CONTRIBUTION OF COVID-19 CONTAINMENT MEASURES ON EPIDEMIOLOGY OF DIARRHEA DISEASE AMONG PATIENTS ATTENDING JARAMOGI OGINGA ODINGA TEACHING AND REFERRAL HOSPITAL, KISUMU COUNTY, KENYA. 2018-2021

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A Thesis Submitted to in Partial Fulfillment of the Requirement for the Award of the Degree

of

MASTER OF SCIENCE IN EPIDEMIOLOGY & BIOSTATISTICS

DECLARATION

I, Omondi Fredrick Onduru hereby declare that this research thesis is my original work and has not been presented for any academic award in any other university or institution of learning.

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This thesis is dedicated to:

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ABSTRACT

Diarrhea is the second leading cause of child morbidity and mortality, particularly in developing countries. It is the third leading cause of death in the world and continues to impose a significant burden, accounting for 2.8 billion diarrhea episodes among older children, adolescents, and adults. Severe Acute Respiratory Syndrome coronavirus type 2 (SARS-CoV-2) - Covid-19 outbreak was declared a pandemic on 11th March 2020 which prompted the implementation of ant-covid preventions and control measures in attempt to curb its transmission from person to person. The interventions were not only impactful in managing Covid-19 transmission rates, but also helped reducing the rates of infectious diarrhea diseases with associated risk factors as personal hygiene, sanitation, contact handshake, lockdown and travel restrictions. This study aimed to assess the contribution of covid-19 containment measures on epidemiology of diarrhea in the adolescent and adult patients attending Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County, Kenya, 2018-2021. Given the already manipulated treatments of enforced Covid-19 containment measures as intervention. The specific objectives were; to examine the trend/seasonality of diarrhea during the two time periods, to determine the current baseline estimate/ prevalence of diarrhea between the adolescence and adult age group, and to determine the influence of covid-19 containment measures on the trends of diarrhea episodes. The research provides evidence-based information of hygiene policies to diarrhea prevalence to inform decision making and priority setting. A cross-sectional retrospective survey was carried out on the entire the outpatient new client (OPD) records at 80% power, 95% CI, alpha of 0.05 and N of 345,499 to detect a smaller effect size. Descriptive statistics was used to summarize and organize the data. The relationship between the dependent variables, independent and intervening variable was explained through trend analysis, & Generalized Linear Mixed Effect Model (GLMEM Poisson log link) with both random intercept and fixed slope. The prevalence of diarrhea during covid-19 pandemic period was 0 .6% significantly lower compared to the pre covid-19 pandemic 2.7%. On average, the month of January had the highest prevalence of diarrhea (2.1%) followed by April (1.9%) & May (2%) with June registering the lowest prevalence during 2018 to 2021. During covid-19 pandemic October turned to have the highest prevalence of diarrhea. January, February and October had a significant increased rate of diarrhea 1.46, 1.26 & 1.31 respectively compared to month of April. There was a statistically significant reduction in the adjusted incidence risk of diarrhea during covid-19 by 79% (*IRR = 0.21, 95% CI [0.20, 0.23], p < .001*). The study finding raises the possibility that the deployed interventions against Covid-19 could have had significant effect on reducing the incidence and prevalence of diarrhea cases. Understanding the burden, trends, and prevalence of diarrheal disease, as well as its seasonal variation, is critical for developing effective control programs for the overall reduction of diarrhea disease among people of all ages.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

AWD:	Acute Watery Diarrhea
BF:	Breastfeeding
CDC	US-Centre for disease Control and Prevention
CI	Confidence Interval
ETEC	Enterotoxigenic *Escherichia coli*
GLMMs	Generalized Linear Mixed Effect Models
IRR	Incidence Rate Ratio
JOOTRH:	Jaramogi Oginga Odinga Teaching and Referral Hospital
KHIS	Kenya Health Information System
MERS-COV:	Middle East respiratory syndrome coronavirus.
MICE:	Multivariate Imputation by Chained Equations *algorithm*
ML	Maximum Likelihood
MOH:	Ministry of Health
OPD:	Outpatient Department
ORT:	Oral Rehydration Therapy.
SARS-CoV:	Severe Acute Respiratory Syndrome Corona-Virus.
SARS-CoV-2:	Severe Acute Respiratory Syndrome Corona-Virus type 2.
TD:	Traveler's Diarrhea (TD)
WHO:	World Health Organization

LIST OF FIGURES

LIST OF TABLES

DEFINITION OF TERMS

Acute Watery Diarrhea:	A type of diarrhea which occurs in cases like cholera
Adult:	A person older than 19 years of age.
Before-COVID-19:	Are the number of cases of diarrhea before Covid-19 pandemic.
Children:	A young human being below the age of five.
Covid-19:	Corona Virus caused by Coronavirus SARS-COV-2
Dehydration:	Rapid loss of body fluids and important salts required for proper control of body functions.
Diarrhoea:	Loose watery stool at least three times a day
During -Covid-19:	The number of cases of diarrhea after Covid-19 pandemic strike.
E. coli:	*Escherichia coli*
Fecal–oral:	Group of disease being transmitted by person-to-person contact, through water, food or directly to the mouth.
Household:	People who live together and share the same pot
Older children:	Young human being between the ages of 5-9 years.
Pandemic:	An epidemic that spreads to more than one continent.
Pre-Covid-19	Are the number of cases of diarrhea before Covid-19 pandemic.
Teenage/adolescent:	A young human between ages of 10-19 years.

CHAPTER ONE
BACKGROUND TO THE STUDY

1.1 Introduction

This chapter highlights specific knowledge gap which is the problem invoking the need of this study. It also points out key study objective/ research questions and justification/ benefits of carrying out this study. It presents a brief literature on background study defining the magnitude of the problem.

1.2 Background of the Study

Diarrhea is the passage of liquid stool three or more times a day, or basically more than is normal for the individual. Diarrhea results in dehydration, which is the rapid loss of body fluids and important salts minerals required for proper control of body functions, particularly in the brain, nerves and muscles. Infectious diarrheal diseases are a great problem throughout the world and are responsible for considerable morbidity and mortality, especially in developing countries (WHO, 2017). Although the disease's progression is typically moderate, and fatality rates have dramatically declined over time, infectious diarrhea continues to be a significant issue in industrialized nations as well as sub-Saharan region. The burden is felt in various ways; cost of medical care or hospitalizations, significant economic loss by patients' absenteeism from work and missing out of school by children. In cases of domestic infectious diarrhea in industrialized nations, viruses are likely to be the primary culprits, as opposed to bacteria like enterotoxigenic *Escherichia coli* (ETEC). Diarrhea affects about one-third of visitors from developed nations to underdeveloped nations (Fedor, Bojanowski, & Korzeniewski, 2019).

In all parts of the world and among all age groups, diarrhea is a significant cause of morbidity and mortality (Chang et al., 2018). Mild to moderate diarrhea can cause children older than five, adolescents, and adults to miss school or work, and it may necessitate the need to seek medical attention. Serious complications include Guillain Barre syndrome and hemolytic uremic syndrome, as well as hospitalization and, in some circumstances, death, can result from more severe diarrhea (Alashmali, 2021). It would be great to be able to prevent diarrhea, especially the more severe bouts that have a higher probability of escalating to complications or mortality. Even though the majority

of diarrhea episodes are self-limiting and dehydration can typically be treated with oral rehydration therapy (Gathogo, 2021). Some preventive measures, like better water and sanitation, common hygiene precautions, and avoiding unnecessary travel, are generalizable and do not require knowledge of the causes of diarrhea; however, other measures, like vaccines, would greatly benefit from a thorough understanding of the overall burden of pathogen-specific diarrheal disease. Diarrhea is a fecal-oral disease that is spread through person-to-person contact, water, food, or directly to the mouth. The absence of a proper water supply, the presence of trash and filthy surroundings, and an abundance of flies are typical conditions in which these diseases thrive. Breaking the fecal-oral cycle is the foundation for control through personal hygiene, increased water quantity, improved water quality, food hygiene, and sanitation provision. (Webber, 2016).

Though mortality rates in older children, adolescents, and adults are lower than in children under the age of five, diarrhea remains a significant burden, and accounts for 2.8 billion episodes in older children, adolescents, and adults (Lamberti, Fischer Walker, & Black, 2012). In developing countries and poor communities, diarrhea disease is a major cause of malnutrition, delayed physical development, and mortality. The loss of water and essential minerals is the leading cause of death in diarrhea. Several factors, including socioeconomic (poverty), environmental, and behavioral factors, illiteracy, poor water supply and sanitation, poor hygiene practices, and insufficient health services, are likely to contribute to the extremely high diarrhea morbidity and mortality rates (Zicof, Rahardjo, & Murti, 2018) .Diarrhea is a symptom of infection caused by a host of viruses (e.g. Rota virus); bacteria and parasites organisms most of which can be spread by contaminated water, food and poor hygiene (Yimer, Gezhagne, Biruk, & Dinaol, 2015).
The etiology of diarrhea is important not only for epidemiological surveillance but also, in many cases, for proper treatment. Numerous studies on childhood diarrhea have been published, with clinical symptoms and microbiological findings. However, only a few reports on the etiology of infectious diarrhea in adults have been published, especially in developing and underdeveloped countries (Svenungsson et al., 2000). A 1-year prospective study was carried out in Sweden to identify enteropathogens in adults with diarrhea and healthy control subjects using standard laboratory n = 851 n = 203 methods.

Polymerase chain reaction was used to identify virulence factor genes in diarrheagenic Escherichia coli. Enteropathogens were found in 56% of patients and 16% of controls. Patients with symptoms for at least one week and travelers were isolated at a rate of 65%; 11 pathogens were found in 11% of patients. Campylobacter (13%) was the most common enteropathogens, followed by Clostridium difficile (13%), enterotoxigenic Escherichia coli (8%), Salmonella (7%), Shigella (4%), *Blastocystis hominis* (4%), caliciviruses (3%), rotavirus (3%), enteroaggregative *E. coli* (2%), Aeromonas (2%), *Giardia intestinalis* (2%), *Cryptosporidium* (2% Verotoxigenic *E. coli* was isolated less frequently (1% of patients) (Svenungsson et al., 2000). Potential enteropathogens were identified in 68% of children and 38% of adults with gastroenteritis in a Swedish study conducted in the 1980s (Svanteson et al., 1988). The advancement of molecular analysis techniques has increased the ability to identify potential enteropathogens in stool specimens, and several new agents have been increasingly recognized in association with diarrheal disease in recent years. These include *E. coli* that causes diarrhea, cryptosporidia, microsporidia, Rota virus, and caliciviruses.

Since the start of the Covid-19 pandemic and deployment of strict guidelines for containment and reduction of incidences and transmission of SARS-CoV-2, there has been an anticipated reductions in the cases of infectious diarrhea disease with associated risk factors as global & domestic travels(Levi, 2021), personal hygiene (Salmon, Pittet, Sax, & McLaws, 2015), sanitation, contact handshake(Ghareeb, Bourlai, Dutton, & McClellan, 2013), hand mouth touch(CDC, 2018) and overcrowding. The Covid-19 outbreak was declared a public health emergency on 30th January 2020 and a pandemic on 11th March 2020 and a lot of public health containment measures were deployed in an attempt to curb the transmission rates. Some of the Public health control measures by World Health Organization (WHO) includes; lockdowns and restricted movements, increase personal hygiene, hand-washing by soap, hand sanitization, reduced handshake, surface and object disinfection using chlorine components, wearing face mask, minimizing unnecessary face-mouth touch i.e. mouth, nose or eye, avoidance of overcrowding places such as public gathering as well as keeping rooms well ventilated (WHO, 2021).

This study aimed to assess the contribution of covid-19 containment measures on epidemiology of diarrhea among the adolescent and adult patients attending Jaramogi Oginga Odinga Teaching and Referral Hospital who are well oriented in time, space and place to adhere to covid-19 guidelines and diarrhea prevention pre and during the covid-19 pandemic using 2018-2021 diarrhea surveillance hospital data in Kisumu County. The study anticipated that the introduced guidelines for Covid-19 pandemic preventions have had a significant effect on the trends and incidences of diarrheal disease.

1.3 Statement of the Problem

Diarrhoea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms. Diarrhea is mainly transmitted by person-to-person contact, through water, food or directly to the mouth. Diarrhea diseases can be eliminated by increase vaccination, hygiene, sanitation, safety food & water, quantity of water & socio-economic (Webber, 2016). A lot of control measures have been set in place to help reduce the incidence, hospitalization and burden of the disease on the population but high and relatively stable prevalence of diarrhea diseases are still being witnessed over the years (Agegnehu, Bewket Zeleke, Goshu, Ortibo, & Mehretie Adinew, 2019).

