limits, and ethical issues. Chapter four discusses the study's findings and conclusions, beginning with the first objective: to determine trends in diarrhea disease prevalence in pre-flood and post-flood situations, the second objective to identify the most vulnerable groups to diarrhea associated with flooding, the third to assess communities' susceptibility to diarrhea disease transmission in the pre-and post-flood period and lastly to determine the community's coping mechanisms for reducing the effects of floods on diarrhea.

CHAPTER 2 Literature review

2.1 The nexus between flooding and diarrhea disease

Floods in cities happen without warning and in places that aren't ordinarily prone to flooding, making them difficult to track and predict (Susana, 2015). Rapid urbanization, climate instability, and transition, as well as accompanying changes in urban hydrology, have increased urban flood events throughout Africa (Amoako, 2012). In urban areas, floods are less pleasant. They have a disproportionately negative impact on poorer urban dwellers who cannot afford to construct in higher-elevation locations. "High population density, poor housing, little to no access to infrastructures such as clean water and public health facilities, and low adaptation abilities make squatter and other informal settlements very vulnerable," according to the IPCC (2001). Flood impacts are divided into two categories: tangible flood impact and intangible flood impact. Floods can be classified to help understand the damage or losses they might produce. There is broad consensus in the literature on how flood damage should be classified. The most common distinction drawn is between tangible and intangible damage. Tangible harm, according to Messner et al (2007), is damage that can be measured in monetary terms. Intangible damages, on the other hand, are those that are difficult to categorize. For example, physical damage to properties can be defined as tangible damage, yet the ill-health of flood victims would be considered intangible damage.

Both stagnant floodwater and drinking water from numerous water bodies make up floodwater. Pollution from a variety of sources, such as sewage due to broken pipes, oil spillage, and chemicals, collect in the floodwaters, affecting both of them (Euripidou & Murray, 2004). Contaminated water sources and the environment increases the risk of transmission of diarrhea diseases. Flooding has been known to affect water quality as contaminants and pollutants are washed into surface water bodies and flooding may dilute pollutants due to increased water volumes in surface water bodies. These may cause indirect health impacts on people and the environment. Contamination is one factor that can increase diarrheal illness.

A study conducted in Accra, Ghana (Abu, M., Nii, S., & Codjoe, A. 2018) on the relationship between floods and diarrhea diseases showed positive relationships. An extensive literature review was conducted in 2017 in Kenya, and published literature from 2000 to 2017 was retrieved. Infectious illness epidemics such as waterborne, rodent-borne, and vector-borne diseases have been linked to flooding, according to the study (Okaka & Odhiambo, 2018). No such kind of study has been conducted in Malawi.

2.2 Vulnerable groups to flood-related diarrhea

According to Cutter (2011), vulnerability is an internal risk factor of a subject or system exposed to a hazard that correlates to the subject's or system's intrinsic potential to be harmed. It refers to a community's physical, economic, and social vulnerability to harm in the case of threatening natural or man-made events.

In Africa, diarrheal disease is thought to contribute to approximately 19% of the deaths in children under the age of five (Black et al 2010). It has also been well documented that, alongside malaria and acute respiratory infection, it is one of the leading causes of death in children under the age of five in Malawi (MICS, 2006). Diarrhea disease can affect people of all ages, with the most vulnerable groups (the young, elderly, pregnant, and Immuno--compromised) being the most vulnerable to symptoms (Morse, 2011). They are the major causes of illness and mortality in people of all ages, especially children under the age of five. According to the World Health Organization (WHO), 3 million deaths occur every year from diarrheal diseases worldwide. Furthermore, outbreaks of infectious disease place a strain on caregivers, especially women and girls, and add to their burden.

Waterborne diseases are among the major public health problems in developing countries like Malawi with flooding increasing the risk of transmitting these diseases. Waterborne diseases are viral, bacterial, and parasitic diseases that use water as a common means of transmission (Demena & Workie, 2003), floods affect the water quality. According to a Bangladeshi study, those with weakened immune systems, the elderly, and children under the age of five are the most vulnerable to flood-related diarrhea (Hashizume, M.,

Wagatsuma, Y., Faruque, A. S. G., Hayashi, T., Hunter, P. R., Armstrong, & Sack, D. A., 2008)

2.3 Communities' susceptibility to the transmission of diarrhea disease

According to Smith (2009), referenced by Few (2003), squatter and other informal settlements with high population density, poor shelter, little or no access to resources such as safe water and public health services, and low adaptive capacity are especially vulnerable IPCC (2001). Poorer residents also suffer more, because they have fewer resources to assist them in dealing with floods. Floods can be dangerous to humans, and can destroy houses including water and sanitation infrastructure, either by the force of the floodwaters or because materials are weakened when wet (Mwaniki, 2009). During flooding, the flood water can burst sewer lines, where they exist, and overwhelm waste treatment plants (Sholihah, Q., Kuncoro, W., Wahyuni, S., & Puni, S, 2020). Pit latrines and septic tanks are prone to overflowing in other regions, sanitation facilities in urban and slum areas are highly vulnerable to flooding because they are often poorly designed and constructed (Morshed & Sobhan, 2010). Flooding causes the contamination of the drinking water supply. Flooding transport bacteria parasites and viruses into clean water systems that lead to the outbreak of water-borne diseases including diarrhea diseases.

2.4 The prevalence of diarrhea disease in the post and non-flood situations

WHO reports that floods can increase the transmission of cholera (WHO 2010). The problem of water-borne diseases is particularly prevalent in areas where general hygiene and environmental sanitation are low, and where there is a lack of safe water supply, where flooding events provide a favorable environment for the spread of disease (Ana Maria de Roda Husman, 2013). It is estimated that inadequate sanitation, dirty water, or a lack of water are responsible for 80% of all infections worldwide (WHO Monica II). Floods also endanger human health through wound infections, diarrheal illness, and post-traumatic stress disorder in evacuees (Rui et al., 2018). Flooding causes damage to water, sanitation, and hygiene practices(WASH), damage to WASH facilities, such as pit latrines, has the potential to cause the spillage of human wastes into water bodies, which in turn

results in increased rates of infection to waterborne and other diseases (*Malawi 2019 Floods Post Disaster Needs Assessment Report*, 2019). Liao (2019) adjusted a model which estimated that flood had immediately increased the risk of dysentery and have caused a 21% increase of all-cause diarrhea in the post-flood period. In low-income countries where the water supply and sanitation system and causative agents of diarrheal are likely to be different from those in high-income countries, post-flood increases in cholera (Sur et al. 200), rotavirus diarrhea (Ahmed et al 1991; Fun et al 1991) cryptoridiidios (Katsumata et al 1998) and nonspecific diarrheal (Woodruff BA et al 1990; Siddique et al 1991; Bisusas et al 1999; Mondal et al 2001; Kondo et al 2002; Kunii et al 2002) have been reported. A recent study in Bangladesh reported flood-related diarrheal epidemics which were primarily explained by cholera (Schwartz et al 2006). Non-specific diarrhea, cryptosporidiosis, rotavirus, and typhoid in Kenya research have shown that there is an association between cholera outbreak and flooding while looking at the interaction between climatic, environmental, and demographic factors on cholera outbreaks in Kenya there was evidence that flooding was associated with an increased risk of cholera.

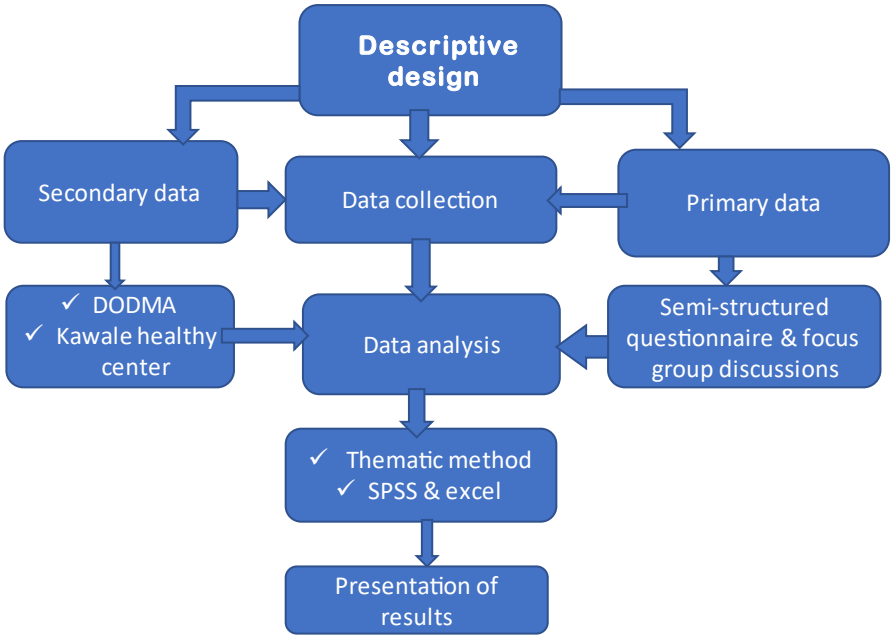
2.5 Coping mechanisms in response to the impact of flooding on diarrhea

Because the majority of the population lives in cities, disaster risks in cities must be addressed (DID, 2016). Different interest groups must be informed about the threats they face and the steps they might take to alleviate them. The numerous interest groups involved include governments (at various levels), municipal authorities, corporations, and individuals (Poell, R., Doornbos, A., & de Laat, M., 2001). The Environment Department, for example, launched a public awareness campaign. Following severe floods in England and Wales in 1998, the Flood Relief Agency (the body in charge of such activities in England and Wales) was founded with the following communications objectives: Ensure that people are aware of the consequences of flooding and that flooding remains a national concern. To reduce future vulnerability to infectious illnesses following flooding, comprehensive surveillance and risk assessment, early warning systems, emergency preparedness, and well-coordinated collaborations are required.

CHAPTER 3: METHODOLOGY

The methodology of this study is depicted in Figure 1, which starts with the research design, which is a descriptive design, and continues with data collection, data analysis, and results presentations. More information can be obtained in the sections below (3.1 to 3.4).

