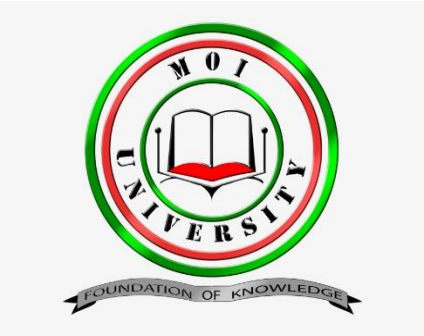

COURSE TITLE: STATISTICAL CONSULTING PROJECT

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STATISTICAL ANALYSIS OF CHOLERA CASES IN KISUMU COUNTY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF DEGREE OF BACHELOR OF SCIENCE IN APPLIED STATISTICS WITH COMPUTING, DEPARTMENT OF MATHEMATICS, PHYSICS AND COMPUTING IN THE SCHOOL OF SCIENCES AND AEROSPACE STUDIES AT MOI UNIVERSITY

DECLARATION

This research project is our own original work and has not been presented to this or any university for an award degree.

This project is presented for approval by our University Supervisor

Name of the supervisor ……Prof. Ann Mwangi……

Signature …… date ……16/7/2024……

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Lastly, we wish to thank our loving parents for the support they accorded us in coming up with this research project. They have been very encouraging and actively involved in a number of ways, may God bless you all.

LIST OF ABBREVIATIONS AND ACRONYMS

IDSR - Integrated Disease Surveillance and Response strategy

MOH – Ministry of Health

CDC - Centre for Disease Control and Prevention

WHO – World Health Organization

ECDC – European Centre for Disease Prevention and Control

MDG – Millennium Development Goals

IFRC- International Federation of Red Cross and Red Crescent Societies

WASH- Water, Sanitation and Hygiene

CFR – Case Fatality Ratio

CTU – Cholera Treatment Units

CHV – Community Health Volunteers

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ABSTRACT

This study focused on understanding how key factors such as availability of safe water for drinking, sanitation and hygiene have influenced the emergence of cholera cases. The core subject is Kisumu County, which is the third largest city in Kenya, with a population of 1,155,000 according to 2019 National Census. Kisumu reported a total of 58 suspected cases listed as of 28th April 2023,11 cases were confirmed through laboratory diagnosis and 2 deaths were recorded. In Kisumu County, limited access to clean water poses a significant threat for cholera outbreaks, primarily attributed to the consumption of water contaminated with fecal matter. This contamination is exacerbated by inadequate drainage system, the absence of proper sewerage system, and the prevalence of shallow pit latrines, wells, and boreholes. The study conducted an investigation on the factors contributing to cholera outbreaks in Kisumu County, with the aim of identifying risk factors, patterns, and potential interventions to prevent the spread of cholera in the region.

The study used retrospective cohort study design to assess potential risks factors and their relationship to the spread of cholera. Both descriptive and Inferential statistics were used to analyze the relationship between the variables as per the objectives.

Expected results are based on geographic mapping and data-driven insights which identify cholera hot spots and concentration areas enabling more precise prevention and control measures.

CHAPTER ONE

INTRODUCTION

Background Information

Cholera is a highly contagious and potentially life-threatening disease that continues to be a major public health concern in Kenya. It is the leading cause of diarrheal illness globally with an estimated 1–4 million cases and tens of thousands of deaths occurring each year. Most cases of the illness are mild, with severe illness in up to 20% of those infected. Cholera is one of the priority diseases under Kenya's Integrated Disease Surveillance and Response (IDSR Report, 2015) strategy. The country has continued to report an increase in the number of cases in various regions with large cyclical epidemics occurring approximately every five to seven years that last for two to three years.

Cholera outbreaks in Kenya have also been associated with high mortality rates, especially among vulnerable populations such as children and the elderly. The severity of cholera-related deaths is largely dependent on the timely access to appropriate medical care and rehydration therapy. Efforts to reduce the death toll caused by cholera in Kenya have primarily focused on strengthening healthcare systems, improving access to healthcare facilities, and training healthcare providers on effective management of cholera cases.

According to surveillance, data from the Ministry of Health Kenya has experienced annual outbreaks with the highest number of cases recorded in 2015, declining in 2016, and steadily increasing from 2017 through to 2019. In the year 2020, a total of 711 cases, and 13 deaths were

Reported (C Kiama et al.,2023). In 2021, a total of 38 cases. It has been observed that the highest number of cases are reported during the rainy seasons. Kisumu County, the area of this case study, with a population of 1.2 million, reported a total of 58 suspected cases listed as at 28th April 2023,11 cases were confirmed through laboratory diagnosis and 3 deaths were recorded. The county however managed to contain the outbreak of the cholera transmission within a period of 15 days.

Cholera remains a significant public health concern in Kenya, the simultaneous progression of several cholera outbreaks, compounded in regions within Kenya, poses challenges to outbreak response and risks further spreading the disease. By analyzing the infection and death figures, it is evident that a multi-faceted approach is necessary to address the underlying factors contributing to cholera transmission. The overall capacity to respond to the multiple and simultaneous outbreaks is strained due to the lack of resources, including the oral cholera vaccine, as well as overstretched public health and medical personnel, who are often dealing with multiple disease outbreaks at the same time.

Purpose of the study

The purpose of this study is to describe the demographic characteristics of cholera cases, their modes of transmission and the factors contributing to the spread of cholera.