The etiology of diarrhea must be understood not only for epidemiological purposes, but also for proper treatment. Numerous studies on childhood diarrhea have been published, with clinical symptoms and microbiological findings described. Only a few similar reports, however, have been published on the etiology of infectious diarrhea in adolescents and adults, particularly in developing and underdeveloped countries (Bo Svenungsson, Asa Lagergren *et al.*, 2000). With missing literature of such findings in Kenya or basically Western regions of Kenya particularly in Kisumu; this study intended to bridge in the knowledge gap by providing current baseline estimates on the current prevalence, incidence and trend of diarrhea across adolescents and adults group.

Diarrhea, a common symptom of gastro-intestinal or enteric infection, is the world's fourth leading cause of disability, including Sub-Saharan Africa (Alebel et al., 2018). So, to speak, diarrhea disease also contributes to malnutrition, delayed physical development, mortality, absenteeism from school or work and hospitalization among adolescence and adults. Over one third of the world's population currently lives in "slums or informal

settlements," which account for more than half of all urban regions. Despite the fact that access to safe water and sanitation is generally better in cities (Bain, Wright, Christenson, & Bartram, 2014), the risk of enteric infection may be greatest in poor urban areas because of the combination of high population density and limited public health infrastructure. A recent study of pathogen diversity in infant food in Kisumu's low-income informal neighborhoods found that these conditions pose multiple risks for food contamination (Tsai et al., 2019).-

Since the pandemic (SARS-CoV-2) came in and interventions deployed to help curb the transmission, and minimize the incidences, there has been an expected reduction in the cases of infectious diarrhea disease due to increased level of hygiene and sanitation practices. Thus, this study tried to determine the changes in trends of the diarrhea disease for before and during COVID-19 pandemic, to assess the contribution of covid-19 containment measures on epidemiology of diarrhea among the adolescent and adult patients attending Jaramogi Oginga Odinga Teaching and Referral Hospital who are well oriented in time, space and place to adhere to covid-19 guidelines and diarrhea prevention pre and during the covid-19 pandemic using 2018-2021 diarrhea surveillance hospital data in Kisumu county.

1.4 Objectives of the Study

1.4.1 General objective

This study aimed to assess the contribution of covid-19 containment measures on epidemiology of diarrhea in the adolescent and adult patients attending Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County, Kenya**,** 2018-2021.

1.4.2 Specific Objectives

i. To determine the changes in trends of diarrhea based on the seasonality pre and during covid-19 pandemic in outpatients attending JOOTRH.
ii. To determine the prevalence of diarrhea based on adolescent and adults pre and during covid-19 pandemic in outpatients attending JOOTRH.
iii. To determine the influence of covid-19 containment measures on the changes in diarrhea trends in outpatients attending JOOTRH.

1.4.3 Research Question

i. What is the trend of diarrhea based on the seasonality pre and during covid-19 pandemic in outpatients attending JOOTRH?
ii. What is the prevalence of diarrhea on adolescent and adults pre and during covid -19 pandemic in outpatients attending JOOTRH.?
iii. What is the influence of covid -19 containment measures on the changes in the trend of diarrhea in outpatients attending JOOTRH.?

1.5 Justification of the Study

According to the CDC, unsafe water, inadequate sanitation, and poor hygiene are responsible for approximately 88% of diarrhea-related deaths. Hence, this study made use of the already manipulated treatments of enforced Covid-19 control and prevention measures as intervention to examine the effect in the diarrheal cases. Some of the manipulated risk factors included increase personal hygiene, hand-washing by soap, hand sanitization, lockdowns & restricted travels, reduced handshaking, increased surface and object disinfecting using chlorine components, wearing face mask, minimizing unnecessary face-mouth touching, avoidance of overcrowding places such public gathering (WHO, 2020).This was achieved by comparing diarrheal morbidity data for pre and during Covid-19 pandemic to examining the trends, prevalence and incidence rate both by seasonality and two age groups.

1.6 Significance of the Study

The research was to provide evidence-based information of hygiene policies to diarrhea prevalence to inform decision making and priority setting. Some of the beneficiaries from the findings of this study are; Scientific researchers in providing the literature knowledge on diarrhea current estimates on adolescence and adults group in western Kenya. Data to action agencies in providing services and policies associated with diarrhea on adults and adolescence. The public in examining the impact of Covid-19 pandemic prevention measures on general health. Public health polies makers in evaluating the outcome and impact of the Covid control measures on diarrhea incidence as well the public positive uptake of interventions, and health planner’s in-terms of recourse allocation.

1.7 Scope of the Study

This study aimed to assess the contribution of the covid-19 deployed prevention & intervention measures on epidemiology of diarrheal diseases among the adolescent and adult population who are well oriented in time, space and place to adhere to covid-19 guidelines and diarrhea prevention before and during the covid-19 pandemic within Kisumu central sub-county, Kenya: from 2018-2021. This was achieved by evaluating the trend among adolescents (10 to less 20 years) and adults (over 20 years) populations. The study was conducted at Jaramogi Oginga Odinga Teaching and Referral Hospital and was conducted for a period of 8 months.

1.8 Limitation of the Study

This study had some limitations both at the design and analysis that may tamper with the result and causal inferencing. This being a cross sectional study design it was hard to predict causal inference. Data analysis was performed on data collected in the health care facility under the study which may not have been very representative of the entire population or generalizable since it excluded those who underwent home treatment care. This data being secondary data, the analysis suffered data incompleteness problems and missing key parameters having to do away with some key confounders that could have been adjusted for. The study effect may also not only be as a result of the covid-19 intervention but also due to some establish running programs in effort to control diarrhea. For variable missing less than 20% of the observations, machine learning algorithm (MICE) was used to impute for them. For limitations due to cross-sectional retrospective design robust analysis techniques was used to minimized estimates standard errors.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Diarrhea disease is a gastro-intestinal tract disturbance characterized by changes in intestinal motility and absorption, resulting in an increase in the number of stools and changes in their consistency(Burgers, Lindberg, & Bevis, 2020). However, when the presumed or proven cause of these disturbances is infectious, as previously stated by it is called to as infectious diarrhea (Burgers et al., 2020). (WHO, 2017) described diarrhea disease manifestations as the passage of three or more watery stools in a day. (Webber, 2016) equally asserted that if one who has had steady weight gain over a period and who has been in a habit of passing one normal non watery stool a day begins to pass frequently loose and watery stool that are of an unpleasant odor, he is probably suffering from diarrhea disease. (Webber, 2016) also described diarrhea as food and water borne diseases whose intake by people results in symptom relating to gastrointestinal problems. Onset of symptoms may occur within few hours of exposure or not until days and even weeks later, between exposure and organism

Diarrhea within the context of this study is any type of loose, watery stool that occurs more frequently than usual. (WHO, 2017) *classified diarrhea into three clinical types* which includes: Acute watery diarrhea, dysentery and persistent diarrhea. Acute watery diarrhea refers to diarrhea that begins acutely, last less than 14 days and involve passage of frequent stool without visible blood. Dysentery is diarrhea with visible blood in the faces, while persistent diarrhea is the diarrhea that begins acutely but is of usually long duration (at least 14 days). However, it is important to note that the classification of diarrhea does not influence the causes. Diarrhoea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms, most of which can be spread by contaminated water. It is more common when there is a shortage of clean water for drinking, cooking and cleaning. Diarrhea in most cases *is caused by three major groups of micro-organisms* – viruses, bacteria and protozoa or parasites (Kasper et al., 2012; Tanimola & Owoyemi, 2009). The main agents of diarrhea according to them are Enteroviruses (e.g. *rotavirus*. These are further grouped in the following ways: Viruses (e.g. *Rotavirus*), Bacteria (e.g. *Shigella, Escherichia coli, Vibrio cholerae, Salmonella,*

and Campylobacter spp) and Parasites (e.g. *Entamoeba histolytica, Cryptosporidium, and Giardia lamblia*). Gastroenteritis can be caused by bacteria and virus, *E. coli* serotype and enter-virus or sometimes by irritant foods or even emotional upset. Diarrhea is *mainly transmitted by* person-to-person contact, through water, food or directly to the mouth. According to the CDC, unsafe water, inadequate sanitation, and poor hygiene are responsible for approximately 88% of diarrhea-related deaths. Diarrhea diseases *can be eliminated by* increase vaccination, hygiene, sanitation, safety food & water, quantity of water & socio-economic (Webber, 2016).

All over the world, viruses especially rotavirus have been identified as the major causes of acute diarrhea in children. A similar study done in western Kenya and in Nigeria also found virus as the major cause of diarrhea in 60 per cent of cases, with bacteria responsible for about only 3 – 20 per cent (Swierczewski et al., 2013; Tanimola & Owoyemi, 2009).The various causative agents vary according to the signs and symptoms manifesting from the disease. These include mild, moderate, and severe diarrhea. In mild diarrhea, the individual is thirsty, the mouth is dry and passes less urine and weight is being lost. In moderate diarrhea, the patient at this stage shows signs of sunken fontanelle, sunken eyes, rapid deep breathing and loss of skin elasticity. In severe diarrhea, the patient shows signs of rapid weight loss and weak pulse, cold limbs (shock or coma). However, signs of dehydration are not evident until there is acute fluid loss of approximately 4 – 5 per cent of body weight (Shahrabadi & Ahmadi, 2014).The *signs and symptoms of dehydration* include sunken fontanelle, dry mouth, and throat, fast and weak pulse, and loss of skin elasticity and reduced amount of urine. Those who presents with these signs and symptoms has lost enormous fluid and electrolyte from the body which may lead to shock and death. *Diarrhea results* in dehydration, the rapid loss of body fluids and important salts minerals required for proper control of body functions, particularly in the brain, nerves and muscles. Infectious diarrheal diseases are a great problem throughout the world and are responsible for considerable morbidity and mortality, especially in developing countries (WHO, 2017). Although the *disease's progression* is typically moderate, and fatality rates have dramatically declined over time, infectious diarrhea continues to be a significant issue in industrialized nations as well as sub-Saharan region. The *burden* is felt in various ways; cost of medical care or

hospitalizations, significant economic loss by patients' absenteeism from work and missing out of school by children.

There are numerous shortcomings that point to the necessity of more prospective research in these age ranges globally. Planning successful control efforts to ultimately lower the prevalence of diarrheal disease among people of all ages requires an understanding of the burden of pathogen-specific diarrheal disease and the variance by area (Fischer Walker, Sack, & Black, 2010). Although the clinical course is modest in compared to similar diseases in underdeveloped nations, enteric infections in adults remain a widespread problem in both developed and developing countries. According to A 1-Year Prospective Study in a Swedish Clinic for Infectious Diseases, only 56% of this adult patient group with diarrhea had enteropathogens found despite thorough laboratory examinations (Svenungsson et al., 2000).

2.2 Diarrhea Intervention Measures Deployed during Covid-19 Pandemic Period.

2.2.1 Hand hygiene

Infectious agents are primarily transferred via hands. The best approach to prevent illness is through good hand cleanliness. Hand hygiene entails using an alcohol-based hand massage or washing your hands with soap and water. The WHO published guidelines on hand hygiene in health care and introduced the "My five moments for hand hygiene" concept to define indications for hand hygiene rooted in evidence-based model for transmission of microorganism by health workers in an effort to harmonize hand hygiene practices globally (Salmon et al., 2015).

2.2.1.1 Hand Washing With Soap and Water.

Soap and water are the most efficient hand hygiene technique. Using soap and flowing water to wash your hands helps to loosen, dilute, and flush away dirt and germs. It's crucial to always remember to thoroughly dry your hands after washing. Up to 1000 times more bacteria are picked up and spread by damp hands than by dry hands. Additionally, thoroughly drying your hands might help get rid of any germs that may not have been rinsed off (Salmon, Pittet *et al.* 2015). When it comes to removing dirt and germs from the hands, many people believe that handwashing is just common sense. In fact, hand washing is more than just common sense. Handwashing is the single most

important procedure for preventing the spread of infection, according to the CDC (CDC, 2018). According to the Association for Professionals in Infection Control and Epidemiology (APIC), "handwashing causes a significant reduction in the carriage of potential pathogens on the hands," and in health care settings, it can result in lower morbidity and mortality from nosocomial infection. Similarly, health care workers come into contact with body secretions that can carry potentially infectious bacteria, viruses, and fungi (CDC, 2018; Salmon et al., 2015), care givers of children are also predisposed to fecal of the infants and children's especially during changing dippers and wiping the child.