FIGURE 1: **METHODOLOGY**



3.1 Research design

The research is descriptive, and it includes both qualitative and quantitative data collection and analysis methods. Quantitative approaches are more focused on counting and classifying features, as well as developing statistical models to explain what has been observed. Qualitative research approaches enable the researcher to obtain a better knowledge of the people's perspectives, opinions, and interpretations. Using both strategies helped to balance out the drawbacks of each.

3.2 Data collection

Two informal settlements along Lilongwe, Msamba, and Mchesi river were chosen. The quantitative method used both secondary and primary data which was obtained from the department of disaster management affairs (DODMA), Kawale healthy center, and directly from the communities (Kawale and Biwi) using semi-structured questionnaires and focus groups discussions. Kawale healthy center and DODMA provided secondary data whereby DODMA provided flood data which showed the exact dates Biwi and Kawale area were affected by floods from 2016 to 2020. The flood data provided by DODMA was used to define the pre-flood period and post-flood period. According to this study, the pre-flood period is the time before the flooding event in a particular year. It is a constant variable and is set as October. On the other hand, a post-flood period is defined as a period of two months after the day the flood has occurred in a particular year. The post-flood period in a particular year depends on whether the flooding event occurred or not. Firstly, flood data was collected from DODMA which helped to define the post-flood period. After the pre-and post-flood period was defined the data of the recorded diarrhea patients during the post and pre-flood period was obtained between the years of 2016 to 2020 from the Kawale healthy center.

The semi-structured questionnaire (refer to appendix b) and focus group discussions (appendix c) provided primary data on the household's perceived risk of diarrhea after the previous experience of the flooding event, the communities' susceptibility to the transmission of diarrhea diseases in pre-and post-flood period, the coping strategies used by the community to alleviate the impacts of flooding on diarrhea.

As already stated, household questionnaire surveys and focus group interviews were used to gather primary data. Residents living along river buffers who had previously been flooded were given the questionnaire. The study enlisted the participation of 50 households from two separate communities (Kawale & Biwi).

Table 1: Number of respondents from different localities

Community	Number of participants
Kawale	25
Biwi	25

One focus group was held at group village headman Mchapura, a village within Kawale that is vulnerable to flooding, with nine participants (4 males and 5 females), one of whom was a member of the Malawi Red Cross Society, an agency that is accessible within the community that assists in the assisting of flood victims. Another focus group was held in the Biwi group, with five participants: two males and three females. The last person I interviewed was a Kawale healthy center employee.

3.3 Sampling technique and sample size

The participants in the Household Questionnaire were purposefully chosen based on the occurrence of floods. Only those who had previously been impacted by flooding and were within the 60 m buffer zone were eligible to participate.

The sample size of the households was calculated using Cochran's formula below:

$$n=[z^2(1-p)\ p]\ /e^2$$

Where: n= sample size

P= estimated proportion of the population (p=0.5 since the proportion of the participant is unknown)

z= Desired level of confidence (z = 1.96 = 95% Confidence level)

e= absolute size of error allowed by the study (e = +10%)

This resulted in a sample size of 96 people. However, due to time and budget constraints, the sample size was reduced to 50. Purposive sampling was used to select individuals who took part in the primary data collection. A healthy worker, a Malawi Red Cross participant,

those who were given questionnaires, and those who participated in a focus group are among them. Some variables, such as age, gender, and level of education, were taken into account to obtain in-depth data that was useful in the analysis. Participants for secondary data were those that matched the post-flood era(number of confirmed diarrhea patients in post-flood period) which has been described as two months after a flood event and pre-flood period (confirmed diarrhea cases before floods set as October).

3.4 Data analysis and presentations

Data analysis involves organizing, accounting for, and explaining data in making sense of the data in terms of participants' definitions of the situation (Kumar, 2011). Descriptive analysis has been used whereby quantitative data was analyzed using Statistical Packages for Social Sciences (SPSS) version 25 and Microsoft Excel. Secondary data and data from the questionnaires were coded into the software for analysis after data collection. Descriptive analysis was used to generate percentages and statistics of the data collected which has been presented in form of tables and graphs.

The chi-square test, also known as Pearson's chi-square test, is a descriptive statistical evaluation method. It is used when categorical data from sampling is compared to expected/true outcomes. It has a p-value (asymptotic significance value). In this study, the standard value of significance used is 0.05, when the p-value is less than 0.05 there is a significant variation in the null hypothesis(H_0) while when the p-value is greater than the standard value the null hypothesis is rejected, there is no significant variation. The chi-square test was used to test the level of significance of the following hypothesis: "there is a significant variation that children are most vulnerable to the spread of flood-related diarrhea" and another hypothesis which states that "there is a significant variation in the confirmed diarrhea cases in the post and pre-flood period". The testing of the significance of the above hypothesis was achieved by comparing data collected from the Kawale healthy in the post and pre-flood period using the SPSS software. SPSS was also used to run a chi-square test to compare data on the perceived risk of the household being affected by diarrhea in the pre-and post-flood period with the previous experience of flooding.

Qualitative data analysis was analyzed by using the thematic method which uses quotations and statements provided by the interviewees during the data collection to come up with the conclusion. The people's quotations and statements were used to obtain data on the community's susceptibility to diarrhea in the pre-and post-flood period and the coping strategies that can be used by the community to alleviate the impacts of flooding on diarrhea,

3.5 Study area

Lilongwe city, in Malawi's central region, was chosen for the study, with a particular emphasis on informal settlements that are vulnerable to flooding, in particular Kawale and Biwi. Lilongwe city is situated in the north-central part of Lilongwe district, with a population that increased from 669 532 to 989 318 between the 2008 and 2018 censuses respectively. People have been forced to place their lives at risk by living along river banks due to unsustainable urbanization raising the risk of flooding in the region. The Lilongwe river is Lilongwe's largest river and the city's main source of water, Msamba and Mchesi are small other rivers in the city. The people who live in these areas rely on surface and groundwater to meet their basic needs. Kawale and Biwi have been experiencing flooding since 2017 due to climate change and some other factors such as urbanization.

Figure 2 depicts the research area map. The settlements within 60 meters of the rivers Lilongwe and Msamba are shown on the map. The researcher planned to investigate the link between diarrhea diseases and flooding events within 60 meters of the rivers of the chosen settlements because the 60-meter distance from the river is prone to floods and its setting is still in a semi-urban environment with active diarrhea cases. Due to poverty, people cannot afford to own safer places, as a result, they tend to live along the 60 m buffer zone, exposing their lives to hazard. Conditions in these areas increase their vulnerability to the effects of floods on diarrhea disease spread for example distance between homes, environmental circumstances (lack drainage systems & poor waste management).

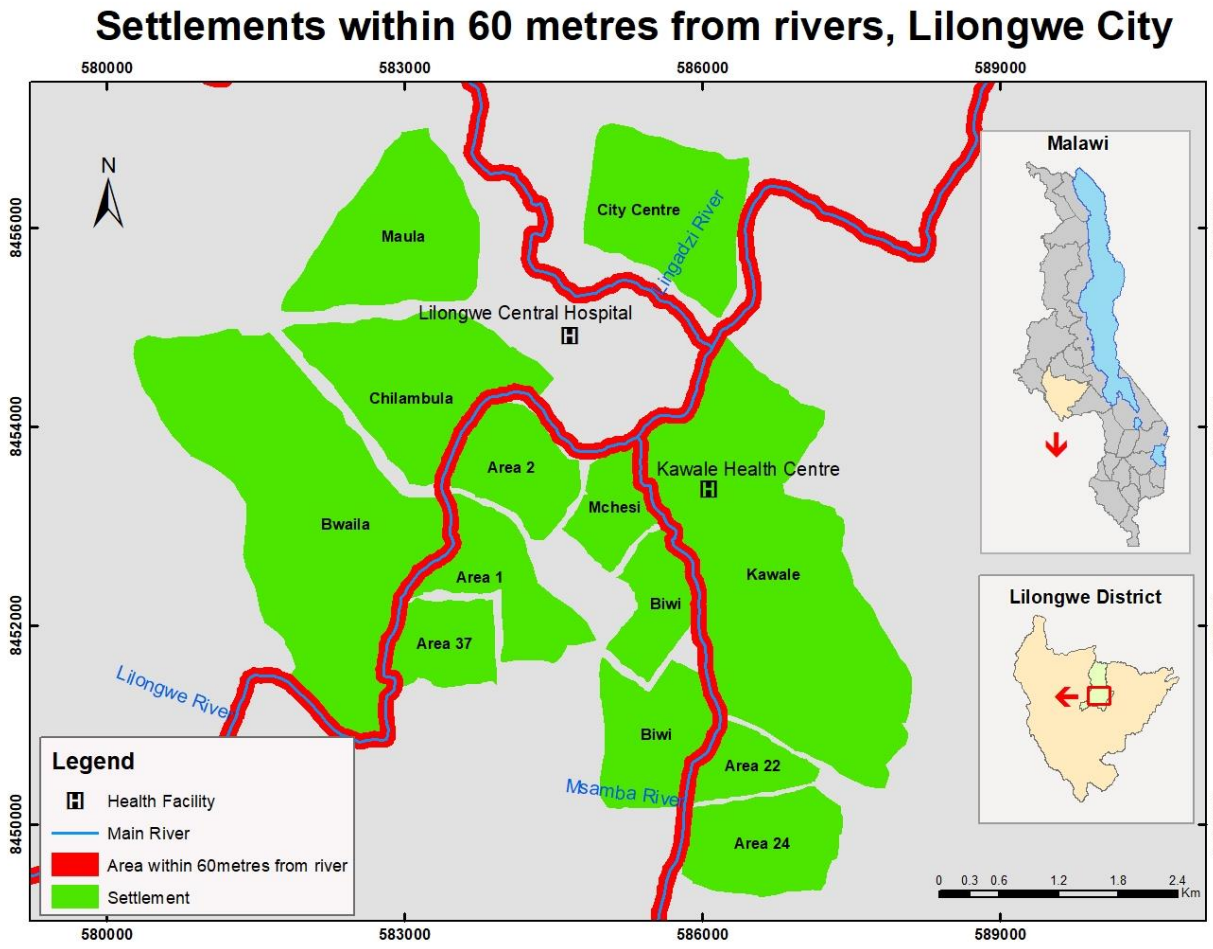


Figure 2 showing the study area map

3.6 Ethical consideration

Since the study involved human subjects, MUSTREC, and the Lilongwe DHO all approved. The researcher made certain that participants in the study did so voluntarily and without compulsion. Their participation was contingent on their giving their informed consent after being advised on the study's goals and importance. The research participants were promised that their participation would be completely confidential and that the data collected would be used purely for the study.