Scope of the study

The study covers cholera cases in Kisumu County as at April 28th 2023

Limitations of the study

i) Having limited data for a better study
ii) The data has some missing information

Assumptions of the study

i) This study assumes that the data collected is accurate
ii) The study assumes that there is a standard case definition that has been used to identify and classify cholera cases

RESEARCH OBJECTIVES.

General Objective

To conduct an investigation on the factors contributing to cholera outbreaks in Kisumu County, with the aim of identifying risk factors, patterns, and potential interventions to prevent the spread of cholera in the region.

Specific Objectives

1. Describe the demographic characteristics of cholera cases in Kisumu County.
2. Describe the symptoms of patients presenting with cholera.
3. Describe the modes of transmission of cholera in Kisumu County.

Research Questions

1. What are the demographic characteristics of cholera cases in Kisumu County?
2. What are the symptoms observed among cholera patients in Kisumu?
3. What are the modes of transmission of cholera within Kisumu County?

PROBLEM STATEMENT

According to WHO (World Health Organization), researchers have estimated that every year, there are 1,300,000 million to 4,000,000 million cases of cholera worldwide. In Africa, an estimated 26,000 cases and 660 deaths were reported as of 29th January 2023 in ten African countries. In Kenya, the disease has been widely reported as primarily affecting the poor and vulnerable communities living in informal settlements in peri-urban areas and refugee camps where overcrowding, inadequate sanitation and water shortages are frequent (Stoltzfus et al., 2014; Hounmanou et al., 2016).

A recent cholera hotspot mapping study done identified urban informal settlements, large refugee camps, pastoral areas, arid and semiarid lands, areas bordering the lake region and Mwea irrigation scheme as high priority (Kiama et al., 2023). Inadequate hygiene practices, lack of clean water, insufficient toilet facilities and ineffective waste treatment centers significantly increase the risk of cholera outbreaks in informal settlements. Additionally, improper solid waste management aggravates the problem by causing clogged drainage systems and flooding, further increasing the risk of cholera outbreaks.

For people living in Kisumu County, limited access to clean water is a major risk factor for cholera outbreaks. Increased cholera outbreaks in the County have been attributed to by consumption of water contaminated with fecal matter. This contamination is brought about by poor drainage systems, lack of a proper sewerage system, shallow pit latrines and shallow wells and boreholes. During the rainy season, flooding may result to overwhelming of sanitation systems leading to the mixing of sewerage with water sources hence the rate of transmission increases (Jutla et al., 2013). Thus, cholera outbreaks remain an important public health challenge in Kisumu.

Significance of the Study

It is expected that this study will be beneficial to the county government for purposes of economic and social planning. Uniformities and differences of cholera cases within a country reveal the distribution of other related factors. The study has attempted to come up with a better understanding of the relationship between cholera and its variant influences. Such an understanding would be useful in making of concrete public policies geared towards the improvement of socio-economic and health status of Kisumu County.

This study, also seeks to emphasize the most effective strategies for preventing spread of cholera in Kisumu County. Especially in areas with low hygiene practices and few health facilities such as: peri-urban slums like Nyalenda A and Manyatta with inadequate access to clean water and sanitation , by promoting protective hygiene measures such as storage of food and safe disposal of waste products for both adults and children and setting up of more health facilities as well as increasing the number of community health workers in such areas.

Furthermore, this study will be beneficial to the residents of Kisumu County in sensitizing them on common symptoms of cholera, modes of transmission and those at risk of infection and how to take proper intervention measures.

CHAPTER TWO

LITERATURE REVIEW

In October 2022, World Health Organization assessed the risk of cholera as being very high, at the global level. This poses a great threat to global public health .In Africa alone, 29 countries have reported instances of cholera outbreaks , with many of those nations reporting higher case numbers and case fatality ratios (CFR) than in previous years. In light of these latest developments, this research was birthed from the unease created by the aforementioned disturbing information, to assess the prevalence of Cholera within Kenya, risk mitigation measures put in place to control the latter and possibly attempt to provide pragmatic solutions to mitigate the cases of Cholera and its deaths, within Kenya.

Despite diagnosed cases of Cholera and their eventual deaths being relatively low globally, its case fatality ratio remains at an alarmingly high rate. For instance, from a WHO study, about 21,000 to 143,0000 deaths from Cholera are reported from a case load of about 1,300,000 to 4,000,000 annual reported cases(WHO Weekly Epidemiological Record 25 August 2017, No 34, 2017, 92, 477–500.) . In 2021, the average cholera CFR reported globally was 1.9% with Africa contributing about 2.9% of this. This therefore remains as a reminder that although the caseload remains relatively low, its CFR is inversely high with Cholera having high morbidity and mortality if not addressed within 48 hours of being infected. Thus necessitates the need for continuous monitoring and surveillance in communities.

Cholera is an extremely harmful disease that can cause severe acute watery-diarrhea (Zafar e al., 2016). It takes between 12 hours to 5 days for a person to exhibit symptoms after consuming contaminated food or water. Cholera affects both children and adults. It has the potential to cause

death within hours if untreated. Most people infected with *the virus* do not develop any symptom. Although, the bacteria are present in their bodies for around 1-10 days after infection and are shed back into the environment, through defecation especially open defecation. Most of the people who develop symptoms have mild to moderate symptoms, while a few develop acute-watery-diarrhea with severe dehydration. This can lead to death if left untreated. Cholera can be endemic or epidemic. A cholera-endemic area is an area where confirmed cholera cases were detected during the last 3 years with evidence of local transmission (meaning the cases are not imported from elsewhere). A cholera outbreak can occur in both endemic populations and in populations where cholera does not regularly occur.