Handwashing behavior is influenced by factors such as sink/tap placement, unacceptable handwashing products, the effect of handwashing products on skin condition, and awareness of the importance of hand washing in preventing infection. The placement of a sink, handwashing products, and appropriate towels is frequently suggested as a way to encourage frequent and appropriate handwashing. Sinks with faucets that can be turned off without using one's hands (e.g., foot pedals) and sinks that minimize splash can help to avoid immediate recontamination of washed hands. In the effort to manage the spread of the covid-19 pandemic, the national and county government through Ministry of Health (MOH) enforced the installation of water tap preferable with foot pedals and detergents in public places, such us hospitals, schools, public work offices, marketplaces to enhance hand hygiene. A lot of campaigns was also deployed; geared towards encouraging handwashing with soap detergents before access to most areas or services both in private or public places to safeguard lives. Handwashing promotion help reduce diarrhea episodes in both the age groups by creation of awareness, however, less is known about how to help people maintain hand washing habits in long term (Ejemot-Nwadiaro, Ehiri, Arikpo, Meremikwu, & Critchley, 2021).

2.2.1.2 Hand sanitization

Rubs made of alcohol are a quick and efficient approach to get rid of germs that you might have picked up via contacting contaminated surfaces. Alcohol-based hand sanitizers help to lower the number of bacteria on your hands, but they are less effective in getting rid of grime. The best method for cleaning your hand is to wash it with soap and water if it is obviously unclean (Merlin, Newton, Ellery, Milverton, & Farah, 2013).

The most effective method for hand antisepsis when using an alcohol-based antimicrobial cleaner, according to CDC (CDC, 2018), is a vigorous one-minute rub with adequate alcohol (usually 3-5ml is recommended). Because of improper technique or the use of insufficient alcohol hand rub solution, surfaces on the hands may not be completely covered. Basically, this approach has also become quite dominantly used by most individuals to ensure hand hygiene both after touching fomites, accidentally shaking hand or simply before touching any opening. And to most office workers with no physical and visible dirt, it was like a substitute to handwashing with soap in the effort stop covid-19 transmission.

2.2.1.3 Reduced Handshake

A handshake is a well-known method of transmitting bacteria and viruses between people (Ghareeb et al., 2013). Handwashing has become a widespread healthcare endeavor to lower the rates of diarrheal illness transmission, although up to 80% of people retain some disease-causing germs after washing. An alternative to the increasingly common handshake is the fist bump. Comparing the fist bump to the normal handshake can help further decrease the spread of pathogens by minimizing the amount of contact time and exposed surface area (Ghareeb et al., 2013). Although a firm handshake is a common greeting, contaminated fingers and palms can also spread the germs and virus that cause the infectious diarrheal sickness. Contagious illness prevention relies heavily on hand sanitization, but doing it properly takes too much time to guarantee adequate compliance. A proposal to outlaw handshakes in healthcare settings has to be replaced with a different, less contagious welcoming method. Particularly susceptible to illness and sickness spread from person to person are cruise ships. On smaller cruise ships, the fist bump, which is common in some cultures and among certain age groups, has gained popularity as the preferred greeting. A variation of the fist bump known as the "cruise tap" further reduces contact area by allowing only two knuckles to touch each other briefly (Jones et al., 2020).In the cause of the fight against the pandemic Covid-19, handshake was not recommended as a mitigation against covid-19. Different groups of people, ages (adolescent and adults), religions and culture has invented and adopted different modes of greeting; elbow greeting, fist bump, hand waving, just mere verbal greeting etc. in effort to obey the health restriction policies. Which by great length has

help in breaking the chain of infectious disease transmission and minimizing person contacts.

2.2.2 Environmental Cleaning, disinfect of objects and surfaces & increase sanitation

Regular surface cleaning with water and detergents will get rid of germs and lower the chance of someone getting sick from potentially contaminated surfaces. Cleaning agents and water combined with vigorous scrubbing will lift and loosen dirt from surfaces. Rinse the area with water, then let it air dry (Salmon, Pittet *et al.* 2015). Surfaces and object frequent disinfection by chlorine components is one of the major applied technics that was used especially those which are regularly touched places, an attempt to curb the transmission of covid-19. Cleaning and disinfect of chairs, shared keyboards, table surfaces, phones screens, door surfaces, door handles, etc.

On the other hand, the modern father of epidemiology John Snow demonstrated that the source of drinking water and the accessibility of latrines were associated to the occurrence of diarrhea (Coleman, 2020). Given how few families in sub-Saharan Africa have access to properly safe water, this is not surprising(Swierczewski et al., 2013). In this instance, the type of water source tells us very nothing about the quality of the water.

2.2.3. Reduced unnecessary mouth touch

According to the CDC (CDC, 2018), shaking hands, touching filthy things or surfaces and then touching your own mouth, nose, or eyes increases the transmission rate for infectious diseases causing agents (e.g., viruses, bacteria and fungi) both respiratory illness like covid-19 caused by SARS-CoV-2 as well as gastrointestinal infection caused by viruses (like rotavirus & norovirus), bacteria (salmonella & shigella), and parasites (Giardia). During the covid-19 fight, the public health practitioners discourage the public to minimize the mouth, eye and nose touch because this opening serves as portal of entry to the virus. This did not only help to reduce the respiratory related illness but also the gastrointestinal disease that are transmitted through oral route with mouth as the portal or entry from a contaminated hand.

2.2.4. Ban and discouraged public gathering

Public gatherings places like churches, markets, festivals, funerals and weddings were banned some minimized the attendance and activities like cooking, in order to prevent the transmission of covid-19 through contaminated fomites and utensils. With restricted handshake, cooking and eating restrictions and water tabs with soap for hand hygiene in those small attend events. This helped to minimize the episodes of diarrhea outbreaks from undercooked or contaminated food in such gatherings like funerals, weddings, churches and festivals.

2.2.5 Traveler's diarrhea (TD)

Tourists from developing nations frequently experience traveler's diarrhea (TD) as a medical issue (Levi, 2021) and is expensive to both the traveler and the host country. One of the most frequent infectious dangers for short-term visitors to developing countries is diarrheal disease, with some studies estimating that over 50% of visitors experience it during a two-week stay in an endemic nation (Leder et al., 2013). Africa, Latin America, and Asia are regions with a high risk of TD. Although TD may be brought on by a number of infectious agents, bacteria are to blame in 80% of cases (Walters et al., 2020). Although techniques for identifying the bacteria, viruses, and parasites that cause TD have improved, the etiology of 15%-55% (and, in rare cases, up to 75%) of cases remains unknown (Walters et al., 2020). Traveler's diarrhea's etiology varies geographically and seasonally. Following travel to countries other than their own, some previously healthy patients developed diarrhea that lasted several weeks to months. Long have researchers attempted to link the symptoms and signs of diarrheal diseases to a specific etiology, usually with little success (Xu, Cao, & Shen, 2021). Although it has often been unable to compare people with TD from diverse etiologies adequately, some trends have been identified (Riddle et al., 2017).

The clinical characteristics of traveler's diarrhea (TD) were studied in 126 adult Finnish tourists who became ill during or shortly after visiting Morocco. Enteric pathogens were found in 76 (60%) of the cases, while the etiology was unknown in 50 (40%). In terms of the time of onset of illness or the median frequency of unformed stools in the first 24 hours, patients with an identified pathogen did not differ from those with TD of unknown etiology. Although numerous studies have shown that diarrhea is the most common

illness during the first few weeks of travel, there have been no studies of the incidence of diarrhea during long-term residence in developing countries (Riddle et al., 2017).

International travel for tourism or business has grown significantly as a result of the availability of quick and inexpensive air transportation. Every year, approximately 12 million people travel from a developed country to a developing country in the tropics or subtropics. They will be exposed to a far more contaminated environment than they are used to at home as a result of this travel. Consuming contaminated water and unsanitary food, in particular, puts them at risk of enteric infections and diarrheal diseases. Despite the globalization of businesses and large numbers of expatriate person working in different parts of the country and external parts of the country, no active surveillance study of the incidence of diarrhea among the adult and adolescent travelers' group has been conducted. While it is largely assumed that longer time in a foreign place is associated with protective immunity, it is unknown how rapid immunity differs to different pathogens. To help address this, this study will use a cross sectional design approach to examining the existing cases of diarrhea disease before and during covid-19 period. Noting that during covid-19 pandemic there was a permanent and partial lockdown both in the country and in most counties in Kenya. Movement and traveling restrictions were set in place to curb for the inter-countries and within counties transmission of SARS-CoV-2. Which must as well have helped in reducing the cases of diarrhea associated with travelling or movements to endemic place or enable some people to build the protective immunities against different enteric pathogens over the periods.

2.2.6 Ages, Seasonality

2.2.6.1 Ages

Diarrhea imposes a significant cost, accounting for 2.8 billion diarrhea episodes in older children, adolescents, and adults, even though fatality rates are lower than those seen in children under five years of age (Jung et al., 2016).Mild to moderate diarrhea in adults and adolescents can cause absenteeism from work or school and may call for medical attention. Hospitalization, significant complications such Guillain Barre syndrome and hemolytic uremic syndrome, and in some cases death can result from more severe diarrhea (Thuthikkadu Indhuprakash et al., 2021).

According to an etiology of gastroenteritis study conducted in Netherland the findings report that, no peak was observed among young children; the highest percentage to test positive was found among case patients aged 5–29 years (de Wit et al., 2001). Young individuals are thought to be more susceptible to exposure from eating certain foods and exposure from traveling abroad. Age range of 15 to 59 group involves young adults who are beginning their own families and people who travel (Walters et al., 2020),both of which are known to be risk factors for infection with *Campylobacter species*. The fact that these patients are parents or caretakers of children in high-risk age groups may be contributing to the minor rise in the prevalence of rotavirus infection among the 15-29-year-old patients as well as *G. lamblia* infection among the 30-59-year-old patients. Among the age group of >= 60 years, it is surprising that 3.9 % of people in this age range have astrovirus infection. Results from a study done in the UK revealed a comparable overall percentage of patients who test positive for astrovirus (2.0%), despite the fact that the tendency toward positivity reduced with age (de Wit et al., 2001). The prevalence of diarrhea1 disease was significantly related to the child's age and gender. Male children were found to have higher morbidity than females, especially after the age of one year. Males had a 4-fold higher period prevalence than females at 24 months.

2.2.6.2 Seasonality

A rotavirus-caused diarrhea morbidity study conducted in Siaya County, revealed that rotavirus was the leading cause of diarrheal diseases (Omore et al., 2016). Stool samples collected during typically warm and dry months were twice as likely to be rotavirus-positive as samples collected during typically cool and rainy months., (142/691 [20.5%] vs 70/673 [10.4%]; OR = 2.16, 95%CI, 1.58–2.96).

2.3. Theoretical and Conceptual framework

2.3.1 Theoretical Framework

2.3.1.1 The chain of infection theory.

The chain of infection is a theory that attempts to explain how an individual can contract an infection from another person or simply from a source. In many cases, the chain of infection theory provides a means for epidemiologists to gather the necessary information for preventing disease spread or eliminating its occurrence. The chain of infection theory consists of six links, each of which must be suitable for the organism in order for a

disease to spread. This means that a broken link in the chain can interfere with an endemic (Juraja, 2007). The chain contains; infectious agent, reservoir (source), portal of exit, transmission mode, portal of entry and the susceptible host. For the public health, understanding the processes involved in the chain of infection presents numerous positive implications such as introduction of the control measure targeted at the management of infectious diseases. Because of this, healthcare providers will be able to develop an action plan for addressing a problem; among such intervention are vaccinations to develop antibodies, isolations of host to prevent direct transmission, protective equipment's for shielding portal of entry, hand hygiene, surface and object hygiene.

2.3.1.2 Health action process approach.

Schwarzer's approach to the health action process argues that a person's decision to take a particular health action is influenced by a variety of factors (Schwarzer & Warner, 2013). He refers to this time as the motivation phase (decision-making phase). This choice takes effect during the action (volition) phase. According to the model, the most important predictors of intentions are risk perception, outcome expectations, and self-efficacy. One notable aspect of this theory is that it proposes that actions are influenced not only by intentions and cognitive control, but also by the perceived and actual environment. This theory appears to be able to predict changes in diarrhea cases based on the level of knowledge improved personal and domestic hygiene. In cases of emergency, such as pandemic outbreaks, people may or may not perceive the outcome of their actions. Increase hand washing with soap, hand sanitization, reduce hand shake and surface or objects sanitization behaviors as result of the fight against Covid-19 pandemic, participated greatly in controlling the dynamics of transmission most diarrhea disease both among children and even elderly population.