3.7 Research limitations

- The data was collected in the 60 m buffer zone of the two informal settlements in Lilongwe city (Kawale and Biwi), which may not completely reflect the situation throughout the city, as people develop flood coping tactics based on the specific situation they face. A larger sample could not be employed due to time and other resource restrictions.
- The communities were first reluctant to provide the data, assuming that someone from the government was attempting to relocate them and secondary data was not available at Biwi Community Hospital due to its newness, the hospital had to rely only on data from Kawale Hospital.
- In 2020, there were concerns with hospital attendance, according to the in-charge doctor at Biwi Hospital. Floods struck Kawale and Biwi just as the threat of coronavirus was reaching new heights. People preferred to stay at home rather than risk being diagnosed with coronavirus; nevertheless, this does not mean they were not ill. This could have an impact on diarrhea confirmed cases in the post-flood period in 2020. Another issue is that the study found that people with mild to moderate diarrhea were unwilling to go to the hospital, which influenced secondary results

Chapter 4: results and discussions

The study's results and discussion are presented in this section.

4.1 The trends of diarrhea disease prevalence in pre-flood and post-flood situations

According to the flood data obtained from DODMA, table 2 shows the exact dates Kawale and Biwi were affected by floods.

Table 2: The exact dates Kawale and Biwi were affected by floods between the years 2016 to 2020 (refer to appendix d)

Year	Kawale	Biwi
2016	No floods	No floods
2017	16 /012/17	16/012/17
2018	No floods	No floods
2019	10/01/19	10/01/19
2020	01/01/20	01/01/20

The post-flood period was defined using table 2 above, and diarrhea cases of all ages were gathered from the Kawale healthy center in the post and pre-flood periods, as shown in table 3.

Table 2 shows the statistics for the years 2016 to 2020. Floods struck Kawale and Biwi in 2017, 2019, and 2020.

Table 3 shows how diarrhea disease affected different age groups in the pre-and post-flood periods.

Years	Flood status	Under 5	6-15 years	16 -35 years
2016	No floods			

2017	Post flood period	2568	1110	780
2017	pre flood period	400	218	60
2019	Post flood period	2112	718	704
2019	Pre flood period	118	200	150
2020	Post flood period	1341	330	294
2020	pre flood period	100	162	118
Total	Pre flood period	618	580	328
	Post flood period	6021	2 158	1778

People in the 60 m buffer zone had diarrhea in both the post-flood and pre-flood periods, as well as when there were no floods, according to the data. However, the results of confirmed diarrhea patients in the pre-and post-flood period, as well as in the absence of flooding, such as in the year 2016, show that the number of confirmed diarrhea cases increased in the months when there was a lot of rain, with an increase in confirmed diarrhea cases when the community was flooded. When there were no floods in 2016, the outlook for diarrhea cases is shown in table 4.

Table 4: The confirmed diarrhea cases in the year 2016

	January	February	October	November	December
2016	1112	950	947	995	692

When compared to verified diarrhea cases in the same months in 2017, 2019, and 2020, table 4 shows that flooding events have an impact on the spread of diarrhea disease in the communities.

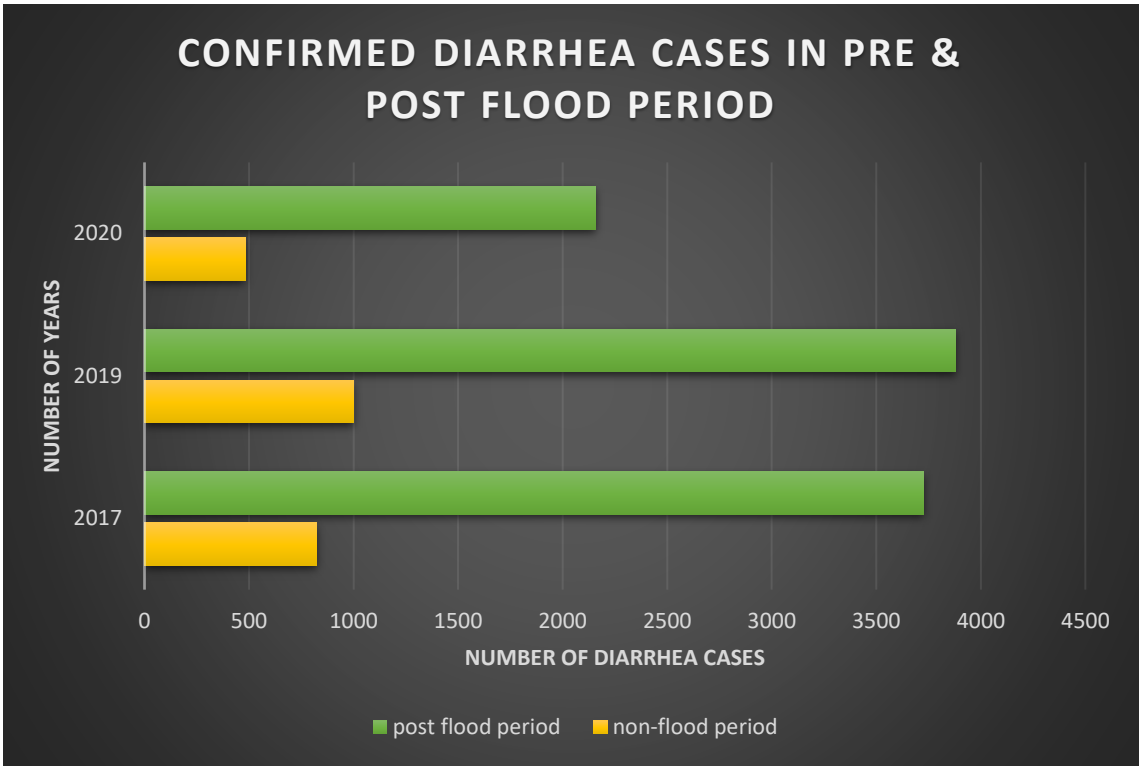


FIGURE 3: Diarrhea disease prevalence in pre-and post-flood periods in various years of a flooding event.

Figure 3 depicts the number of years in which localities were inundated against the confirmed diarrhea cases during the post-flood and pre-flood periods. According to data collected from the health center, there was a massive rise in the confirmed number of diarrhea cases in the post-flood era compared to the pre-flood period (non-flood period), confirming the evidence that more people were affected by diarrhea after flooding.

The post-flood period was dominated by a high number of confirmed diarrhea cases in all of the years. Figure 3 further demonstrates that, according to data received from the Kawale healthy center, variations in the number of confirmed diarrhea cases are more prevalent in the post-flood period than in the pre-flood period.

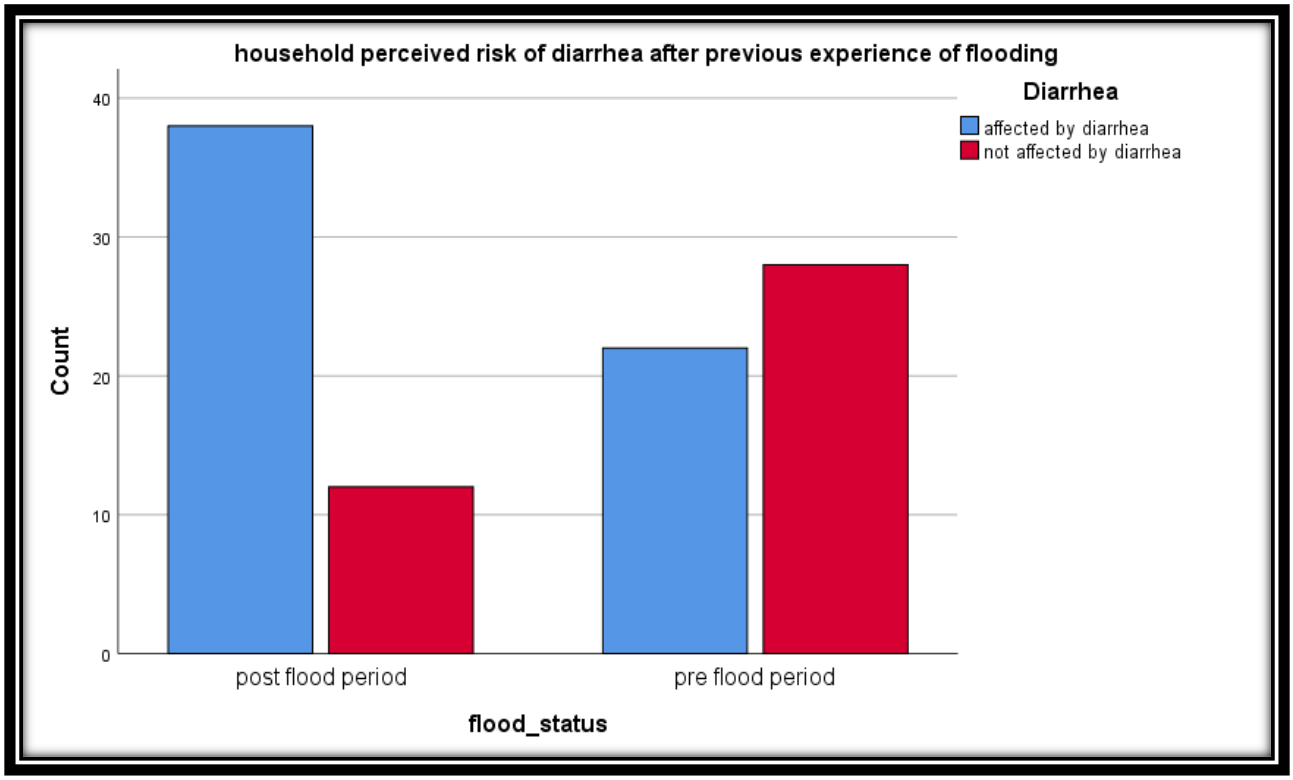


Figure 4: The household's perception of the danger of diarrhea as a result of prior flooding.