In cholera endemic populations, an outbreak can be seasonal and represent a greater expected number of cases. In a population where cholera does not regularly occur, an outbreak is characterized by the occurrence of at least one confirmed case with evidence of local transmission in an area where there are usually no cholera cases.

Cholera transmission is closely associated with inadequate access to clean water and sanitation facilities. At risk areas include peri-urban slums and camps for internally displaced persons or refugees, where minimum requirements of clean water and sanitation have not been met (IFRC, Report 2023).

The consequences of a humanitarian crisis – such as disruption of water and sanitation systems, the displacement of populations to inadequate and overcrowded camps – can increase the risk of cholera transmission, should the bacteria be present or introduced.

Since the beginning of this year, 195,752 cases (86,044 confirmed; 109,708 suspected) and 3,061 deaths (CFR: 1.6%). Cholera cases were reported from 18 Africa Union countries : Burundi (1,082 cases; 9 deaths), Cameroon (20,672; 487), Congo (93; 9), DRC (36,084; 303), Eswatini (2; 0), Ethiopia (24,441; 320), Kenya (8,814; 145), Malawi (42,955; 1,260), Mozambique (34,974; 146), Nigeria (2,860; 84), Somalia (14,191; 38), South Africa (1,074; 47), Sudan (817; 35), South Sudan (1,471; 2), Tanzania (87; 3), Uganda (78; 10), Zambia (934; 19) and Zimbabwe (5,123; 144).

Since the last update (MOH, 6 October 2023), the Ministry of Health reported three new-suspected cases and no new deaths of cholera.

Cumulatively, 8,814 cases (1,828 confirmed; 6,986 suspected) and 145 deaths (CFR: 1.6%) were reported from 27 of the 47 counties in Kenya. Currently, the outbreak is active in one of the 27 counties (Garissa). Thirty-three per cent of the total cases are children below 10 years.

Gaps: Access to water Millennium Development Goal (MDG 7) on drinking water was met globally in 2010. The target was to provide half the proportion of the world's population with sustainable access to safe water. The 48 least-developed countries did not meet the target, but substantial progress has been made with 42 per cent of the current population in these countries gaining access to improved drinking-water sources since 1990.

Sharp geographic, sociocultural and economic inequalities persist, not only between rural and urban areas but also in towns and cities where people living in low-income, informal or illegal settlements usually have less access to improved sources of drinking water than other residents.

Water and Health-Contaminated water and poor sanitation are linked to transmission of diseases such as cholera. Absent, inadequate, or inappropriately managed water and sanitation services

expose individuals to preventable health risks. This is particularly the case in health care facilities where both patients and staff are placed at additional risk of infection and disease when water, sanitation and hygiene services are lacking. Globally, 15% of patients develop an infection during a hospital stay, with the proportion much greater in low-income countries.

Inadequate management of urban, industrial and agricultural wastewater means the drinking water of hundreds of millions of people is dangerously contaminated or chemically polluted.

Some 842,000 people are estimated to die each year from diarrhea because of unsafe drinking water, sanitation, and hand hygiene. However, diarrhea is largely preventable, and the deaths of 361,000 children aged under 5 each year could be avoided each year if these risk factors were addressed. Where water is not readily available, people may decide handwashing is not a priority, thereby adding to the likelihood of diarrhea and other diseases.

Water sources-The MDG water target is measured by the proxy indicator of use of ‘improved’ or ‘unimproved’ drinking-water sources. But ‘improved sources’ are not necessarily safe. At least 1.8 billion people use a drinking-water source that is contaminated with faecal matter. A substantial proportion of water supplied through pipes is contaminated, especially where water supply is intermittent or treatment is inadequate. Even where the source is good, water can be contaminated while being transported or stored.

Economic and social effects -When water comes from improved and more accessible sources, people spend less time and effort in physically collecting it, meaning they can be productive in other ways. It can also result in greater personal safety by reducing the need to make long or risky journeys to collect water. Better water sources also mean less expenditure on health, as

people are less likely to fall ill and incur medical costs, and are better able to remain economically productive.

With children particularly at risk from water-related diseases, access to improved sources of water can result in better health and therefore better school attendance, with longer-term consequences for their lives.

As of August 2023, cholera remains a significant public health concern in Kenya, with the country experiencing outbreaks since 1971, and most recently in 2022. The disease is caused by the infectious bacteria Vibrio cholera, and each year, 21,000-143,000 people worldwide die from cholera, which affects an estimated 1.3-4 million persons. Cholera prevention, preparedness, and control in Kenya involve hotspot mapping, genotyping, exposure assessment, and WASH & oral cholera vaccine interventions. The Ministry of Health, along with other ministries, has launched cholera vaccination drives and initiated alerts after confirming cases in multiple counties. The prevalence of cholera in Kenya is relevant for reducing the burden of illness and death in the country and the region.

CHAPTER THREE

METHODOLOGY

Study area

Our research focused on Kisumu County, with specific locations within Kisumu such as Kasipul, Kisumu East, Kisumu Central and various wards within the city.

Study design

This study utilized retrospective cohort study design that involved analyzing the historical data of patients who presented symptoms of cholera in Kisumu, as at 28th April 2023. A retrospective cohort study allowed for the assessment of potential risk factors and their relationships to the development of the disease.

Study Population

The study included patients who presented symptoms of Cholera from Kisumu County.

Sample size

The study involved fifty-eight patients suspected to present symptoms of Cholera.

Data collection

The research used an already existing dataset collected by Kisumu County Cholera Response Unit Department of Medical Services.