2.4. Conceptual Framework

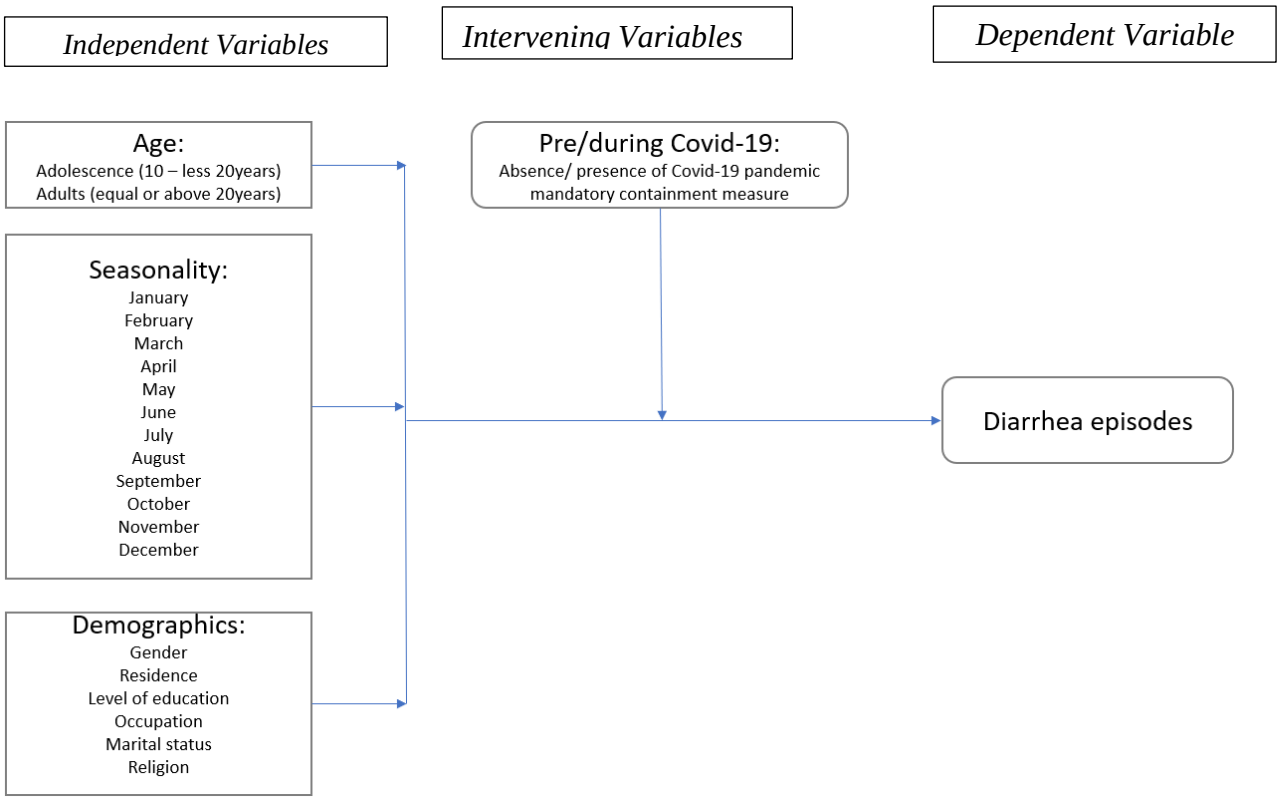

Figure 1: Conceptual framework describing diarrhea associate factors (self-owned)

Figure 1, show the conceptual framework used in answering the problem statement of this study. The key explaining variables in explain the outcome of interest diarrhea episodes for determining diarrhea burden in terms of prevalence and incidence across different risk group. Key explaining variables of study were age which was classified as adolescence (10 – less than 20 years old) and adults (equal or above 20years) base on WHO mode of classification, seasonality described in terms of aggregated months across the study years & demographic highlighting gender, residence, level of education, occupation, marital status and religion of the patients. Pre & during Covid-19 pandemic was explored as intervening variable to factor in the effect of absence and presence of Covid-19 pandemic mandatory containment measure.

CHAPTER THREE
METHODOLOGY

3.1 Study Area

Kisumu is Kenya's third largest city, and it is estimated that these peri-urban communities house up to 60% of the city's population. The study was carried out within Kisumu central sub-county (No 240) in Kisumu County with an area of approximately 32.70km^2 and consisting of 6 county assembly wards. Based on capacity and services offered, this study was conducted at the Jaramogi Oginga Odinga Teaching and Referral Hospital in Kisumu central sub-county. According to 2019 censor data, the total population of Kisumu central sub-county is 174,140 with 84,155 being male and 89,985 being female and there are 52,331 households. The choice of study setting was influenced by the findings from a *recent study on food pathogen diversity in Kisumu's low-income informal neighborhoods which* found that hygiene, water and sanitation pose multiple risks for food contamination (Tsai et al., 2019).

3.2 Study Design

The epidemiology, trends and seasonality of diarrheal disease was investigated using a cross-sectional study design among adolescent and adult ages pre and during the Covid-19 pandemic, 2018-2021 based on JOOTRH outpatient new client records (hospital registries for recording outpatients' patient demographics, diagnosis and treatment information & for this case applicable only for new patients).

3.3 Study Population

The study population consisted of the outpatient adolescent and adult individuals living within Kisumu central sub county and visited JOOTRH facility during the study period 2018-2021 as new clients at Outpatient Department (OPD).

3.4 Inclusion Criteria

The study included the outpatient new client records from 2018 to 2021 at JOOTRH of the adolescent (10-19years as per to WHO) and adult ages.

3.5 Exclusion Criteria

Study excluded individuals of less the 10 years of age due to their lack of inform awareness of time, space and place on the adherence to covid-19 guidelines and diarrhea

prevention before and during the covid-19 pandemic. This might have influenced the finding of the study in influencing the output as a confounder. None of the inpatient and revisit diarrhea related morbidity data was used in the analysis since the study intended to identify new episodes of diarrhea.

3.6 Sample Size Determination

Because of a gap in the current literature on the recent prevalence of diarrhea among adolescents and adults with 1999 -2003 surveillance study carried out in Western rural Kenya postulating the prevalence to be 32% which may not be the same now (Brooks et al., 2006).

From ***Figure 2***. The survey was carried out on the entire OPD attendance (346,561 records from 2018 to 2021 as per 25th July 2022 from KHIS2) at both statistical power of 80%, and 95% confidence interval of two sided direction test to help to ensure smaller precision on the finding and enable the study to find at least a smaller effect size (0.0047331) using pwr package in R software version 4.2.2 (Ahlmann-Eltze & Patil, 2021; Champely et al., 2018). Since all the entire existing data was to be used from OPD attendance records, there was need to calculate the study expected effect size based on the entire data (optimal sample). The blue vertical dotted line is the optimal sample size at 80% power, while red line indicates variation in power by different sample size

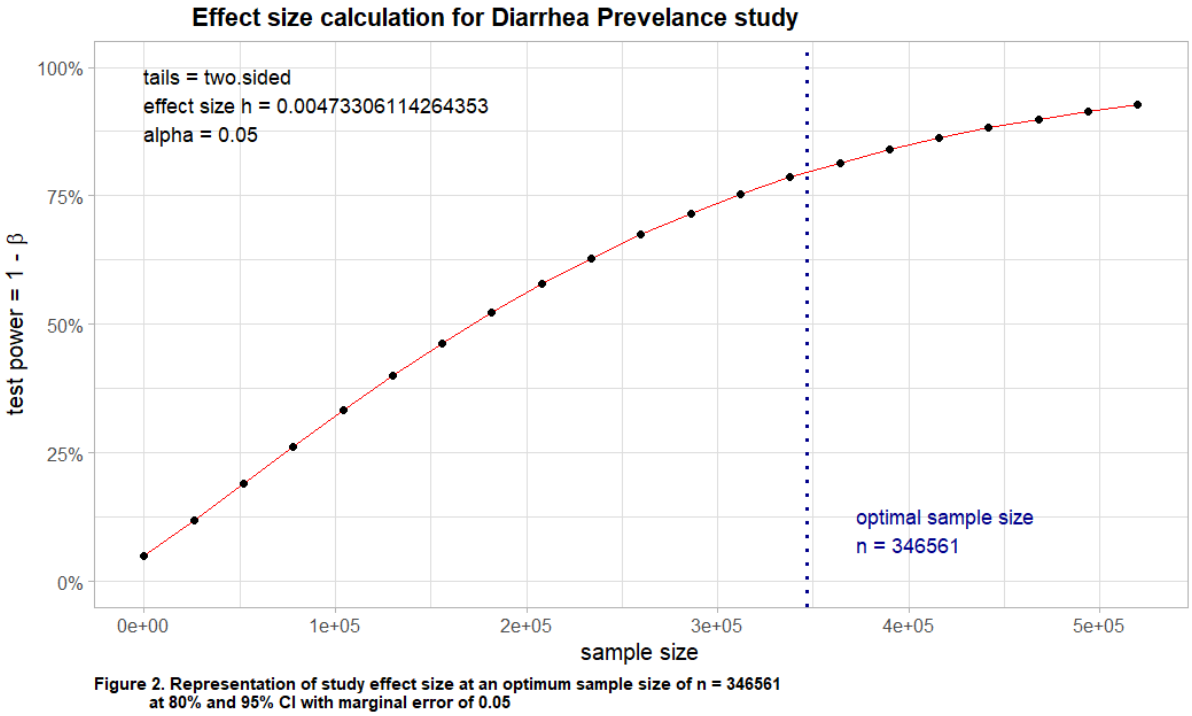

Figure 2. Representation of study effect size at an optimum sample size of n = 346561 at 80% and 95% CI with marginal error of 0.05

Figure 2*: Effect size calculation based on optimal sample size (plotted in R software (R 4.2.2))*

3.7 Sampling Procedure

The survey was carried out on the entire 2018-2021 outpatient new client hospital surveillance (The OPD attendance records).

3.8 Data Collection Methods

To abstract data from outpatient hospital surveillance data, a survey method with patient data abstraction was used. Some of data sources were KHIS database, fan soft and hospital registries for 2018 to 2021. This was achieved by abstracting study related data from the new outpatient client registries.

3.9 Key Variables of Interest

The data abstraction variables entailed; seasonality (dates of visit) and demographic-socioeconomic variables (sex, age) and diagnosis and residence. Key explaining variables of study were age which was classified as adolescence (10 – less than 20 years old) and adults (equal or above 20years) base on WHO mode of classification, seasonality described in terms of aggregated months across the study years & demographic highlighting gender, residence, level of education, occupation, marital status and religion

of the patients. Pre & during Covid-19 pandemic was explored as intervening variable to factor in the effect of absence and presence of Covid-19 pandemic mandatory containment measure.

3.10 Data Quality Assurance

The collected data was checked for completeness, structure error and for consistency before any analysis was used to ensure threshold was attained. Variable with more than 20% missing values were excluded in the analysis; some of which includes, diagnosis, any comorbidity, residence, education level, religion, and marital status.

3.11 Data Management and Analysis Plan

This section entails the processes from data abstraction to analysis & result dissemination.

3.11.1 Storage, Integrity and Confidentiality

Data was abstracted using Microsoft excel. And to ensure confidentiality patient names/identities and column with no relevance to the study was deleted and the required data exported to MySQL database to ensure data storage and access restriction. Excel copy was password protected and kept as backup. Password restriction was enforced to ensure access barrier to unauthorized entity. Records anomaly was implemented to hide the identity and privacy of each participant records.

3.11.2 Missing data

Complete cases analysis was used for descriptive analyses. For the other variables missing less than 20% machine learning imputation techniques algorithm was explored (*Multivariate Imputation by Chained Equations* algorithm).

3.11.3 Effect Modification & confounding

Interaction terms between independents variable and effect modifiers and confounders was determined using Generalized Linear Mixed Effect Model (Poisson log link)-GLMMs with statistical significance of interaction assessed with likelihood ratio test.

3.11.4 Analysis Procedure

Data analysis was done in R software version (R 4.2.2). Proportions, mean and frequencies was calculated as descriptive statistics analysis with respect to demographic

and other explanatory. The association between the independent and dependent variables was explained through both trend analysis, GLMMs (Poisson log link) with both Random intercept and Fixed slope.

To select contender variables for the multiple Generalized Linear Mixed Effect Model (GLMMs Poisson regression), bivariate analysis of the explanatory variables with dependent variables was performed. The primary variables with p-values of 0.2 in bivariate were used as cut-off to construct the multiple Poisson in order to identify predisposing factors associated with diarrhea. A multivariable analysis was performed to determine whether significant factors identified in the bivariate analysis remained independently associated with the outcome variable. The fitness model was tested using the likelihood ratio test with a p-value of 0.05. The calculation of the variance inflator was used to check for Multicollinearity between independent variables, and the results are presented in the form of tables, graphs, and summary statistics. At p-value 0.05, IRR with 95% confidence interval (CI) was used to report statistical significance.

3.11.5 Dissemination

The data analysis finding is to disseminated via the publication of paper and a copy of this thesis and publication will be shared in the schools and the facility where the data was sourced.

3.12 Validity

Expert consultation with my supervisors was used to ensure both face, content validity and construct validity. Using the entire outpatient record helped to increase probability of finding an outcome when there be an outcome to be found, hence increasing the power of the study to help ensure true internal validity. Expert opinion was used to validate and standardize the data abstraction tool to ensure increase construct content validity. To ensure internal and theoretical validity, intense literature review was carried out during the study processes to help compare the study findings with the opinion of other expects in the similar study field.