The clustered bar graphs in figure 4 depict the household risk of being afflicted by diarrhea in the post- and pre-flood periods, with the post-flood people having more people affected by diarrhea.

The households' estimated risk of diarrhea from the communities' previous flood experience was examined to confirm the evidence that more people suffer from diarrhea after a flood than before. In SPSS, the chi-square test was used to determine the significance of the following hypothesis:

Null hypothesis: "there is a significant variation in the confirmed diarrhea cases in the post and pre-flood period"

Alternative hypothesis: "there is no significant variation in the confirmed diarrhea cases in the post and pre-flood period".

Table 5: The Chi-square test yielded the following outcomes (more details described in the methodology, section 3.4 data analysis, and presentations)

	Value	Df	P value
Pearson Chi-Square	12.026[a]	1	0.002

The null hypothesis is accepted since the p-value of 0.002 in table 4 is less than the standard p-value, indicating that there is a significant difference in confirmed diarrhea cases between the post and pre-flood periods, with more people suffering diarrhea in the after-flood period. People's experiences from prior flooding, on the other hand, reveal a higher rate of verified diarrhea cases than hospital cases. This is because people with mild to light indicators of diarrhea were hesitant to go to the hospital.

4.2 The most vulnerable groups to diarrhea associated with flooding

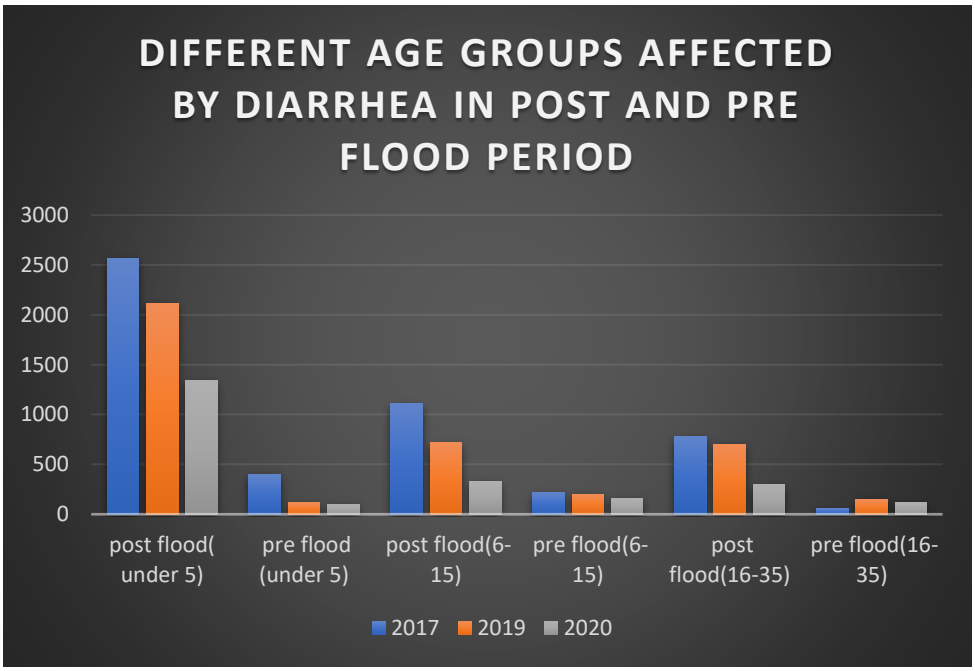


Figure 5 depicts the various age groups affected by floods in the pre-and post-flood periods of 2017, 2019, and 2020.

Children under the age of five were disproportionately affected by diarrhea in both the post-flood and pre-flood periods, according to the figures given in Figure 5. Children appear to be the most vulnerable to flood-related diarrhea, according to data collected after floods.

In SPSS, the chi-square test was used to determine the significance of the following hypothesis:

Null hypothesis: "there is a significant variation that children are most vulnerable to the spread of flood-related diarrhea"

Alternative hypothesis: "there is no significant variation that children are the most vulnerable to flooding after diarrhea"

The null hypothesis is accepted since the chi-square test yielded a p-value of 0.001, which is smaller than the conventional p-value of 0.05. There is a substantial correlation between the occurrence of floods and the number of children affected by diarrhea, implying that children are the most vulnerable to flood-related diarrhea. The children are the most vulnerable to flood-related diarrhea, as seen in the clustered bar graph in Figure 6:

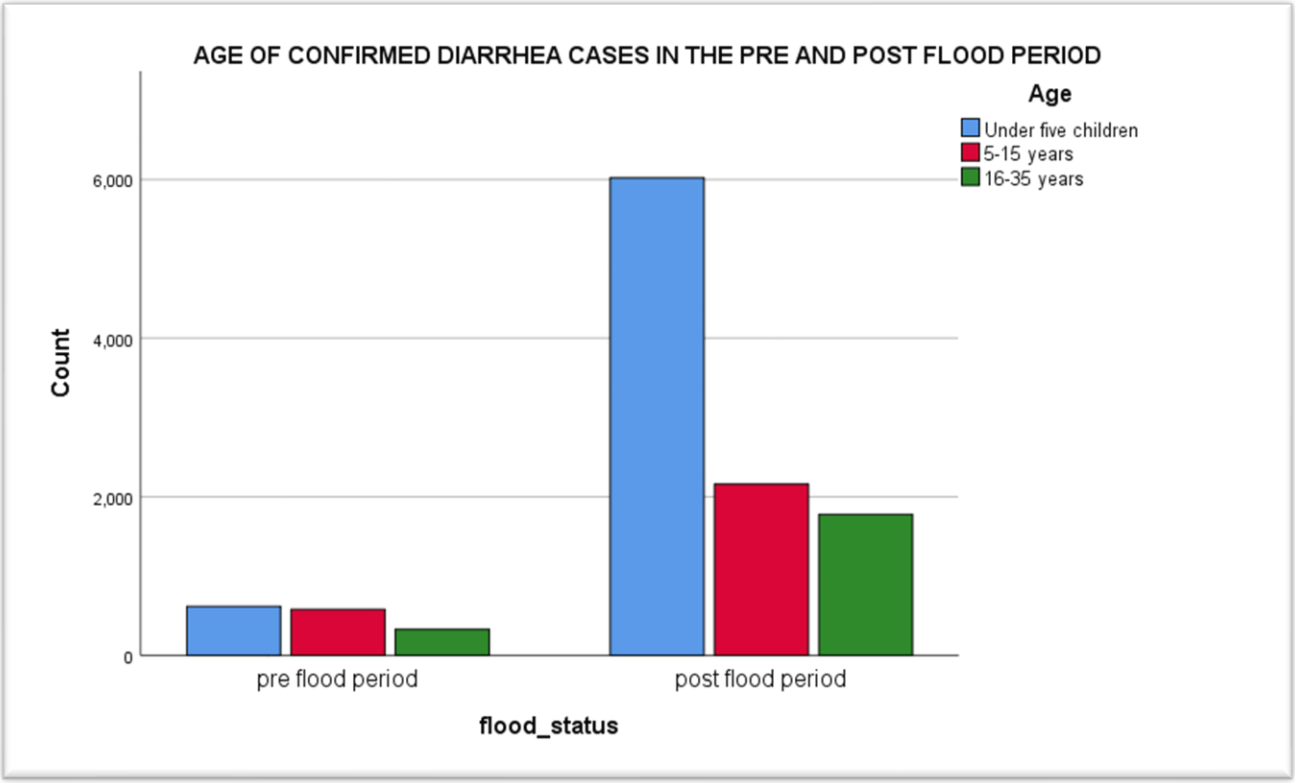


Figure 6: In the pre-and post-flood periods of 2017, 2019, and 2020, figure 6 depicts clustered bar graphs of different age groups affected by flooding events.

4.3 The communities' susceptibility to diarrhea disease transmission in the post- and pre-flood period

The following factors influence a community's susceptibility to the effects of flooding on diarrhea.

4.3.1 Housing

In a study investigating the relationship between flooding and diarrhea diseases conducted in the buffer zone of the two informal settlements of Lilongwe city, it was observed that most households live in poor-quality housing. Houses with poor building materials (houses that are not well thatched, houses constructed with mud bricks, houses with weak walls), houses with minimal spacing between them (more houses concentrated in a small area), and houses that are within 0 to 60 meters of the river are all considered poor quality housing (refer to appendix d). As a result of substandard housing, the community confronts

a multitude of issues during flooding. The community has a variety of challenges during flooding as a result of inadequate housing. During focus group discussion, the following points were identified as the effects of poor-quality housing on the likelihood of diarrhea disease spread in the aftermath of a flood:

- Filthy flood water gets into houses and contaminates utensils, and children with weakened immune systems are quickly affected when they come into contact with it.
- The houses in the research region do not provide a sanitary environment for the population during flooding, and as a result, disease transmission thrives.