Data Analysis

The analysis involved both descriptive and inferential statistical approaches to derive insights from the dataset. Data cleaning was undertaken to prepare the data for appropriate insights generation,

guided by our research questions. This process was executed using both R and Python programming languages.

a) Descriptive statistics:

Herein, various markers were used to summarize data, with a one-to-one mapping to each objective:

1) Data visualization: graphs were majorly used to summarize the data: cholera cases across sex, cases across wards and cases across age groups.

2) Cross-tabulation: this approach was used to describe the symptoms of patients presenting with cholera by looking at the relationships between the variables: outcome, ages, wards, and sex.

Terms Used:

i. **Vibrio Cholerae Ogawa**: patients confirmed to test positive to Cholera
ii. **Positive to RDT**: patient who tested positive to a rapid tool kit test but not to a laboratory test
iii. **Awaiting results**: referring to patients whose samples were taken but results were yet to be released
iv. **Not Known**: this is the proportion of patients whose record was missing from the dataset
v. **No Vibrio Isolated**: patients who turned out negative but were later quarantined for further observations
vi. **Sample not collected**: gold test from patient was not taken
vii. **Not applicable:** patients whose eventual cholera laboratory test would have been inconsequential because they were likely lost to follow up. This would have been attributed to that the patient was later established to have another disease, in between theis should time he or she was clinically confirmed to have the disease to the time of the laboratory test.

b) Inferential statistics:

1) Fisher's Exact Method: Fisher's Exact test was used to check for the association between modes of transmission and variables such as source of water of the patients and whether the patients had a treatment plan for the water they were using.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This study used an already existing dataset collected by Kisumu County Cholera Response Unit Department of Medical Services as of 28th April 2023. Analysis of this data was done using R and Python programming languages. The data was visualized to describe the demographic characteristics of cholera cases and the relationships between different variables as per the objectives.

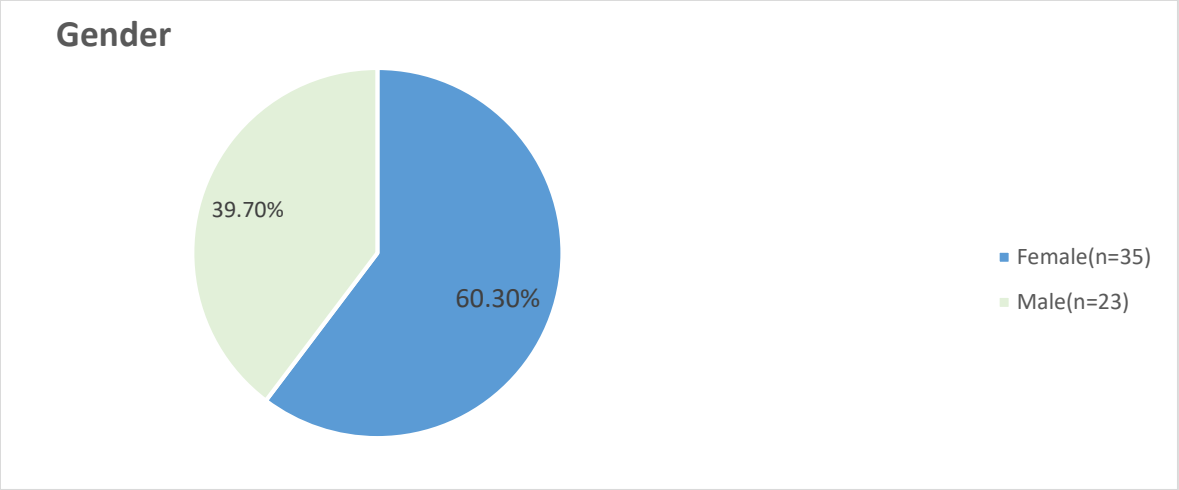
Data Visualization

This section contains several plots that represented cholera patients across different variables