3.13 Reliability

A large sample size was also to ensure high precision and higher power in the study findings therefore maximizing reliability with less error of 0.05 to ensure internal

reliability (Alpha Coefficient). Using the entire outpatient record helped to increase probability of finding an outcome when there be an outcome to be found, hence increasing the power of the study to help ensure true internal validity. Expert opinion was used to validate and standardize the data abstraction tool to ensure increase consistence of the finding.

3.14 Ethical Consideration & Permission

Before any data was abstracted, the Jaramogi Oginga Odinga Teaching and Referral Hospital Ethics and Review Committee's ethical approval (Approval number: ISERC/JOOTRH/604/22) and a research license from NACOSTI (License No: NACOSTI/P/22/20543) were secured. The ethical consideration was ensured by enforcing confidentiality and anonymity of the data. Permission was obtained from the data abstraction site from the ones in charge (Chief Executive Officer) before the commencement of data abstraction and collection.

CHAPTER FOUR

RESULTS

4.1. Introduction

This chapter outline the finding from each specific objective and their interpretation in effort to answer the broader study objective.

4.2. The Distribution of risk factors by Diarrhea prevalence

Figure 3, shows the proportions distribution of the cases of diarrhea across the four years. Of the total cases (4,960), 2018 have the highest recorded cases of diarrhea 2401 (48.6%), followed by 2019 at 1272 (25.7%), to 2020 at 718 (14.5%) and 2021 having the least cases of diarrhea recorded 560 (11.3%).

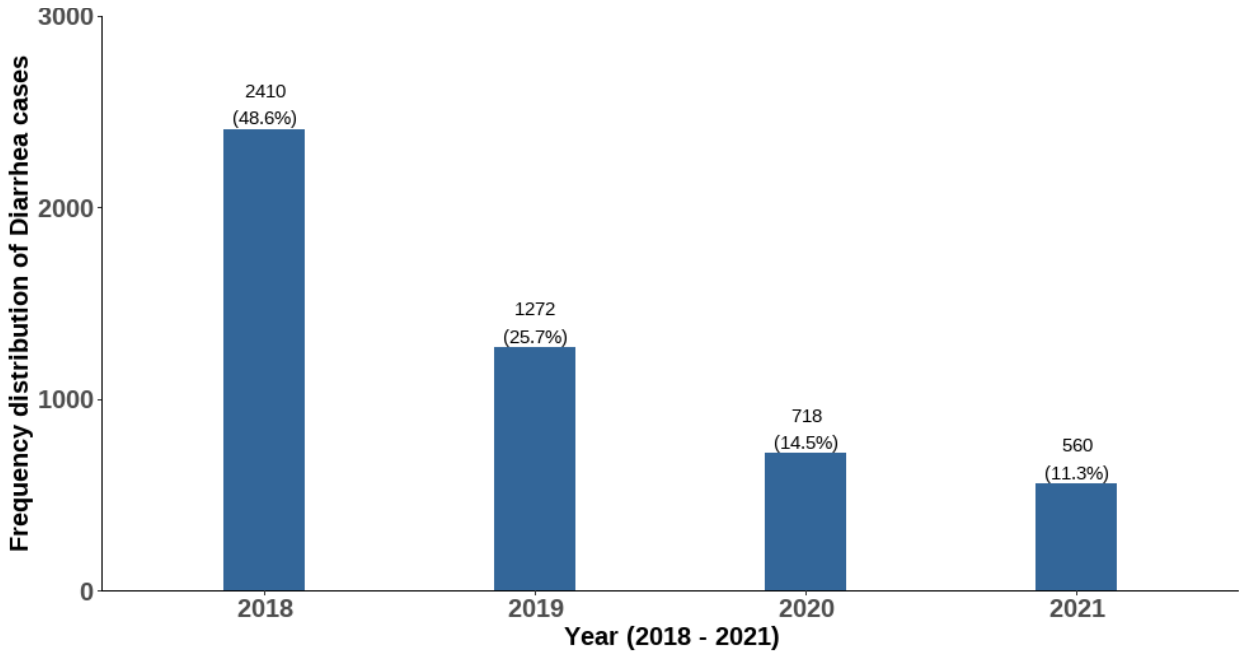

Figure 3: *The Distribution of Diarrhea cases from 2018-2021*

Table 1: *The Distribution of risk factors by Diarrhea prevalence*

Risk factor	**Overall**, N = 345,499[1]	**Diarrhea (Yes)**, N = 4,960[1]	**Diarrhea (No)**, N = 340,539[1]
Gender			
Female	209,178 (60.5%)	3,091 (62.3%)	206,087 (60.5%)
Male	136,321 (39.5%)	1,869 (37.7%)	134,452 (39.5%)
Age categories			
Adolescence	162,902 (47.1%)	2,343 (47.2%)	160,559 (47.1%)
Adults	182,597 (52.9%)	2,617 (52.8%)	179,980 (52.9%)
Covid			
During Covid	208,456 (60.3%)	1,278 (25.8%)	207,178 (60.8%)
Pre Covid	137,043 (39.7%)	3,682 (74.2%)	133,361 (39.2%)
Years			
2018	63,742 (18.4%)	2,410 (48.6%)	61,332 (18.0%)
2019	73,301 (21.2%)	1,272 (25.6%)	72,029 (21.2%)
2020	90,845 (26.3%)	718 (14.5%)	90,127 (26.5%)
2021	117,611 (34.0%)	560 (11.3%)	117,051 (34.4%)
Months of the Year			
January	29,641 (8.6%)	613 (12.4%)	29,028 (8.5%)
February	21,614 (6.3%)	407 (8.2%)	21,207 (6.2%)
March	26,147 (7.6%)	422 (8.5%)	25,725 (7.6%)
April	23,587 (6.8%)	456 (9.2%)	23,131 (6.8%)
May	25,782 (7.5%)	503 (10.1%)	25,279 (7.4%)
June	37,310 (10.8%)	322 (6.5%)	36,988 (10.9%)
July	24,715 (7.2%)	409 (8.2%)	24,306 (7.1%)
August	20,037 (5.8%)	297 (6.0%)	19,740 (5.8%)
September	31,446 (9.1%)	313 (6.3%)	31,133 (9.1%)
October	34,788 (10.1%)	534 (10.8%)	34,254 (10.1%)
November	37,460 (10.8%)	376 (7.6%)	37,084 (10.9%)
December	32,972 (9.5%)	308 (6.2%)	32,664 (9.6%)

[1]n(%) :- n ~ Frequency, (%) ~ Percentages

From ***Table 1***, a total of 345,499 was enrolled in the study to try and assess the contribution of Covid-19 deployed prevention measures on the changes in the prevalence of diarrhea disease among the adolescent and adult group for the four-study duration of 2018 to 2021 clustered as pre-and during covid-19 within Kisumu central sub county. From the total number of enrollments during the study period, 4,960 (1.44%) tested diarrhea positive at one point in time as new outpatient-client. From the overall enrollments there was 209,178 (60.5%) female and 136,321 (39.5%) males. Females have 3,091 (62.3%) of the total recorded cases of diarrhea. 182,597 (52.9%) of the

enrollments were adults and only 162,902 (47.1%) were adolescent group. Adult group had 2,617 (52.9%) of the total cases of diarrhea during the study period. A total of 208,456 (60.3%) enrollment took place during covid-19 pandemic. 1,278 (25.8%) of the total recorded cases of diarrhea occurred during covid-19 pandemic.

4.3. The changes in trends of diarrhea based on the seasonality pre and during covid-19.

The study was set out to examine the changes in the episodes of diarrhea disease across different months of the year both during and pre-covid-19 pandemic for between the four study years. The aim was to help identify the months with high peak of diarrhea cases and compare the finding for pre and during the covid-19 pandemic to asses if the covid-19 period had the effect on changes on the trend.

Analysis and Interpretations

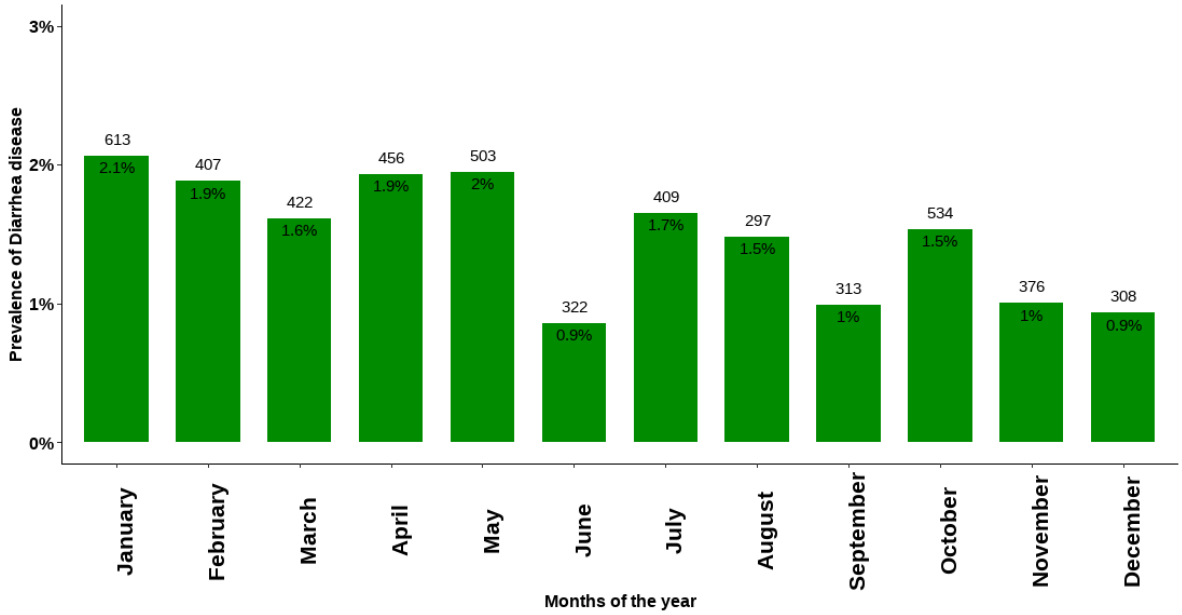

Figure 4: *The Prevalence of diarrhea disease across the year*

Figure 4, shows that January has the highest prevalence of diarrhea 613(2.1%) followed by the month of May 503 (2%), with June having the least registered prevalence of diarrhea disease.

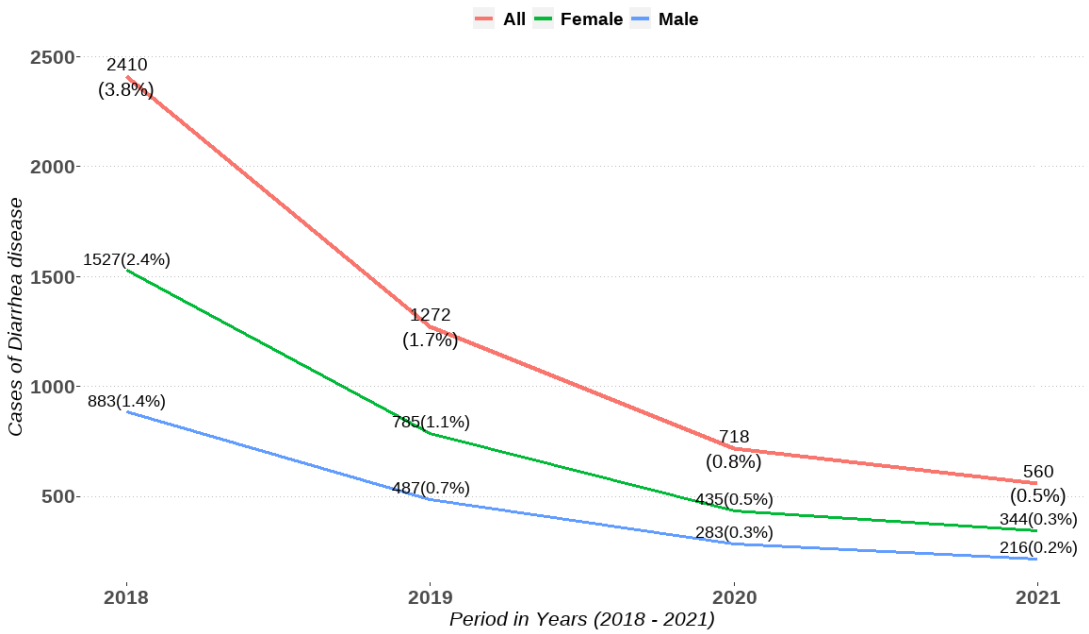

Figure 5: *The trend of diarrhea disease by the four study years*

Figure 5 shows the trend of Diarrhea cases from 2018 to 2021 both for the general study population and stratified by Sex. From the graph it can be clearly seen that there is a steady and exponential drop in the prevalence of diarrhea prevalence from 2018 to 2021. Both the prevalence of males and female are at downward trend respectively from 3.8% in 2018 to (560) 0.5% in 2021 generally. The prevalence of diarrhea is high among the Female than the male counterpart across the four study years ranging from 2.4% among females and 1.4% among males in 2018, and dropped to 0.3% among females and 0.2% among males.