4.3.2 Water sources

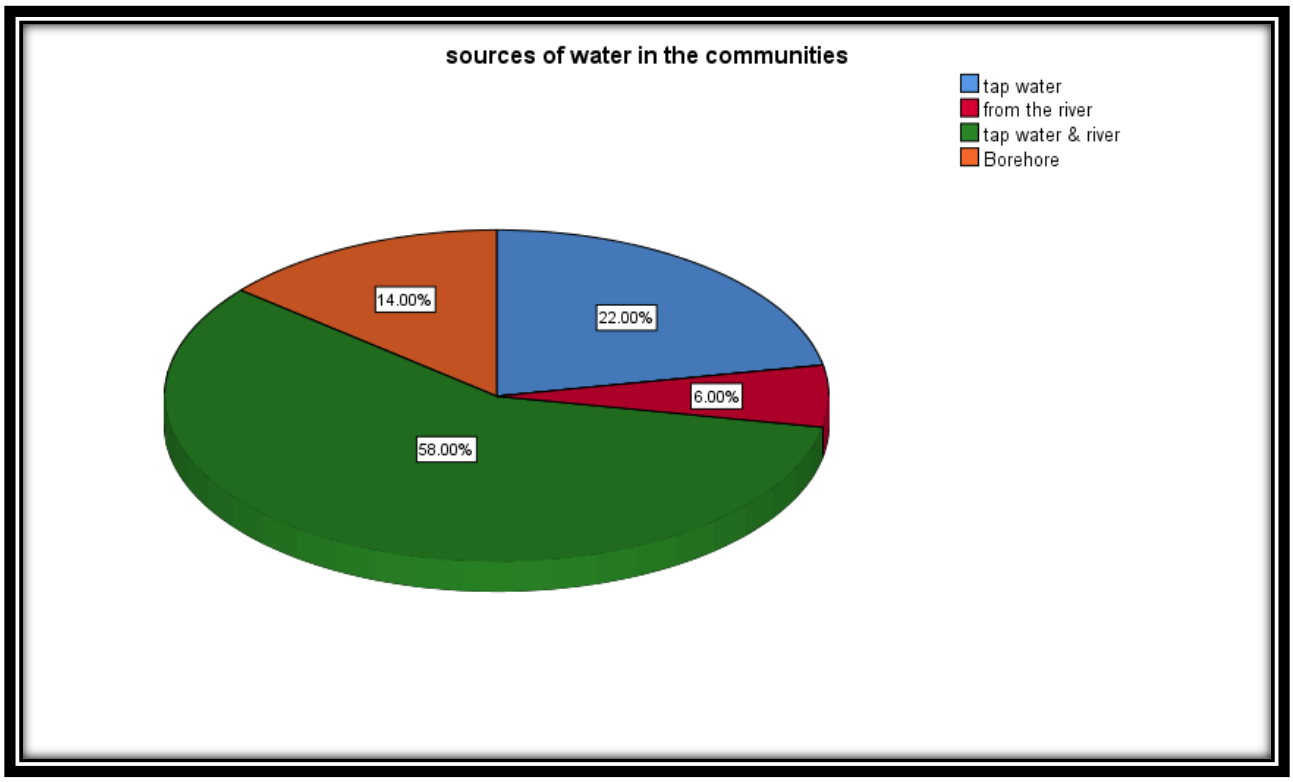


Figure 7 shows the different water sources used by the communities of Kawale and Biwi

According to the findings, for all home duties, 58 % utilize water from both rivers (the Lilongwe, and Msamba, rivers) & taps, 22% use tap water, 14% use boreholes, and 6% use river water. Findings from focus group discussions show that people in the area tend

to utilize well water for domestic uses such as washing, cleaning plates, and occasionally cooking, and only use tap water for drinking due to financial difficulties, exposing their lives to permissive settings for water-borne diseases.

The majority of the people in these places are extremely impoverished, and urbanization has driven them to leave their villages in quest of better economic opportunities. They are already exposed to the propagation of diarrhea diseases in the pre-flood environment. As a result of these conditions, settlement residents are at a higher risk of diarrhea epidemics during the flooding event. This is because the same wells they rely on for other household uses are the ones that flood, bringing all runoffs and even sewers. Despite this, people continue to use the water for daily purposes, exposing themselves to contaminated water and increasing their likelihood of developing diarrhea.

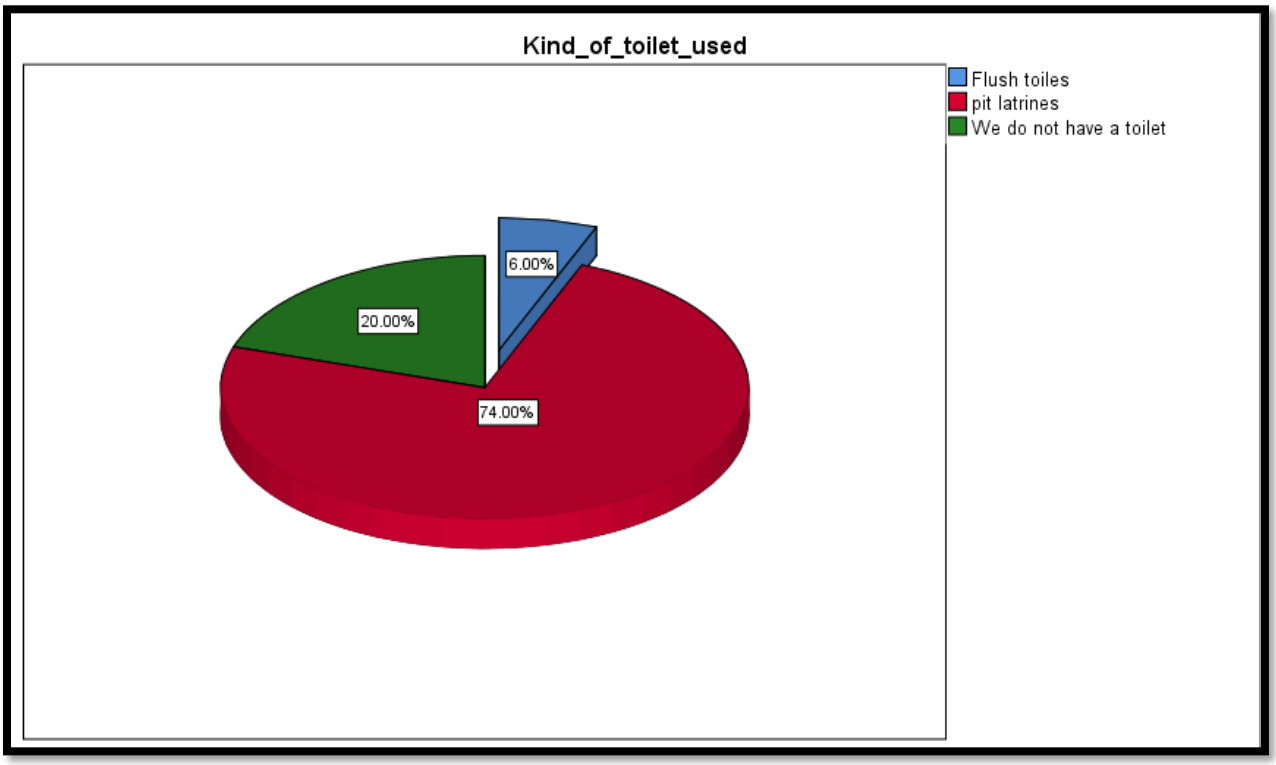


Figure 8 shows the kinds of toilets used by the participants in the study

Pit latrines are used by 74 % as toilets, and they are not only poorly constructed but also positioned within 0 to 60 meters of rivers. Respondents described during focus group discussions that it is exceedingly difficult for them to use the toilets when flooding occurs; nonetheless, because they have no other option, they choose to use the damaged toilets. During floods, open defecation occurs because toilets are destroyed to the extent where sharing toilets is insufficient for the entire people in the affected areas. As rivers overflow, the water levels in toilets rise, causing feces to mix with floodwaters in the river, increasing the risk of diarrhea infections because the river water is frequently used by the population for various household purposes.

Another finding from focus group discussions is that inhabitants use pit latrines that are shared by several households, and that at night, due to insecurity, they become unsafe for women and children, who are forced to relieve themselves in buckets or the open.

4.3.3 Waste management

Observations collected throughout this investigation revealed that waste is dumped haphazardly in these informal settlements (refer to appendix d). Waste and other material dumped by floodwaters cause additional property damage and flood losses in the community during flooding. After a flood, waste can restrict access, serve as a source of pollutants, and serve as a breeding ground for disease, increasing the community's susceptibility to diarrhea cases in the aftermath.

The residents of Kawale and Biwi use a variety of methods to dispose of rubbish as illustrated in figures 9 A & 9 B.