Demographic Characteristics of Cholera Cases

GENDER REPRESENTATION OF CHOLERA CASES

Figure1.1: Gender Representation of cholera cases

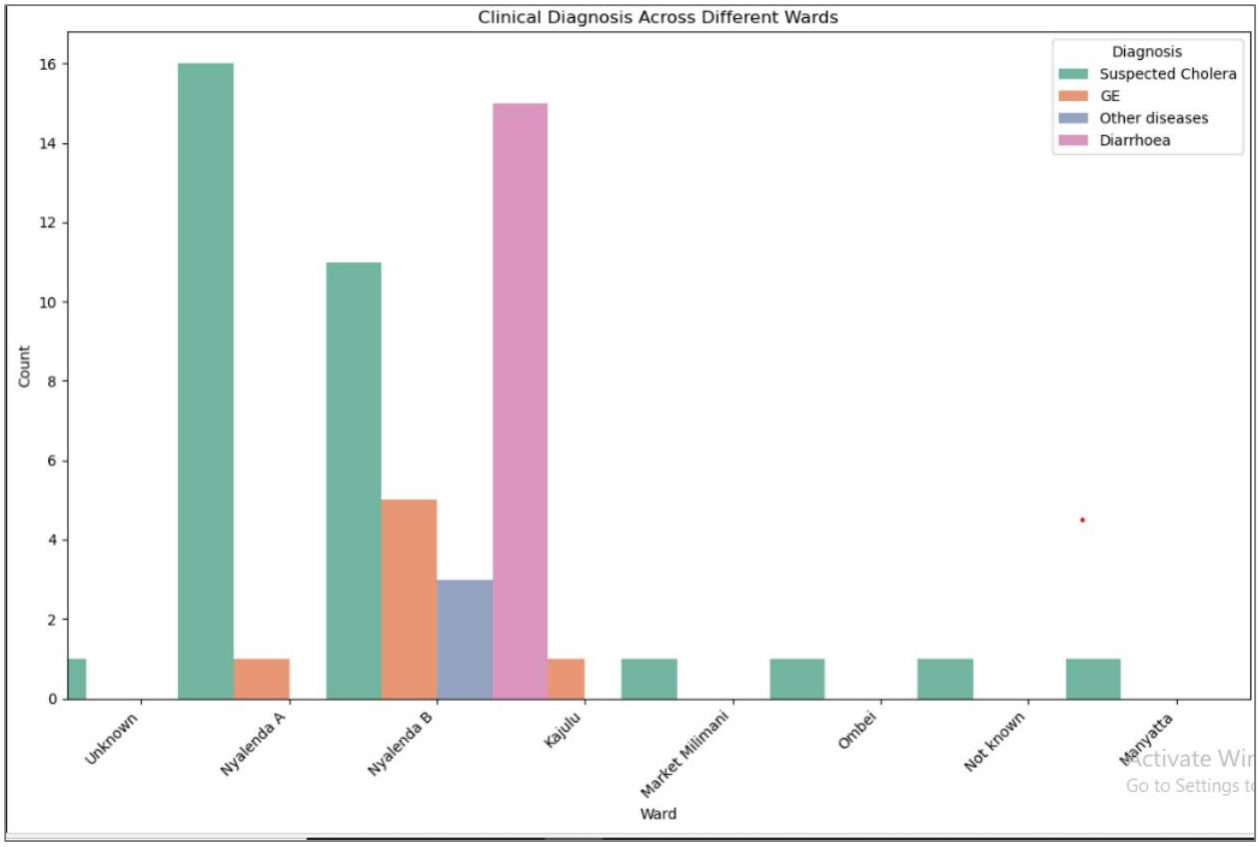


Out of the 58 suspected cholera cases reported in Kisumu County, 35 of the patients (60.3%) were female while 23 (39.7%) were male.

CLINICAL DIAGNOSIS ACROSS DIFFERENT WARDS

Figure 1.2 shows that Nyalenda A is the ward with the highest number of suspected cholera cases with a count of 16 while Nyalenda B has the second highest count of 11 suspected cases of cholera and the rest which are Market Milimani, Ombei , Manyatta and 'Not Known' have a count of one in each.

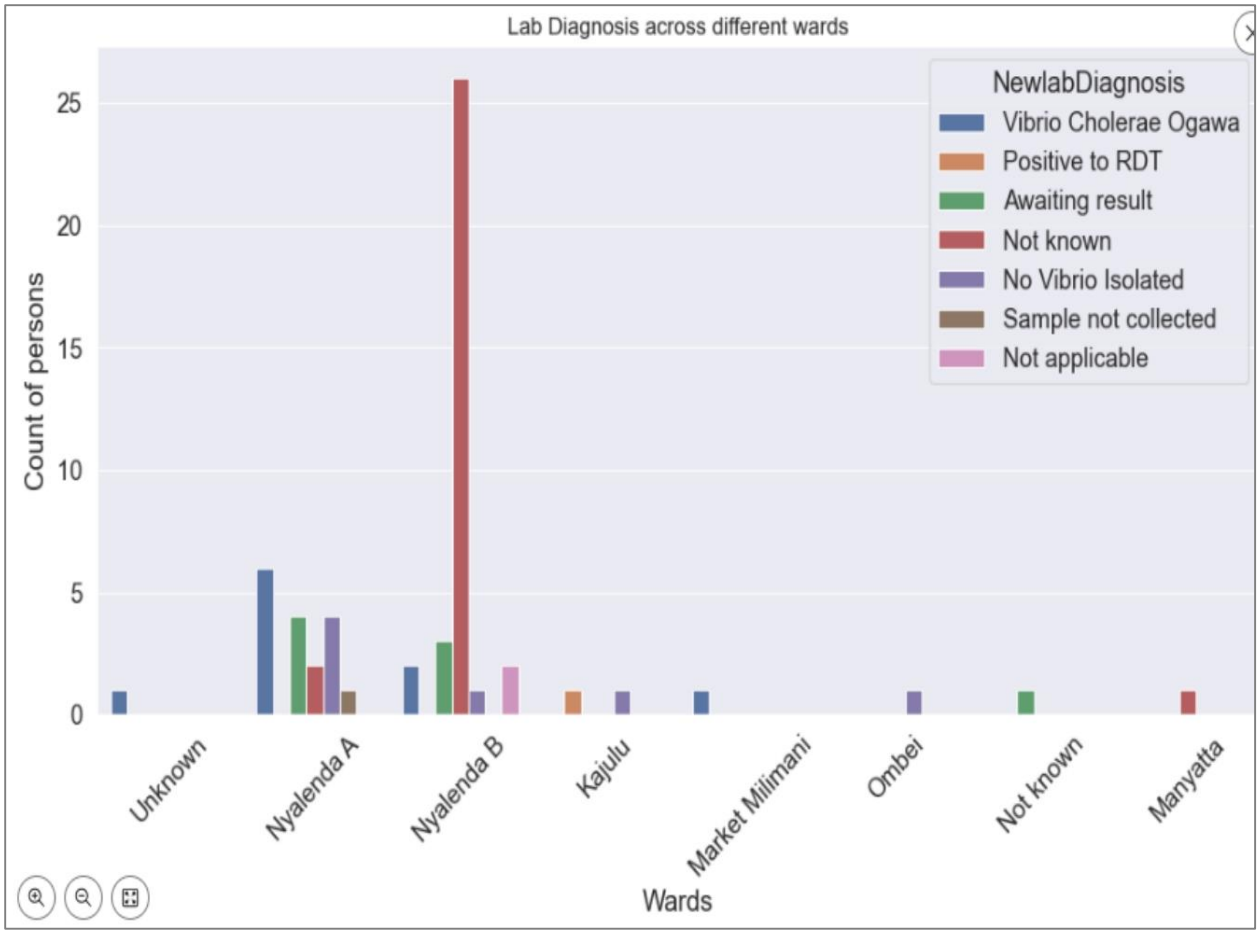
Figure1.2: Clinical Diagnosis across Different wards