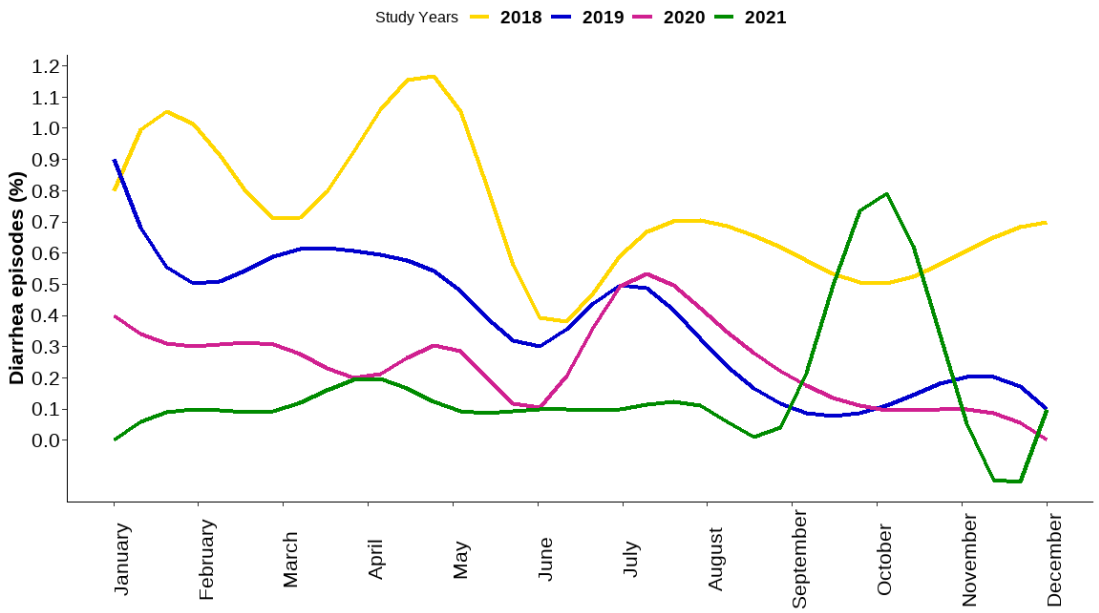

Figure 6: *The trend of diarrhea disease within the study period*

I plotted a line graph to show the trend of diarrhea disease overtime by months from 2018 to 2021. It can be observed in *Figure 6* that, the diarrhea prevalence is high between January & February, April & May, and another peak in July as depict by 2018, 2019 and 2020 epi-curve trend line. It is also worth noting that the trend of diarrhea is on the decline from 2018 to 2021. 2021 curve is almost flattening throughout the entire year. October 2021 recorded the highest cases of diarrhea than the rest of the month same year, which is also the highest compared to the past three years during the same period of the month.

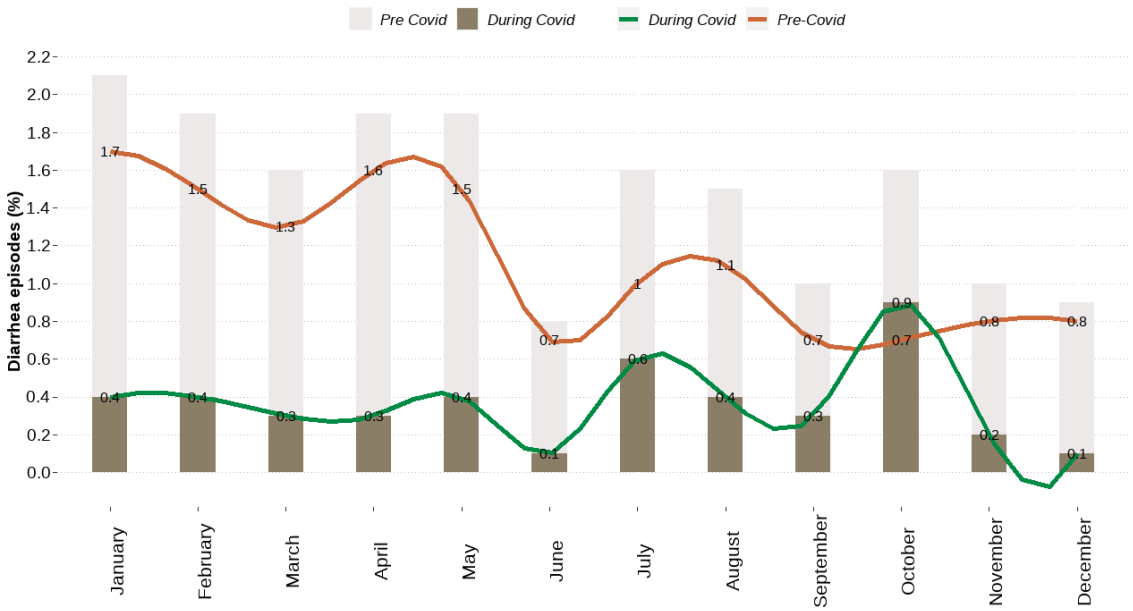

Figure 7: *The trend of diarrhea disease for Pre and During Covid-19 Pandemic*

We plotted a line graph to show the trend of Diarrhea disease overtime by months for pre-Covid-19 period and During Covid-19 within the study period. From *figure 7*, it is worth stating that the prevalence of diarrhea cases During Covid-19 pandemic is lower compared pre-Covid-19 almost across the year. The prevalence of diarrhea cases is high between January & February, April & May and between July & August for the Pre-Covid-19 and During Covid-19.

Table 2: *Proportional Test for Difference in the Proportion of Diarrheal cases*

Characteristic	Pre Covid, N = 137,043[1]	During Covid, N = 208,456[1]	Difference[2]	95% CI[23]	p-value[2]
Diarrhea	3,682 (2.7%)	1,278 (0.6%)	2.1%	2.0 - 2.2	<0.001

[1] *n (%)*

[2] *Two sample test for equality of proportions*

[3] *CI = Confidence Interval*

I fitted a proportion test of hypothesis to test the difference in the proportion of diarrhea disease for pre and during-covid-19. In *table 2*, the proportion of diarrhea between the two groups is significantly different from the test of hypothesis with p value less than 0.001 and proportion difference of 2.1% and 95% CI [2.0,2.2]. The prevalence of

diarrhea among pre-covid-19 group is 2.7% significantly higher compared to during-covid-19 pandemic 0.6%.

4.4. The prevalence of diarrhea based on adolescent and adults pre and during covid-19.

The second aim of the study was to determine the prevalence of diarrhea based on adolescent and adults pre and during covid-19 pandemic.

Analysis and Interpretations

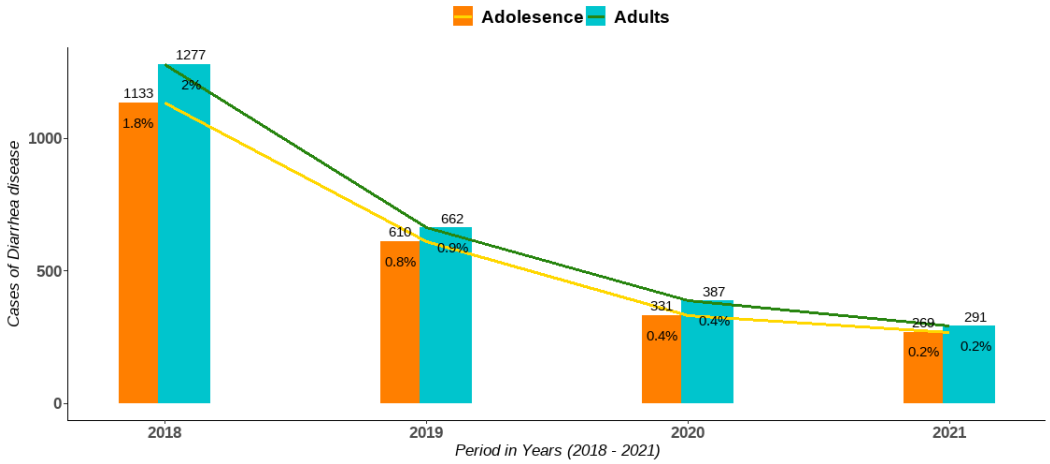

Figure 8: *The Prevalence of Diarrhea Disease Among Adolescence and Adult from 2018-2021*

The prevalence of Diarrhea disease among adult (20 years and above) is 2% in 2018 while for adolescent (10 to less 20) is at 1.8% in the same year. The Prevalence is on a decline from 2018 to 2021 for both the ages. By 2021 both age group have common prevalence of 0.2%.

Table 3: *The prevalence of Diarrhea Disease by Age Group*

Group	Characteristic	Diarrhea (No), N = 133,361[1]	Diarrhea (Yes), N = 3,682[1]
Pre Covid-19	Age category		
	Adolescence	62,987 (97.3%)	1,743 (2.7%)
	Adults	70,374 (97.3%)	1,939 (2.7%)
During-Covid-19	Age category		
	Adolescence	97,572 (99.4%)	600 (0.6%)
	Adults	109,606 (99.4%)	678 (0.6%)

[1]n (%)

The prevalence of diarrhea by the two-age category both during pre-covid-19 and during the covid-19 pandemic is at 2.7% and 0.6% respectively. There is no significant different in the prevalence of diarrhea between adolescent and adult population generally based on the proportion test.

4.5. The influence of covid-19 containment measures on the changes in diarrhea trends

The third objective of the study was to examine the effect of covid-19 containment measures on the episodes of diarrhea. This was due to the fact that a lot of enforced diarrhea related prevention measures like increased personal hygiene, sanitation, surfaces hygiene, and as well as travel restrictions was deployed during the strong fight to curb the transmission rate of Covid-19.

Analysis and Interpretations

Table 4*: Chi-square Test of association between covid-19 and diarrhea prevalence*

Group	Characteristic	Overall, N = 345,499[1]	Diarrhea (Yes), N = 4,960[1]	Diarrhea (No), N = 340,539[1]	p-value[2]
Column Wise Proportion	**Covid**				<0.001
	During Covid	208,456 (60%)	1,278 (26%)	207,178 (61%)	
	Pre Covid	137,043 (40%)	3,682 (74%)	133,361 (39%)	
Row Wise Proportion	**Covid**				
	During Covid	208,456 (100%)	1,278 (0.6%)	207,178 (99%)	
	Pre Covid	137,043 (100%)	3,682 (2.7%)	133,361 (97%)	

[1]n (%)

[2]Pearson's Chi-squared test

I fitted a Pearson's Chi-square test of hypothesis on the independence association between pre & during covid-19 and diarrhea occurrence. It is worth noting that covid pandemic presence is significantly associated with changes in diarrhea prevalence at p-value < 0.001. From the total number of positive diarrhea cases (4960) only 26% (1278) occurred during covid-19 pandemic while the 74% (3682) was recorded on pre-Covid times. It is also worth noting that the hospital workload for during covid-19 is 60%

(208456) of the total outpatient new-client workload (345499) for the four study years' period. The prevalence of diarrhea disease during covid-19 is 0.6% (1278) of the total workload during-covid phase (208,456), while 2.7% (3682) of the total outpatient workload (137,043) for pre covid-19 phase of the study.

Table 5: *Incidence of Diarrhea Disease*

	IRR[1]	95% CI[1]	p-value
Years			
2018	—	—	
2019	0.46	0.43, 0.49	<0.001
2020	0.21	0.19, 0.23	<0.001
2021	0.13	0.12, 0.14	<0.001

[1]IRR = Incidence Rate Ratio, CI = Confidence Interval

*In **Table 5***. I fitted a Poisson crude model (estimated using ML) to predict diarrhea with study years (formula: Diarrhea ~ Years). Within this model: The effect of years [2020] is statistically significant and positive (IRR = 0.21, 95% CI [0.19, 0.23], p < .001). The effect of years [2021] is statistically significant and positive (IRR = 0.13, 95% CI [0.11, 0.14], p < .001). 95% Confidence Intervals (CIs) and p-values were computed using a Wald z-distribution approximation.