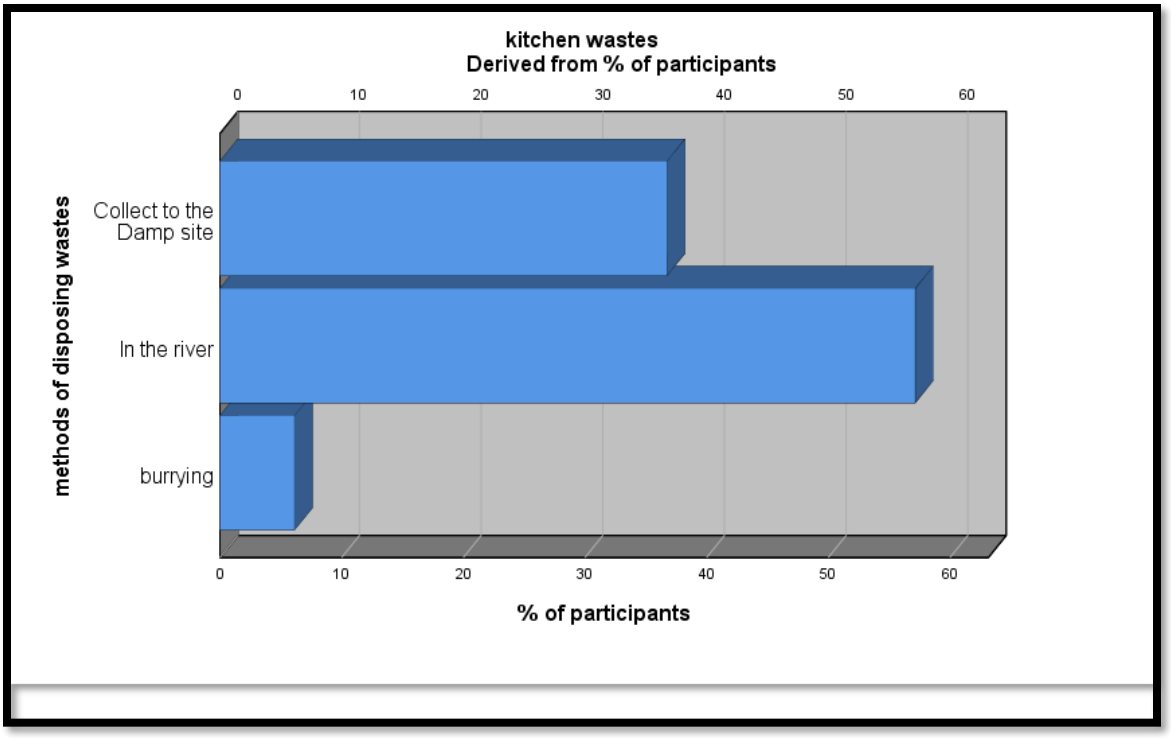


Figure 9 A shows methods of disposing of kitchen waste

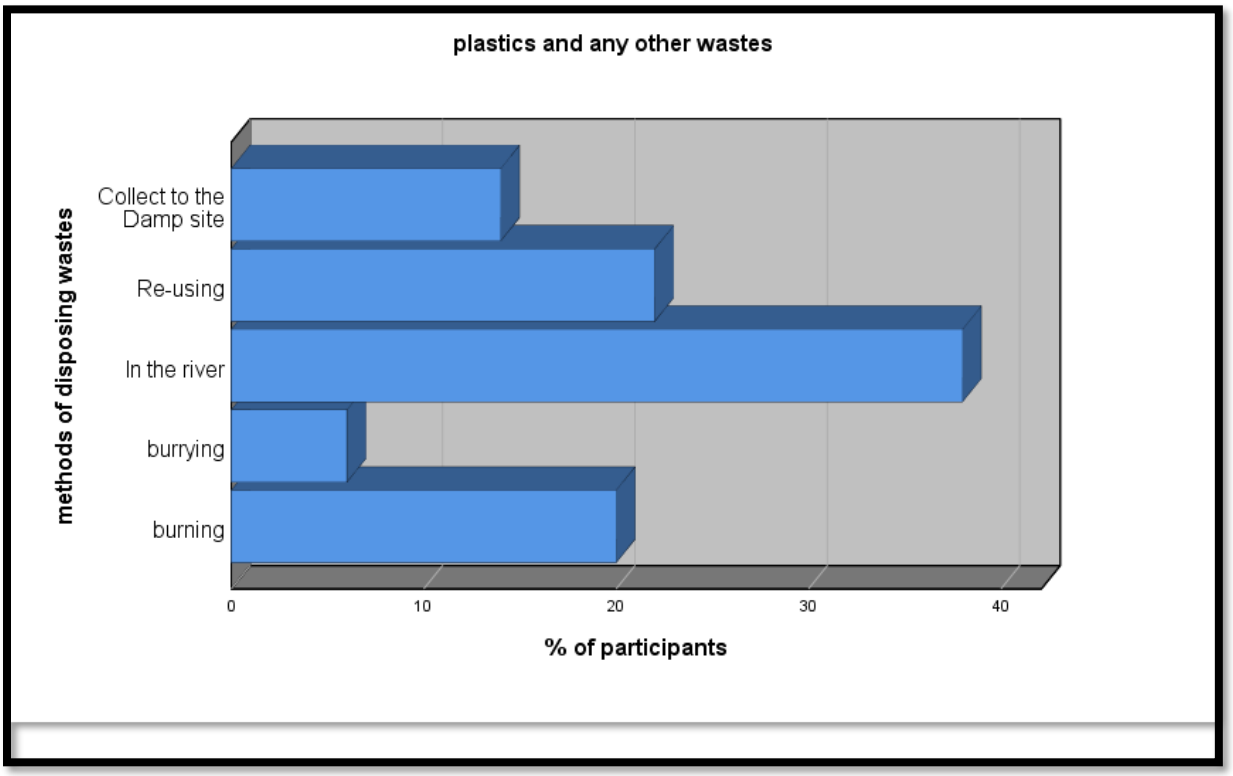


Figure 9 B shows various methods of disposing of plastics and any other wastes

Figures 9 A and 9 B demonstrate that 59% of kitchen garbage is tossed in the river and 38% of plastics and any other wastes are discarded in the river as well, posing more complicated challenges such as urban flood danger and diarrhea disease transmission. In the post-flood period, these techniques of dampening wastes enhance the danger of diarrhea disease transmission.

Challenges of waste management in the communities

Figure 10 indicates that 52 % of the respondents lack knowledge on how to manage the wastes while 33% of the respondents lacked instruments for proper waste disposal while 14% were not sure of the problems they are facing. The majority of the participants in focus group discussions revealed that they see an opportunity of being near the river and have no option other than disposing of their wastes in the river. In these areas, no instruments are used to transport waste, and there are no routes for city council vehicles to pass through and take rubbish to appropriate locations because of the way the houses are built.

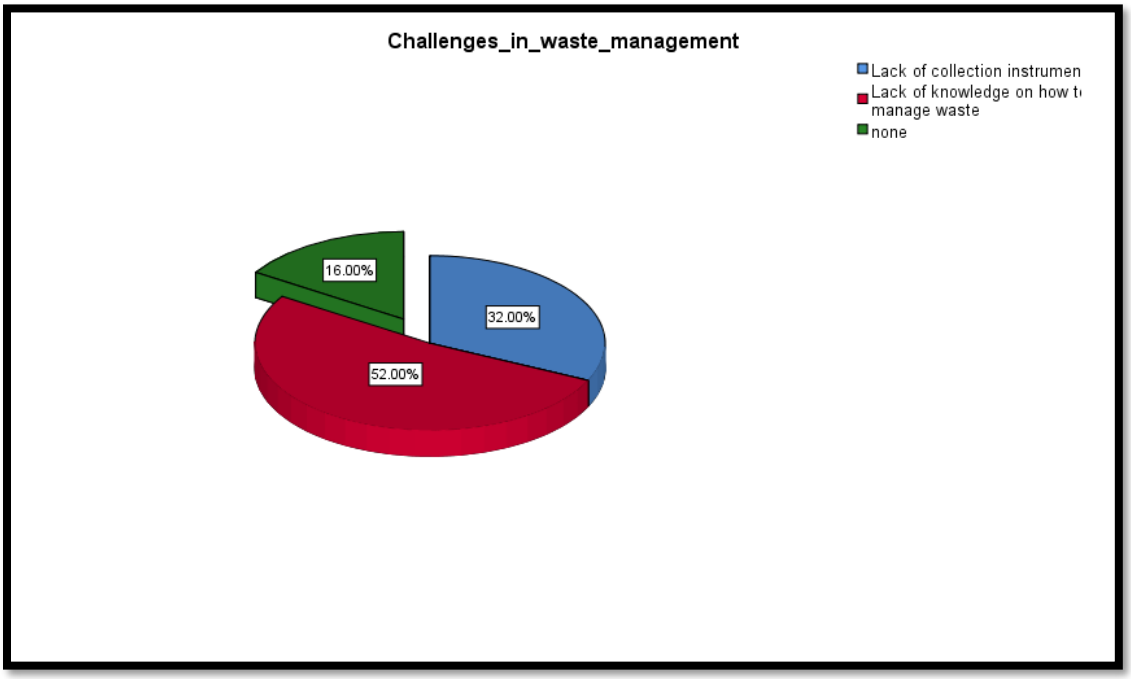


Figure 10: challenges of waste management in the communities

4.3.4 Environmental conditions

Another element that enhances communities' susceptibility to diarrhea transmission is the lack of a drainage system in the area, which accelerates the flow of water into resident's homes even when there is a regular quantity of rain. When filthy water enters homes and children are soon exposed to it, this creates an ideal setting for water-borne diseases to thrive.

In summary, due to their haphazard nature, the 60 m buffer zone poses a significant risk of instability, resulting in unanticipated changes in the environment that fuels a diarrhea disease outbreak. Because of their unplanned character and lack of infrastructure, these areas are prone to diarrhea in post-flood periods. The bulk of the people living in the areas has limited access to sanitation facilities and pipe-borne water. Furthermore, due to the densely populated setting, there is an issue with quick garbage accumulation in these communities, which produces an environment favorable to the spread of infectious diseases worsening the problem in the occurrence of floods.

In addition, there is increased paving of open spaces and increased water run-off in Lilongwe city where wastes frequently clog drainage systems in the study area. This creates fertile grounds for the transmission of water-borne in post-flood periods. To exacerbates the condition, government support for the communities within the 60 m buffer zone is limited, and the region is categorized as an informal settlement. The population of these areas, on the other hand, is expanding at a greater rate than that of urban middle and high-class towns. Because the cost of living in these areas is low, most migrants who move to the city choose to live in them. The study shows that housing, sanitation, and overall environmental conditions in these locations are poor and that these factors might easily contribute to diarrhea outbreaks and rapid spread during flooding occurrences.

4.4 The coping mechanisms to alleviate the impacts of flooding on diarrhea disease transmission in the community.

According to the information given by participants in the focus groups, households devise different methods to prevent the harmful effects of diarrhea after flooding which include:

- piling up sand to prevent floodwater from entering the houses
- Keeping utensils in elevated racks in the houses to prevent direct contact with floodwater
- Washing hands after using the toilet

However, the community's capability is constrained by a lack of income and awareness of disaster preparedness. During an interview with public health officers, it was discovered that when they notice a rise in diarrhea cases, they administer chlorine to the affected homes. During floods, they usually set up tents in the affected areas to treat the diarrhea patients in their homes.

One of the coping strategies the community can use to alleviate the impacts of flooding on diarrhea disease identified in this study is to enhance disaster preparedness for an effective response which is one of the priorities of the Sendai framework of action. Since these Lilongwe city informal settlements fail to prepare for the disasters due to limited resources, these affected communities need to invest in health awareness campaigns. Regardless of the sort of flood that is expected, both pre-flood and post-flood measures should be taken. To make the campaign more cost-efficient, a community-based assessment of the anticipated public health risks during a flood, for example, impacts on water treatment plants or probable disease vectors, where appropriate can be of helpful. Disease outbreaks are not unavoidable following a flooding event: they do not happen by themselves. However, being prepared, educating and motivating both appropriate officials and the general public, and promoting the satisfaction of fundamental sanitary demands are the keys to preventing the spread of the diarrhea disease.