LABORATORY DIAGNOSIS ACROSS DIFFERENT WARDS.

From Figure1.3 it can be seen that 6 people from Nyalenda A tested positive for cholera, 2 people from Nyalenda B were also positive and 1 from Market Milimani as well. Also Nyalenda B has the highest number of people whose lab test are not known and this may affect the findings.

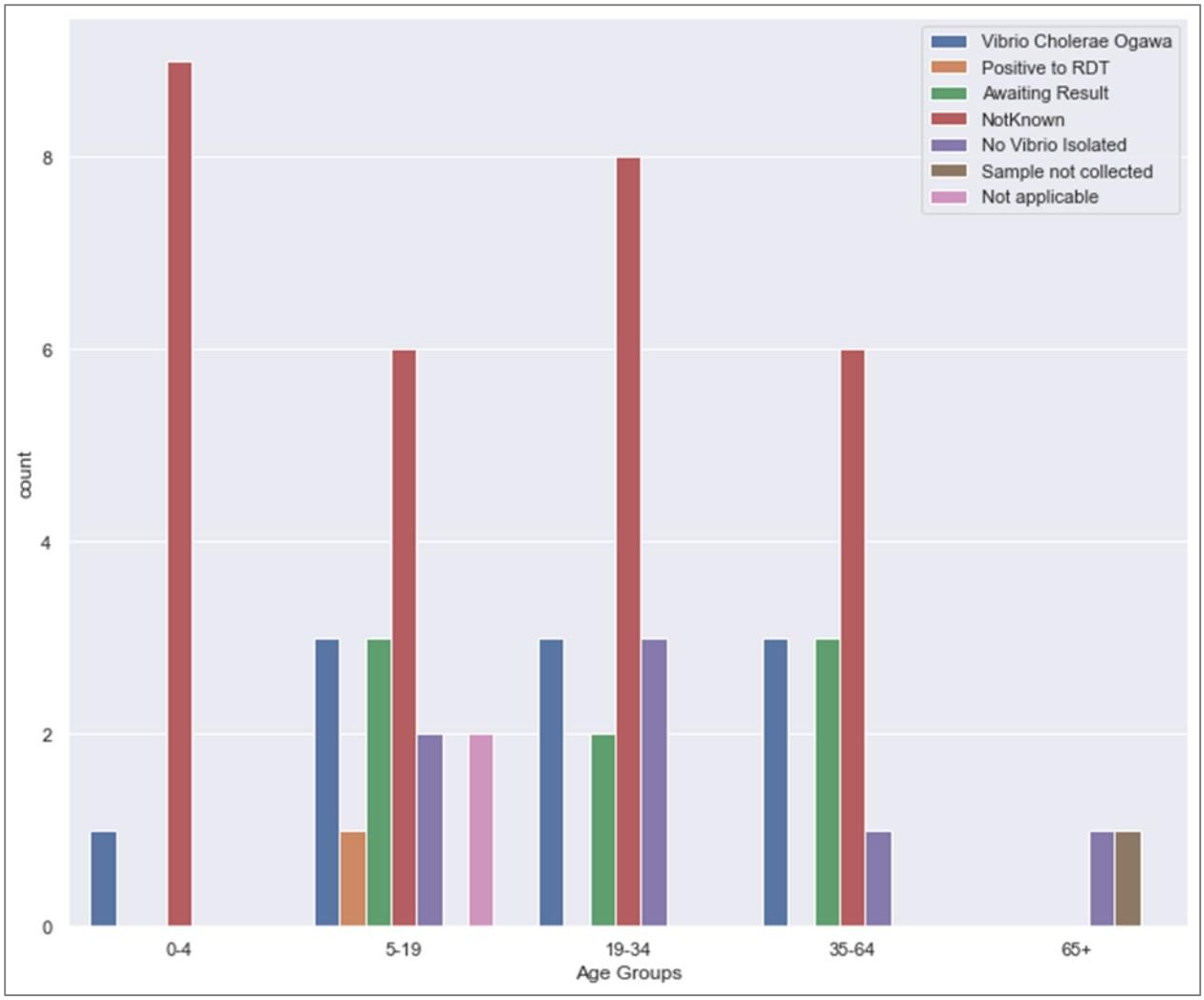
Figure1.3: Laboratory Diagnosis across different Wards



LABORATORY DIAGNOSIS ACROSS AGE GROUPS

Figure1.4 shows laboratory diagnosis across different age groups, It can be seen that many patients between ages5-19 were subjected to the laboratory diagnosis with some testing positive for cholera, others awaiting results and others tested negative for cholera. It can also be seen across different age groups that the laboratory diagnosis was Not known.