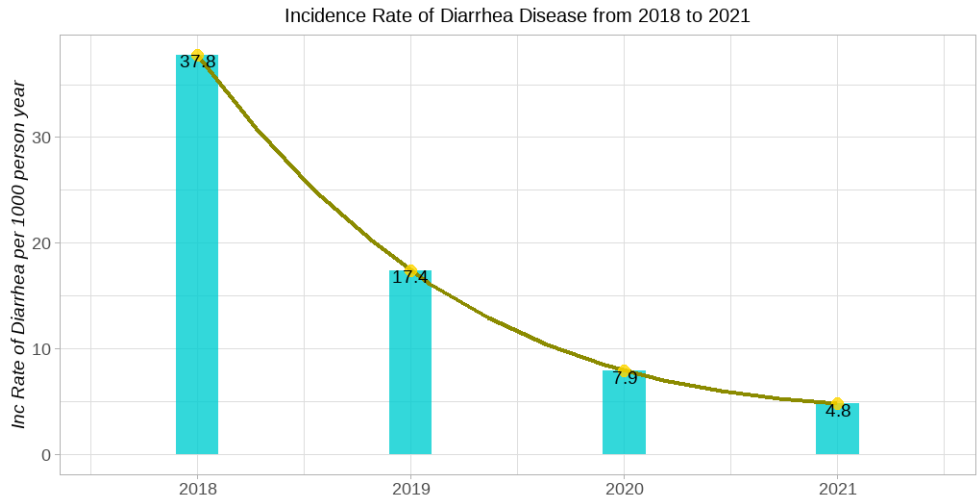

Figure 9: *Trend of Incidences of Diarrhea Disease from 2018 to 2021*

In Figure 9. As revealed by the plot the incidence of diarrhea disease is on a tremendous decline from 37.8 cases of diarrhea per 1000person year in 2018 to 4.8 cases of diarrhea per 1000person year in 2021.

Table 6: *Effect of Covid-19 Presence on the changes in the trend of diarrhea disease*

	Crude GLMEM-Poisson			Adjusted GLMEM Poisson		
Risk factors	**IRR**[1]	**95% CI**[1]	**p-value**	**IRR**[1]	**95% CI**[1]	**p-value**
Covid						
During Covid	0.24	0.19, 0.30	<0.001	0.23	0.15, 0.34	**<0.001**
Age category						
Adults	0.998	0.94, 1.05	>0.9	1.00	0.95, 1.06	>0.9
Gender						
Male	0.93	0.88, 0.98	0.011	0.96	0.91, 1.02	0.2
Months						
April	—	—		—	—	
January	1.38	1.24, 1.53	<0.001	1.38	1.23, 1.54	**<0.001**
February	1.09	0.97, 1.23	0.2	1.09	0.96, 1.23	0.2
March	0.954	0.85, 1.07	0.4	0.95	0.84, 1.08	0.5
May	1.05	0.94, 1.18	0.4	1.05	0.94, 1.18	0.4
June	0.35	0.31, 0.40	<0.001	0.35	0.31, 0.40	**<0.001**
July	0.83	0.73, 0.93	0.002	0.83	0.73, 0.94	**0.003**
August	0.80	0.70, 0.91	<0.001	0.80	0.70, 0.91	**0.001**
September	0.73	0.65, 0.83	<0.001	0.73	0.64, 0.84	**<0.001**
October	1.18	1.06, 1.32	0.003	1.18	1.05, 1.33	**0.004**
November	0.78	0.69, 0.89	<0.001	0.79	0.69, 0.89	**<0.001**
December	0.70	0.62, 0.79	<0.001	0.70	0.61, 0.80	**<0.001**

[1]**IRR = Incidence Rate Ratio, CI = Confidence Interval**

Generalize Linear Mixed Effect Models-: Poisson regression (link = log).

I fitted a generalized linear mixed effect model with random intercept and fixed effects (estimated using ML) to predict diarrhea with covid presence, gender & months of the year as fixed effects and study year as the grouping/cluster level variable. (Formula: Diarrhea ~ Covid + Gender + Months_fct + Age + (1|Years)). The intercept(mean) was allowed to randomly vary with each study year with random effect standard deviation of 0.3551 clustered by Study years/period.

The effect of Covid-19 [during Covid] is statistically significant and negative both in the bivariate & adjusted multivariate analysis (IRR = 0.23, 95% CI [0.15, 0.34], p < .001). Implying there is reduced risk of diarrhea disease by 77% among "during covid-19" era compared to the era of pre covid-19 adjusting for gender and months of the year. The effect of gender [Male] is statistically significant and negative in the bivariate analysis only with (IRR = 0.93, 95% CI [0.88, 0.98], p = .011). Implying males have 7%

reduction in the risk of diarrhea disease compared to the female counterpart un-adjusted for. On the adjusted model gender wasn't significant at alpha of 5% though still showed negative direction of association of 4%.

The effect of months [January] is statistically significant and positive both in the bivariate & adjusted multivariate analysis (IRR = 1.38, 95% CI [1.23, 1.54], p < .001). Implying in January there is an increased risk/ rate of diarrhea disease by approximately 38% compared to the month of April holding other factors constant. The effect of months [October] is statistically significant and positive both in the bivariate & adjusted multivariate analysis (IRR = 1.18, 95% CI [1.05, 1.33], p = .004). Implying in October there is an increased risk/ rate of diarrhea disease by approximately 18% compared to the month of April holding other factors constant.

The effect of months [June] is statistically significant and negative both in the bivariate & adjusted multivariate analysis (IRR = 0.35, 95% CI [0.31, 0.40], p < .001). Implying the month on June has reduced risk of diarrhea disease by approximately 65% compared to the month of April holding other factors constant. The effect of months [July] is statistically significant and negative both in the bivariate & adjusted multivariate analysis (IRR = 0.83, 95% CI [0.73, 0.94], p = .003). Implying the month on July has reduced risk of diarrhea disease by approximately 17% compared to the month of April holding other factors constant. The effect of Months [November] is statistically significant and negative both in the bivariate & adjusted multivariate analysis (IRR = 0.79, 95% CI [0.69, 0.89], p <001). Implying the month on November has reduced risk of diarrhea disease by approximately 11% compared to the month of April holding other factors constant. The effect of months [December] is statistically significant and negative both in the bivariate & adjusted multivariate analysis (IRR = 0.70, 95% CI [0.61, 0.80], p < .001). Implying the month on December has reduced risk of diarrhea disease by approximately 30% compared to the month of April holding other factors constant. The was no significant different in age in terms of the rates of diarrhea disease. Implying equal incidence rate of diarrhea infection between the ages.

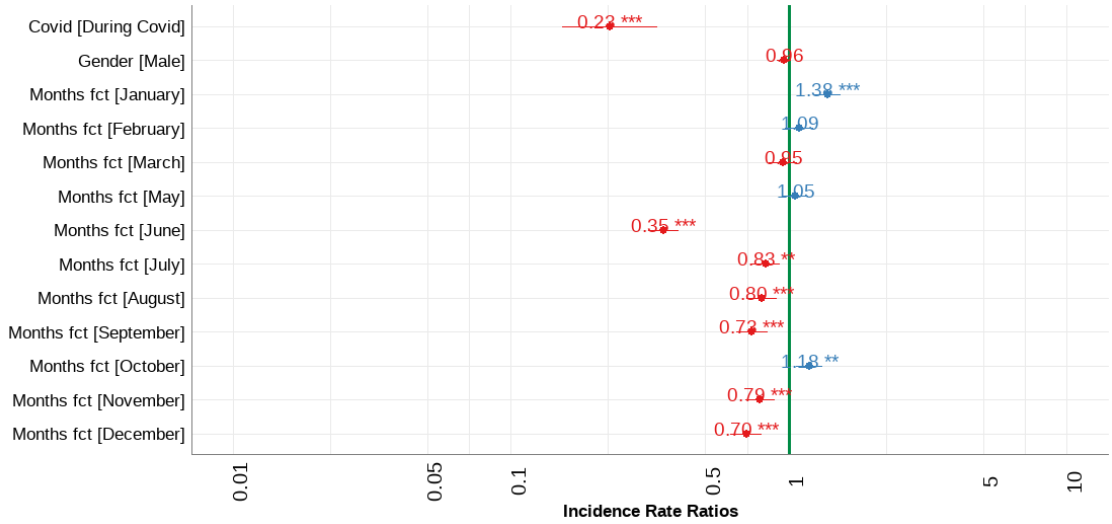

Figure 10: *Adjusted Model Visualization*

In figure *10.* The red estimates & dash lines indicate the reduction in incidence rate ratio with the 95% CI, the light green estimates & dash lines indicate increase risk with its 95% CI. The stars indicate statistically significant estimates. The dark green vertical line indicates threshold point for IRR = 1.

CHAPTER FIVE

5.1. Discussion

The prevalence of diarrhea disease among the adolescence and adults was at 3.8% in 2018 but dropped exponentially overtime to 0.5% by 2021. The dropped was witness across even when the finding was stratified by sex, the overall trend of diarrhea disease stratified by gender from 2018 to 2021, (two years before covid-19 pandemic and two years during covid-19). Though the prevalence of diarrhea is high among the females (2.4% in 2018 and 0.3% in 2021) than in males (1.4% in 2018 and 0.2% by 2021), similar findings was obtained in a study at Bangladesh & Schlagenhauf which also found females to have high prevalence of diarrhea than males i.e. Women are proportionately more likely than men to present with acute diarrhea (OR, 1.13; 95% CI, 1.09-1.38), chronic diarrhea (OR, 1.28; 95% CI, 1.19-1.37) (Schlagenhauf et al., 2010), and In contrast, prevalence of diarrhea was significantly higher ($p<.0001$) among older females (≥15 years) compared to that among older males in Bangladesh(Chowdhury et al., 2015). Yet this study finding was contradicting the finding of a study carried out in Gaza in 2018-2019 on the prevalence of diarrhea, which found males to be having high prevalence of diarrhea (between 2.1% to 4.2%) compared to females (Abuzerr et al., 2019) and other studies in Bangladesh and Sudan also found males to higher prevalence than females (Chowdhury et al., 2015; Mitra, Rahman, & Fuchs, 2000). Otherwise, both genders have been witnessing a drop in the new cases of diarrhea over the time.

The study finding raises the possibility that the deployed intervention, guidelines and mitigation measure against Covid-19-pandemic could have had significant effect on reducing the incidence and prevalence of diarrhea cases. During pre-Covid-19 pandemic January used to have the highest registered prevalence of diarrhea (1.7%) followed by the month of April (1.6%), May (1.5%) & February (1.5%) respectively illustrated in both. During outbreak of Covid-19 pandemic and rolled out mitigations measures to try and reduced the incidence of corona virus, both the prevalence's and trends in the diarrhea cases changed. During Covid-19, the month of October had the highest prevalence of diarrhea 0.9%, while January, February, April and May having approximately less or equal to 0.4% each as compared to pre-Covid pandemic era. A study carried out in Western Kenya on the "Epidemiology, Seasonality and Factors Associated with Rotavirus

in 2008-2012" indicated that the proportion of cases positive for rotavirus was highest in August, December, January, and February, and that stool samples obtained during typically warm and dry months were twice as likely to be rotavirus-positive compared to typically cool and rainy months (Omore et al., 2016). This study finding is contrary to the Rotavirus study, possibly due to the different nature of study design, otherwise both study suggest high prevalence of diarrhea in both January and February. From the Rotavirus study December recorded the highest prevalence of diarrhea in the western Kenya during the pre-Covid pandemic era whereas findings from this study only show 0.8% in the prevalence of diarrhea in the period of pre-covid-19. The prevalence of diarrhea is at 0.1% revealing that probably such level of significant change in the prevalence might have been attributed by the Covid-19 prevention measures that were reinstated during the outbreak of the novel corona virus as seen.

The proportional change in the trend and the prevalence of diarrhea was found to be significant ($p < .001$) suggesting that cases of diarrhea was by good proportion reduced during the pandemic, hence Covid-19-pandemic could have had significant effect on reducing the incidence and prevalence of diarrhea cases. There by raising the possibility that the deployed intervention, guidelines and mitigation measure against Covid-19-pandemic could have had significant effect on reducing the incidence and prevalence of diarrhea cases.

The fecal-oral group of diseases known as diarrhea can be spread from person to person, through water, food, or by direct contact with the mouth. These diseases typically flourish in environments with poor water quality, trash and filthy surroundings, as well as a large population of flies. The foundation of control is breaking the fecal-oral cycle through personal hygiene, increased water availability, improved water quality, improved food hygiene, and the provision of sanitation (Webber, 2016). Some of the deployed intervention against Covid-19 that were of association to risk factors to diarrhea includes global & domestic travels, personal hygiene, sanitation, contact handshake, hand mouth touch and overcrowding. Several factors, including socioeconomic (poverty), environmental, and behavioral factors, illiteracy, poor water supply and sanitation, poor hygiene practices, and insufficient health services, are likely to contribute to the

extremely high diarrhea morbidity and mortality rates (Chowdhury et al., 2015).Based on the *chain of infection theory* the breaking of one link in the chain can intervene with an endemic (Juraja, 2007).The chain contains; infectious agent, reservoir (source), portal of exit, transmission mode, portal of entry and the susceptible host.