Chapter 5: general conclusion and introduction

The study's ultimate goal was to look into the link between flooding and diarrhea diseases in some areas of Lilongwe. DODMA provided secondary data on the occurrences of flooding events in specific areas, and data on reported diarrhea cases within the 60 m buffer zone were obtained from Kawale healthy center. Household questionnaire surveys, key informant interviews, and focus group discussions were used to gather primary data from Kawale and Biwi communities. The following are the study's summary conclusions concerning the study's overall goal and specific objectives.

5.2.1 Specific objective 1: To determine the trends in diarrhea disease prevalence in post-flood and non-flood situations

To achieve this objective secondary data on confirmed diarrhea cases from 2017 to 2020 in pre-and post-flood periods were analyzed by using descriptive statistics. A chi-square test in SPSS was run and it showed significant variation therefore there's a positive relationship between a rise in reported diarrhea cases and the occurrence of flooding. In the post-flood period, there is an increase in diarrhea cases than in the pre-flood period and in the absence of the flooding event.

5.1.2 Specific objective 2: To determine which groups are most vulnerable to diarrhea associated with flooding

This objective was analyzed by running a chi-square test in SPSS using the secondary data obtained from the Kawale health center whereby it showed that in the selected buffer zone of the informal settlements children are at a greater risk of being affected by diarrhea diseases.

5.1.3 Specific objective 3: To assess the communities' susceptibility to the transmission of diarrhea diseases in the post and pre-flood period

The study's findings from the questionnaires, FDG's and general observations indicate that the 60 m buffer zone of the two informal settlements are already susceptible to the spread

of diarrhea diseases due to the type of housing used, sanitation practices, and environmental conditions, with flooding exacerbating the problem.

5.1.4 Specific objective 4: To identify coping mechanisms that the community can use to alleviate the impact of flooding on diarrhea

Households devise various measures to avoid the adverse consequences of diarrhea as a result of flooding, such as piling sand around houses and raising doorsteps to keep filthy floodwater away. Washing hands after using the toilet but the problem is they are reluctant to use chlorine and other preventive measures due to lack of knowledge. It is very essential to invest in awareness campaigns, educate and motivate people on the appropriate measures to reduce risks to enhance preparedness

5.3 Recommendations

The findings and conclusions of the study aided the researcher in formulating the following recommendations for the government, non-governmental organizations, and communities to implement to lessen the effects of flooding on diarrhea disease spread.

- ✓ Governments and non-governmental organizations must work together to make disaster risk reduction a national and local priority with a strong institutional foundation for implementation. Although Malawi developed policies to accelerate the implementation of disaster risk management, for example, one of the roles of the ministry of housing and urban development is the development of national housing and urban development policies, people within the 60 m buffer zone of Lilongwe and Msamba river are capable of building within 0 to 60 meters of the river, exacerbating the risk of flooding and the outbreak of diarrhea disease.
- ✓ Governments and non-governmental organizations must empower households to take preventative actions by creating an environment conducive to long-term development for example through the creation of jobs and employment in rural areas to prevent rapid population increase in cities.

- ✓ NGOs, the media, and vulnerable communities must coordinate investing in disaster preparedness through public health awareness campaigns including all stakeholders, including the government.

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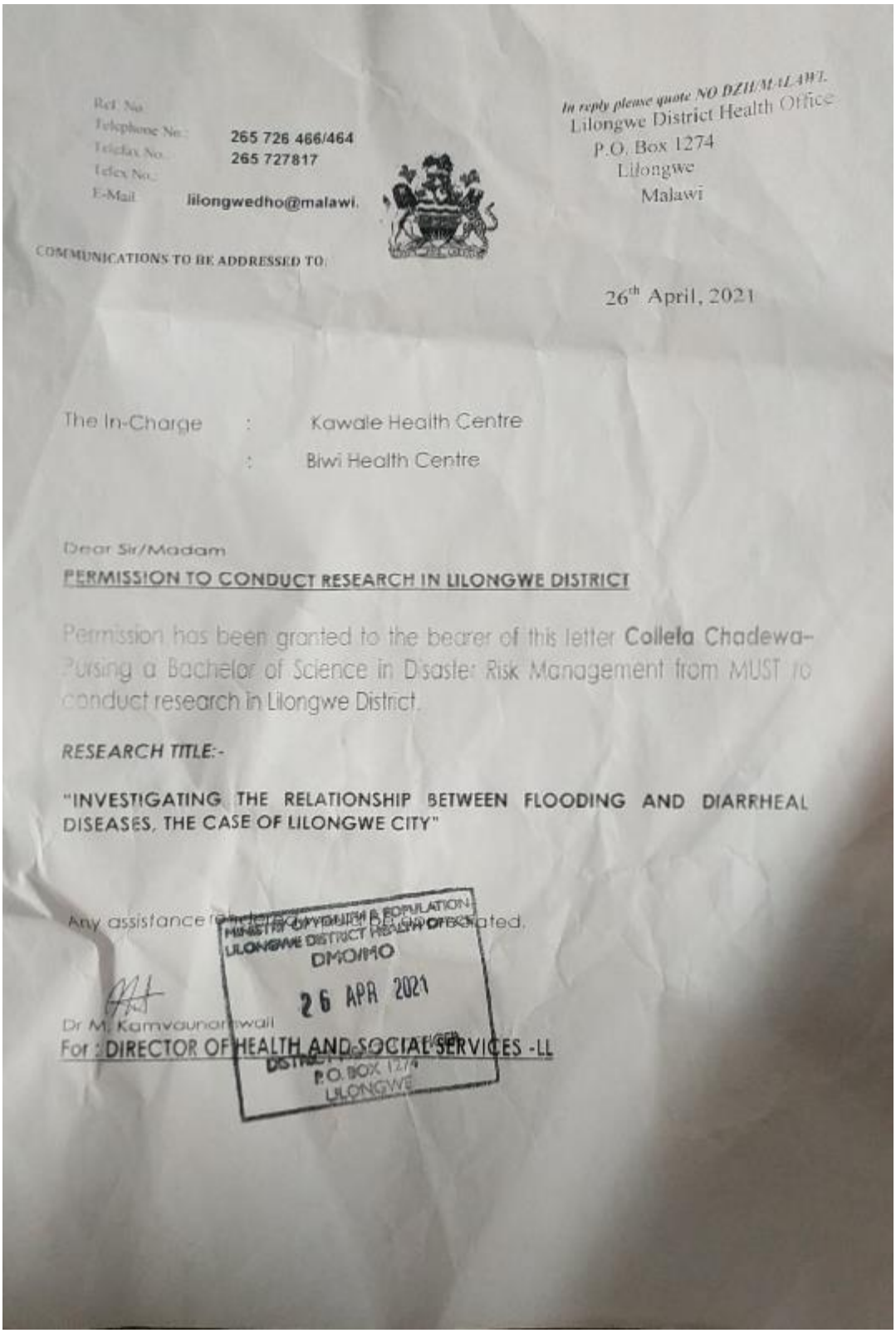
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E-Mail: lilongwedho@malawi.

COMMUNICATIONS TO BE ADDRESSED TO:

In reply please quote NO DZH/MALAWI.
Lilongwe District Health Office
P.O. Box 1274
Lilongwe
Malawi

26th April, 2021

The In-Charge : Kawale Health Centre
: Biwi Health Centre

Dear Sir/Madam

PERMISSION TO CONDUCT RESEARCH IN LILONGWE DISTRICT

Permission has been granted to the bearer of this letter **Collela Chadewa**- Pursing a Bachelor of Science in Disaster Risk Management from MUST to conduct research in Lilongwe District.

RESEARCH TITLE:-

"INVESTIGATING THE RELATIONSHIP BETWEEN FLOODING AND DIARRHEAL DISEASES, THE CASE OF LILONGWE CITY"

Any assistance rendered to the bearer will be appreciated.

MINISTRY OF HEALTH & POPULATION
LILONGWE DISTRICT HEALTH OFFICE
DMO/PO
26 APR 2021

Dr M. Kamvaunanwali
For: DIRECTOR OF HEALTH AND SOCIAL SERVICES -LL

DISTRICT HEALTH OFFICER
P.O. BOX 1274
LILONGWE

CHAPTER 7: APPENDICES

7.1 Appendix A: Research consent form

My name is COLLETA CHADEWA, I am a student at Malawi University of Science and Technology. I am conducting a study on investigating the relationship between flooding and diarrheal diseases, in fulfillment of my Bachelors of Science in Disaster Risk Management.

The study is mainly focusing on investigating how vulnerable the community is to the transmission of diarrheal diseases after the occurrence of flooding, to identify who are the most vulnerable groups to the flood-related diarrheal, comparing the number of confirmed positive diarrheal cases during post-flood and non-flood periods and also to identify coping mechanisms used by the community and strengthen positive ones. To enhance a good understanding of the health consequences of flooding and facilitate planning for mitigation strategies, deeper consideration of the relationship between flooding and the outbreak of infectious diseases is required. This study will help the community to understand the nexus between flooding and diarrhea diseases, what causes the connection, and also it will help the government of Malawi and the non-governmental organizations as it forms the basis for the planning of the mitigation measures.

Your participation will help to achieve and meet the objectives of the study. The survey is voluntary and confidential hence whatever information that you give will not be shared with anyone except for me who is collecting data.