Figure1.4: Laboratory diagnosis across different age groups

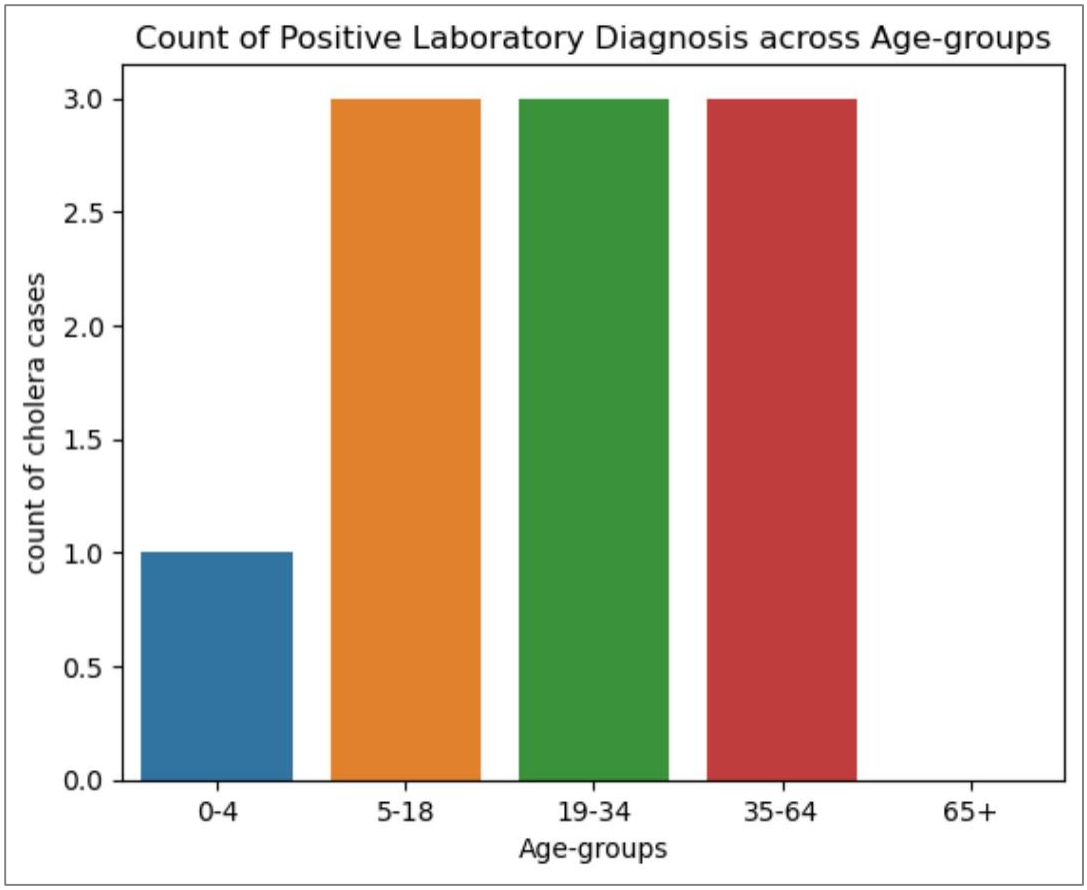


POSITIVE LABORATORY DIAGNOSIS ACROSS AGE GROUPS

Figure 1.5 shows the distribution of confirmed cases across age groups.

The age groups 5-18, 19-34 ,34-64 recorded the highest number of positive cases , age group 0-4 had the lowest count and 65+ had no positive case

Figure1.5 Count of Positive Laboratory Diagnosis


Count of Positive Laboratory Diagnosis across Age-groups
count of cholera cases
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0-4
5-18
19-34
35-64
65+
Age-groups