If there are any questions related to the subject, you are free to ask at any time. May I, therefore, request your consent which will take a maximum of 10 minutes

7.2 Appendix B: A household questionnaire survey

Instructions

1. Answer all questions in the spaces provided

2. Where additional information is required, request a blank page at the end of this questionnaire.

3 Tick in the box where required

Background

1. Questionnaire number……
2. Date ……../Month……/Year……..
3. Gender (tick) Male ☐ Female ☐
4. Location/Village ……

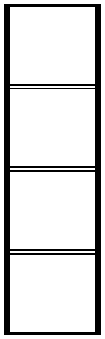
A. Personal and demographic information of the households

1. Gender of respondent: Male: ☐ Female:
2. Age of respondent:
   a) 15- 20 ☐
   b) 20-35 ☐
   c) Above 35 ☐
3. Are you the household head? Yes ☐ No
4. Gender of the household head Male: ☐ Female: ☐

5. Age of household age: _____
6. What is the family size? _____

8. Level of education

a) Primary
b) Secondary
c) Tertiary
d) Not attended



Waste management

1. How do you manage the following wastes?
    i. Plastics
        a) Reusing ☐
        b) Burning ☐
        c) Burying ☐
        d) Collect to dump site ☐
        e) Throw them anyhow ☐
        f) Other (specify)……
    ii. Kitchen waste
        a) Reusing ☐
        b) Burning ☐
        c) Burying ☐
        d) Collect to the dumpsite ☐

e) Throw them anyhow ☐

f) Other (specify)……

iii. Food remains

a) Reusing ☐

b) Burning ☐

c) Burying ☐

d) Collect to the dumpsite ☐

e) Throw them anyhow ☐

f) Other (specify)……

2. Who collects your wastes from your home to the damping site?

a) Yourself ☐

b) Lilongwe City Council ☐

c) Private waste collectors ☐

d) Other (specify)……

3. How frequently does the waste collector collect the waste from your home?

a) Daily ☐

b) Weekly ☐

c) Monthly ☐

d) Other (specify)……..

4. Is the waste collection service in your area effective?

a) Yes ☐

b) No ☐

5. Do you pay for the waste collection service?

a) Yes ☐

b) No ☐

i. If yes, how much do you pay per month? MK.....

i. Who comes to collect the waste in the skip to the damping site?

a) Community volunteers ☐

b) Private waste collectors ☐

c) Lilongwe City Council ☐

d) Other (specify)……

6. What is the most challenging issue for you to manage your waste properly?

a) Lack of collection instruments ☐

b) Lack of knowledge on how to manage waste ☐

c) Laziness ☐

Other (specify

B Flooding and water sources

1 What are the main water sources available in the community

A Rivers/wells

B boreholes

C Tap water

2 How do you use water from the mentioned above sources?

A drinking

B washing clothes

C Bathing

D Cleaning plates

Other……..

3 Does flooding affect the sources of water?

A. Accessibility of water for domestic purposes

(i) yes

(ii) no

B. Availability of safe water

(i) Yes

(ii) No

TABLE 1: DESCRIPTION OF HOUSEHOLD RISK OF DIARRHEA AFTER PREVIOUS EXPERIENCE OF FLOODING

HOUSEHOLD RISK OF DIARRHEA	BIWI COMMUNITY	KAWALE COMMUNITY
Household experienced floods and had a reported case of diarrhea		
The household experienced a flood and had no reported case of diarrhea		
The household did not experience flood but had at least a reported case of diarrhea		

7.3 Appendix C: Guiding questions to focus group discussions and key informant interviews

QUESTIONS	A BRIEF OF ANSWERS FROM THE RESPONDENTS
Is there any risk in the transmission of diarrhea after flooding?	Yes ➢ the houses present in the study area do not provide a hygienic environment for the population during flooding as a result they create fertile grounds for disease transmission. For example during floods, polluted flood water enters the houses. ➢ Due to poverty majority of the population in the informal settlements use water from the rivers for other domestic purposes such conditions place the settlement dwellers at a greater risk of diarrhea outbreaks in the flooding event ➢ During floods, there is also open defecation since toilets are destroyed to the point that sharing toilets aren't enough for the whole population in the affected areas

How do you take care of your wastes in non and post-flood periods?	➢ Those who live near rivers dump their wastes in the river at both times, and even people who live far away from the river dump their wastes in the river, providing fertile ground for water-borne diseases. It is also more difficult for the Lilongwe city assembly to enter these locations to collect waste because there are no roots for a car to drive through. After all, buildings were constructed in such a way that cars cannot pass through. ➢ During flooding, it appears that a mixture of various wastes comes into close contact with the people.
What are the coping mechanisms used in response to the impact of flooding on diarrhea disease transmission?	**The communities** • Pilling up sand to prevent floodwater from entering the houses • Keeping utensils in elevated racks in the houses • Washing hands after using the toilet **The healthy worker** ➢ They do administer chlorine to the affected population ➢ They do build tents in the affected area to treat people in their homes.

What do you think are the causes of the nexus between the flooding event and diarrhea disease?	**The respondent from Malawi red cross society** ➢ To reduce the risk of the impact of flooding on diarrhea there's a need for the planning and housing of the informal settlements. ➢ One respondent in a focus group said poor waste disposal has to be well managed because solid wastes block rivers and increase the risk of flooding and the transmission of diarrhea disease ➢ A healthy responded that there is a need for a health awareness campaign before flooding be
Where do you think the Lilongwe district council needs to improve on the two incidences?	➢ Enforcement of regulations on constructions along the river ➢ Monitoring waste management processes

7.4 Appendix D: Secondary data

The table below shows confirmed diarrhea cases

years	Flood status	Under 5	6-15 years	16 -35 years
2016	No floods			
2017	Post flood period	2568	1110	780
2017	Non flood period	400	218	60

2019	Post flood period	2112	718	704
2019	Non flood period	118	200	150
2020	Post flood period	1341	330	294
2020	Non flood period	100	162	118

How the communities use water from the Lilongwe and Msamba river and the proximity of the houses to the river





(A) unplanned houses within 60 m buffer zone Kawale B) dumping wastes in the river





C) Unplanned houses within 60m buffer zone at Biwi (D) People washing in the river

(a) People washing in the Lilongwe river



(b) A house within 5 meters from the river



LILONGWE DISASTER PROFILE FROM DODMA

21 November 2017	Heavy rains and winds	Chiradzulu	Mpunga	Khuvinda
21 November 2017	Heavy rains and winds	Chiradzulu	Mpunga	Majikuta
21 November 2017	Heavy rains and winds	Chiradzulu	Mpunga	Mwendayekha
21 November 2017	Heavy rains and winds	Chiradzulu	Mpunga	Salira

27/11/2017	Hailstorm	Nkhata Bay	Timbiri	Kamphomombo
27/11/2017	Hailstorm	Nkhata Bay	Timbiri	Malepa
06 December 2017	Stormy rains	Dedza	Kachere	
16 December 2017	Floods	Lilongwe	biwi	biwi
16 December 2017	Floods	Lilongwe	biwi	biwi

08 January 2019	Stormy rains	Balaka	Msamala	Kalimba
08 January 2019	Stormy rains	Balaka	Msamala	Nsamala
08 January 2019	Stormy rains	Balaka	Msamala	Kapalamula
08 January 2019	Stormy rains	Balaka	Msamala	Mtalika
08 January 2019	Stormy rains	Balaka	Nkaya	Chitsinkha
08 January 2019	Stormy rains	Balaka	Nkaya	Mbaza
08 January 2019	Stormy rains	Balaka	Nkaya	Naweta
08 January 2019	Stormy rains	Balaka	Amidu	Magombo
08 January 2019	Stormy rains	Balaka	Amidu	Namwera
08 January 2019	Stormy rains	Balaka	Amidu	Chatawa
08 January 2019	Stormy rains	Balaka	Amidu	Namwera
08 January 2019	Stormy rains	Balaka	Amidu	Chipyali
08 January 2019	Stormy rains	Balaka	Sawali	Kadyalunda
08 January 2019	Stormy rains	Balaka	Sawali	Nsamanyada
08 January 2019	Stormy rains	Balaka	Sawali	Chikalogwe
08 January 2019	Stormy rains	Balaka	Sawali	Maliwata
08 January 2019	Stormy rains	Balaka	Sawali	Chikolorele
08 January 2019	Stormy rains	Balaka	Sawali	Mpoto
08 January 2019	Stormy rains	Balaka	Sawali	Chimatiro
08 January 2019	Stormy rains	Balaka	Sawali	Mgwira
08 January 2019	Stormy rains	Balaka	Sawali	Shumba
08 January 2019	Stormy rains	Balaka	Sawali	Chipwele
08 January 2019	Stormy rains	Balaka	Sawali	Sawali
08 January 2019	Stormy rains	Balaka	Sawali	Katuma
10 January 2019	Floods	Lilongwe city	ngwenya,24,kaliyeka,biwi,	

13 January 2019	Stormy rains	Mangochi	Mponda	
13 January 2019	Floods	Nkhotakota	Mwadzama	

30 December 2019	floods	Nkhotakota	Mphonde	kampanje
30 December 2019	floods	Nkhotakota	Mphonde	mphonde
30 December 2019	floods	Nkhotakota	Mphonde	mtonya
30 December 2019	floods	Nkhotakota	Mphonde	mkombozi
30 December 2019	floods	Nkhotakota	Mphonde	seleman
30 December 2019	floods	Nkhotakota	Mphonde	nchabwe
30 December 2019	floods	Nkhotakota	Mphonde	chikombe
01 January 2020	floods	Lilongwe city	Chitukula	Ngomano
01 January 2020	floods	Lilongwe city	Mgona	
01 January 2020	floods	Lilongwe city	Mvunguti	
01 January 2020	floods	Lilongwe city	Kauma	
01 January 2020	floods	Lilongwe city	kaliyeka	
01 January 2020	floods	Lilongwe city	Senti/chimoko	
01 January 2020	floods	Lilongwe city	chipasula/area 22	
01 January 2020	floods	Lilongwe city	sese/area 24	
01 January 2020	floods	Lilongwe city	kawale/Biwi/Mches	
01 January 2020	floods	Lilongwe city	area 25	Clares/zibwezi
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Khoromani
01 January 2020	Strong winds	Chiradzulu	Nkalo	Malaya
01 January 2020	Strong winds	Chiradzulu	Nkalo	Malaya
01 January 2020	Strong winds	Chiradzulu	Nkalo	Malaya
01 January 2020	Strong winds	Chiradzulu	Nkalo	Zekeya
01 January 2020	Strong winds	Chiradzulu	Nkalo	Namonde
01 January 2020	Strong winds	Chiradzulu	Nkalo	Namonde II
01 January 2020	Strong winds	Chiradzulu	Nkalo	makalani
02 January 2020	floods	Ntcheu	Masasa	mtalimanja