EPI-CURVE FOR CHOLERA CASES

Figure 1.6: Cholera Suspected Cases by date of onset of illness

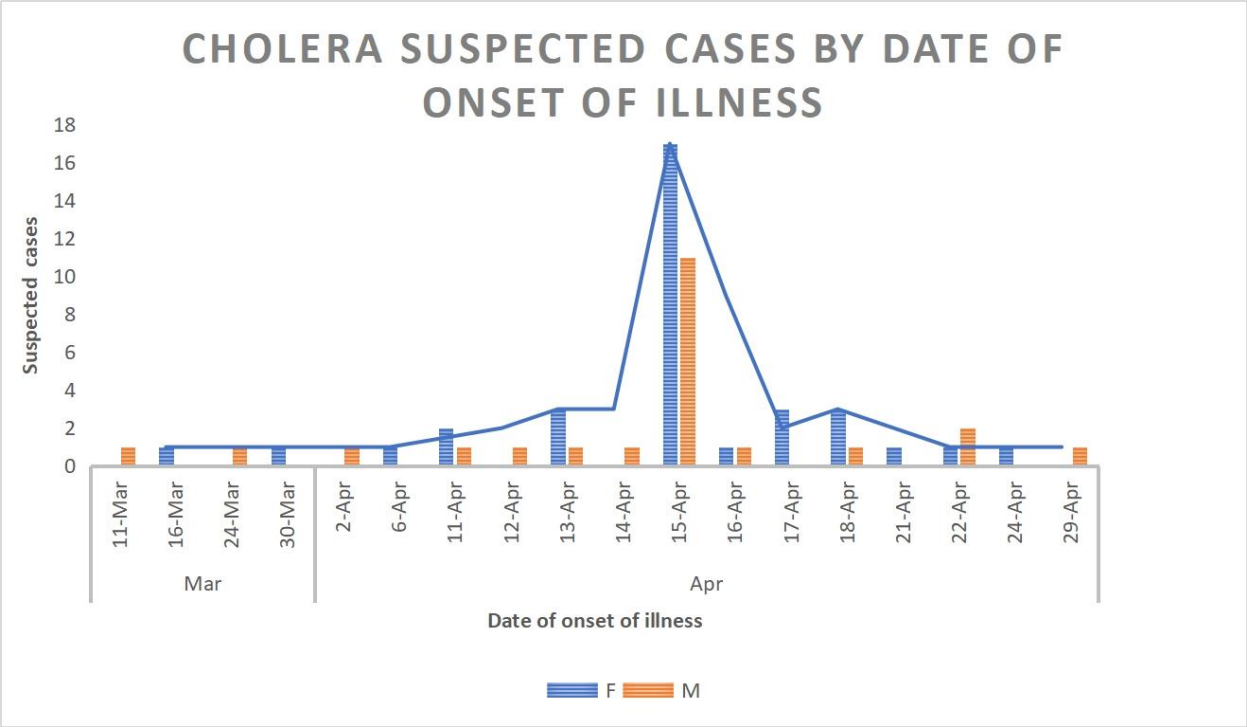


Figure 1.6 shows a total of 58 suspected cases in the cholera outbreak. The first case which is the index case is a male on 11th March 2023, the curve flattens and 29 days later, there is a steep increase in cases followed by the curve tapering down. This is a common point source curve which indicates the outbreak was from a common point i.e. contaminated water, food etc. to which people are exposed for a unique, short well-defined period.

Description of Symptoms of Patients presenting with Cholera.

Outcome	Count	Symptoms Presented	Brief Explanation
Dead	3	Fatigue, Severe Dehydration, Acute rice watery diarrhea with vomiting	Most the Cholera patients, who succumbed to the disease, experienced the severe symptoms of the disease and were older.
Recovered	8	Acute rice watery diarrhea, Severe Dehydration	Despite almost similar symptoms presented to the above group, those recovered were much younger compared to those who succumbed.
Isolated	12	Acute rice watery diarrhea, vomiting	These patients had been set aside for further monitoring of the disease.
Not Known	24	Not Known	The twenty-four, are initial missing information regarding to these patients. Hence, it was not feasible to infer anything regarding the symptoms they presented.

Association between Laboratory Diagnosis and Water source.

Statement of hypothesis

Null hypothesis: There is no association between water source and laboratory diagnosis

Alternative hypothesis: There is an association between water source and laboratory diagnosis.

Figure2.1: Association between laboratory Diagnosis and Water Source

Watersource NewlabDiagnosis	Bore hole	Not known	Shallow well	Spring water	Tap water	Unknown
Awaiting result	1	0	3	0	4	0
No Vibrio Isolated	2	0	5	0	0	0
Not applicable	0	0	2	0	0	0
Not known	0	24	1	0	4	0
Positive to RDT	0	0	0	0	1	0
Sample not collected	0	0	1	0	0	0
Vibrio Cholerae Ogawa	0	0	5	1	3	1

Results

```
        Fisher's Exact Test for Count Data with simulated p-value (based
        on 10000 replicates)

data:  contingency
p-value = 9.999e-05
alternative hypothesis: two.sided
```

.

The P-value of 9.999e-05 is less than P-value of 0.05, we reject the null hypothesis at 5% level of significance and conclude that there is an association between the laboratory diagnosis and the availability of water treatment. This means that those who tested positive for cholera are likely not to have any form of water treatment for the water they consume.

Association between Diagnosis and Availability of Water Treatment.

Statement of hypothesis

Null hypothesis: There is no association between Laboratory Diagnosis and availability of water treatment

Alternative hypothesis: There is an association between Laboratory Diagnosis and availability of water treatment

Figure 2.2: Association between Laboratory Diagnosis and water treatment

NewlabDiagnosis	Awaiting Result	No Vibrio Isolated	Not applicable	NotKnown	Positive to RDT	Sample not collected	Vibrio Cholerae Ogawa
Is any form of water treatment available for the household of the case? Yes/No							
No	7	7	2	29	0	1	9
NotKnown	0	0	0	0	0	0	1
Unknown	0	0	0	0	1	0	0
Yes	1	0	0	0	0	0	0

Results

```
        Fisher's Exact Test for Count Data with simulated p-value (based
        on 10000 replicates)

data:  contingencyb
p-value = 0.0011
alternative hypothesis: two.sided
```

The P-value of 0.011 is less than P-value of 0.05, we reject the null hypothesis at 5% level of significance and conclude that there is an association between the laboratory diagnosis and the availability of water treatment. This means that those who tested positive for cholera are likely not to have any form of water treatment for the water they consume.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter shows the summary of the research, conclusions, and recommendations out of the results deduced.

Summary and Conclusion

This project involved analyzing suspected cholera cases in Kisumu County. It entailed describing demographic characteristics of the patients, their symptoms, modes of transmission and the relationship between the sanitation factors and the outcome. A retrospective case study was used. The analysis showed that more females were affected compared to men. The most affected age group is 19-34. Nyalenda A Ward recorded the highest cases of suspected cases as well as positive cases. There is an association between the number of positive cases and the sources of water used by the patients.

Recommendations

1. The County government should ensure continuous health education on water treatment.
2. Implementation of proper sanitation measures such as sewage treatment and waste management.
3. Invest in upgrading and maintain water supply systems.
4. Encouraging community involvement in monitoring water quality, reporting suspected cases and implementing preventive measures.
5. Enforce regulations and standards for food safety and water quality in public spaces, restaurants and food processing facilities.

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