Controlling the spread of a disease is geared towards the 6 link, For the public health, understanding the processes involved in the chain of infection presents numerous positive implications such as introduction of the control measure targeted at the management of infectious diseases.

The prevalence of diarrhea disease among both adolescence and adults was at 0.6% during Covid-19 era and 2.7% before the Covid pandemic. The finding was slightly agreed with a similar cross section study carried out in Gaza in 2019, "Prevalence of diarrheal illness and health seeking behavior" which found the prevalence of diarrhea to range between 1.2% to 3.1% in age group between 6 and 15years old and more than 16years old respectively (Abuzerr et al., 2019). In *Figure 5*, the overall prevalence rate for all age group in 2018 (pre-Covid pandemic) was at 3.8% which exactly similar to a prevalence obtained in the study finding carried out in Gaza 3.8% (Abuzerr et al., 2019). Despite the fact that the study found no significant difference in the proportion of diarrhea between the two age groups, figure 8 can help to reveal changes in the prevalence across the four study years. In 2018 the prevalence of diarrhea was at 2% & 1.8% respectively among the adolescence and adults which was seen to be high as compared the advanced years.

The change in the prevalence from pre-Covid 2.7% to 0.6% during Covid suggest a likelihood that the changes might have been as a result of the mandatory behavioral changes introduced during the Covid pandemic to curb the transmission hence control the corona virus spread from person to person. The *health action process approach* advanced by Schwarzer *(Schwarzer & Warner, 2013)* purports that when a person is deciding which health action(s) to adopt and implement, he refers to this as the motivation phase or simply the decision-making period. According to the theory, actions are influenced not only by intentions and cognitive control, but also by perceived and actual environment Schwarzer *(Schwarzer & Warner, 2013)*. Based on this theory *"health action process*

approach" it appears the implemented behavioral changes like improved personal and domestic hygiene might have contributed to the reduction on the prevalence of diarrhea. People may or may not perceive the outcome of their behaviors in cases of emergency like pandemic outbreaks. The model further states that "the most important predictors of intentions are risk perception outcome expectancies and self-efficacy". Increase hand washing with soap, hand sanitization, reduce hand shake and surface or objects sanitization behaviors as result of the fight against Covid-19 pandemic, could have participated greatly in controlling the dynamics of transmission diarrhea disease as well. There by raising the likelihood that the deployed intervention, guidelines and mitigation measure against Covid-19-pandemic could have had significant effect on reducing the incidence and prevalence of diarrhea cases.

On average, the crude incidence rate of diarrhea disease was found to be approximately 0.014, implying 1400 cases of diarrhea per 100,000person year. The study finding slightly conflicts a findings on a study carried out in Kenya 2016, "Population-Based Incidence Rates of Diarrheal Disease" with crude incidence as 1,937 per 100,000 person year (Shioda et al., 2016). The incidence rates across the four-study year were found to be 3.78, 1.74, 0.79, and 0.48 cases per 100-person year respectively depicting decline in rates. The findings from this study has shown that there is association between the Presence or absence of Covid-19 with the incidence of diarrhea as revealed by both chi-square test of independence and Multivariable generalized linear mixed effect model. With significant level of confidence, we can purport that the enforced mitigation measures against Covid-19 pandemic with associated risk factor as diarrhea might have had a significant role to play in reducing the diarrhea cases hence the association. We also found out that there was a significant reduction in the Adjusted incidence rate of diarrhea during covid-19 of about 79% compared to the period before Covid (*IRR = 0.21, 95% CI [0.20, 0.23], $p < .001$*). The study finding raises the possibility that the deployed intervention, guidelines and mitigation measure against Covid-19 could have had significant effect on reducing the incidence and prevalence of diarrhea cases. It was also worthwhile stating that Males had 5% reduction in the risk of diarrhea disease compared to the Female though was not found to be significant at alpha of 0.05 (IRR = 0.95, 95% CI [0.90, 1.01], p = .082).

Infectious agents are primarily transferred via hands. The best approach to prevent illness is through good hand cleanliness. Hand hygiene entails applying alcohol-based hand massages or washing with soap and water. The WHO published guidelines on hand hygiene in health care and introduced the "My five moments for hand hygiene" concept to define indications for hand hygiene rooted in evidence-based model for transmission of microorganism by health workers in an effort to harmonize hand hygiene practices globally (Salmon S *et al.*, 2015). In the effort to manage the spread of the covid-19 pandemic, the national and county government through MOH enforced the installation of water tab preferable with foot pedals and detergents in public places, such us hospitals, schools, public work offices, market places, and insisting the placement of water tab and soaps per every business door. A lot of campaigns was also deployed; geared towards encouraging handwashing with soap detergents before access to most areas or services both in private or public places to safeguard lives. Handwashing promotion help reduce diarrhea episodes, however, less is known about how to help people maintain hand washing habits in long term (Ejemot-Nwadiaro et al., 2021).

Alcohol-based hand rubs are a quick and effective way to remove germs picked up from contaminated surfaces. Although alcohol-based hand rubs reduce the number of germs on your hands, they are not as effective at removing dirt (Salmon, Pittet *et al*. 2015). Basically, this approach has also become quite dominantly used by most individuals to ensure hand hygiene both after touching fomites, accidentally shaking hand or simply before touching any opening. And to most office workers with no physical and visible dirt, it was like a substitute to handwashing with soap in the effort stop covid-19 transmission.

The handshake is a well-known vector for pathogen transmission between individuals. Handwashing has become a healthcare system-wide initiative to reduce infectious disease transmission rates, including diarrhea, but up to 80% of people retain some disease-causing bacteria after washing. The fist bump is an alternative to the increasingly popular handshake. *Implementing the restriction on handshake* may further had helped to reduce pathogen transmission by reducing total surface are exposed breaking the chain of infection (Ghareeb et al., 2013). In the cause of the fight against the pandemic Covid-19, handshake was disapproved as a mitigation against covid-19. Different groups of people,

ages (adolescent and adults), religions and culture has invented and adopted different modes of greeting; elbow greeting, fist bump, hand waving, mere verbal greeting etc. in effort to obey the health restriction policies. Which by great length has help in breaking the chain of infectious disease transmission and minimizing person contacts.

Regular cleaning with water and detergents help to remove germs from the surfaces and reduce the risk of potential person picking up germs from potential contaminated surfaces. Using detergents & water, and scrubbing action will loosen and lift the dirt from the surfaces (Salmon, Pittet *et al*. 2015). *Surfaces and object frequent disinfection* by chlorine components is one of the major applied technic that was implemented to help curb pandemic transmission especially those which are regularly touched places, an attempt to curb the transmission of covid-19. Cleaning and disinfect of chairs, shared keyboards, table surfaces, phones screens, door surfaces, door handles.

Public gatherings in places like churches, markets, festivals, funerals and weddings were *banned* during high peaks of Covid-19 and to some extent, minimized the attendance and activities like cooking, in order to prevent the transmission of covid-19 through contaminated fomites and utensils. This helped to minimize the episodes of diarrhea outbreaks from undercooked or contaminated food in such gatherings like funerals, weddings, churches and festivals.

Diarrhea is one of the most common infectious risks among short-term travelers to developing countries, with some studies indicating that more than 50% of travelers are affected during a two-week visit to an endemic country (Leder et al., 2013). Every year, approximately 12 million people travel from an industrialized country to a developing country in the tropics or subtropics. This trip exposes them to a much more polluted environment than they are used to at home. Consumption of contaminated water and unsanitary food, in particular, puts them at risk of enteric infections and diarrheal diseases. While it is largely assumed that longer time in a foreign place is associated with protective immunity, it is unknown how rapid immunity differs to different pathogens. *Implementing restricted movements (lockdown*) during Covid-19 pandemic might have contributed to minimizing the incidence of Travel diarrhea episodes.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1. Summary

Diarrhea is the second leading cause of child morbidity and mortality, particularly in developing countries. It is the third leading cause of death in the world and continues to impose a significant burden, accounting for 2.8 billion diarrhea episodes among older children, adolescents, and adults. Severe Acute Respiratory Syndrome coronavirus type 2 (SARS-CoV-2) - Covid-19 outbreak was declared a pandemic on 11th March 2020 which prompted the implementation of ant-covid preventions and control measures in attempt to curb its transmission from person to person. The interventions were not only impactful in managing Covid-19 transmission rates, but also helped reducing the rates of infectious diarrhea diseases with associated risk factors as personal hygiene, sanitation, contact handshake, lockdown and travel restrictions.

This study aimed to assess the contribution of covid-19 containment measures on epidemiology of diarrhea in the adolescent and adult patients attending Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County, Kenya, 2018-2021. Given the already manipulated treatments of enforced Covid-19 containment measures as intervention. The specific objectives were; to examine the trend/seasonality of diarrhea during the two time periods, to determine the current baseline estimate/ prevalence of diarrhea between the adolescence and adult age group, and to determine the influence of covid-19 containment measures on the trends of diarrhea episodes. The research provides evidence-based information of hygiene policies to diarrhea prevalence to inform decision making and priority setting.

A cross-sectional retrospective survey was carried out on the entire the outpatient new client (OPD) records at 80% power, 95% CI, alpha of 0.05 and N of 345,499 to detect a smaller effect size. Descriptive statistics was used to summarize and organize the data. The relationship between the dependent variables, independent and intervening variable was explained through trend analysis, & Generalized Linear Mixed Effect Model (GLMEM Poisson log link) with both **r**andom intercept and **f**ixed slope.

The prevalence of diarrhea during covid-19 pandemic period was 0 .6% significantly lower compared to the pre covid-19 pandemic 2.7%. On average, the month of January had the highest prevalence of diarrhea (2.1%) followed by April (1.9%) & May (2%) with June registering the lowest prevalence during 2018 to 2021. During covid-19 pandemic October turned to have the highest prevalence of diarrhea. January, February and October had a significant increased rate of diarrhea 1.46, 1.26 & 1.31 respectively compared to month of April. There was a statistically significant reduction in the adjusted incidence risk of diarrhea during covid-19 by 79% (*IRR = 0.21, 95% CI [0.20, 0.23], p < .001*).

The study finding raises the possibility that the deployed interventions against Covid-19 could have had significant effect on reducing the incidence and prevalence of diarrhea cases.

Understanding the burden, trends, and prevalence of diarrheal disease, as well as its seasonal variation, is critical for developing effective control programs for the overall reduction of diarrhea disease among people of all ages.

6.2. Conclusions

This study examined the positive effect of Covid-19 deployed mitigation measures on other infectious diarrhea episodes. In conclusion to the study objectives;

The changes in trends of diarrhea based on the seasonality pre and during covid-19.

Diarrhea peaks in January & February, April & May, July & August; a likely depiction of festivals aftermath, heavy & short rains. This was observed consistently for pre and during covid-19.

The prevalence of diarrhea based on adolescent and adults pre and during covid-19

An exponential drop in prevalence of diarrhea, depict the effect of introduced intervention. And no significant different in the prevalence of diarrhea between adolescent and adult population generally. Applicable for both pre and during covid-19.

The influence of covid-19 containment measures on the changes in diarrhea trends

Significantly lower prevalence, incidence & risk of diarrhea during Covid-19. The study finding raises the possibility that the deployed intervention, guidelines and mitigation

measure against Covid-19 could have had significant positive effect on reducing the incidence and prevalence of diarrhea cases.

6.3. Recommendations

The changes in trends of diarrhea based on the seasonality pre and during covid-19.

Understanding the *burden, trends, and prevalence of diarrheal disease, as well as its seasonal variation*, is critical for developing effective control programs for the overall reduction of diarrhea disease among people of all ages.

The prevalence of diarrhea based on adolescent and adults pre and during covid-19

Planning efficient control plans for the overall reduction of diarrhea disease in the community requires an understanding of the burden/impact of the infectious diseases as well as the variance by the at-risk age groups. Tracking and understanding the current diarrhea estimates among all ages is key towards monitoring and tracking of disease resurgence, endemics, and/or eliminations. Not limited to this only, it as well helps in evaluation of prevention measures uptake rates (in terms of programs performance effectiveness) among different targeted groups at risk.

The influence of covid-19 containment measures on the changes in diarrhea trends

I recommend improving the actions of anti-covid-19 public health mitigation measure to help the push towards reducing the incidence (possible to eliminate) of infectious diarrhea disease. This can be achieved by, improving personal hygiene (*Hand hygiene, Alcohol-based hand rubs, limiting unnecessary handshake*), sanitation, surfaces and object frequent disinfection and discourage unnecessary travels.

There are numerous shortcomings that point to the necessity of more prospective research in these age ranges globally. Many limitations have been identified based on the type of study design and the quality of retrospective survey data used, implying the need for additional prospective studies (with mixed method approach) in these age groups around the world to try and confirm the study findings on the prevalence of diarrhea among adults and adolescents.

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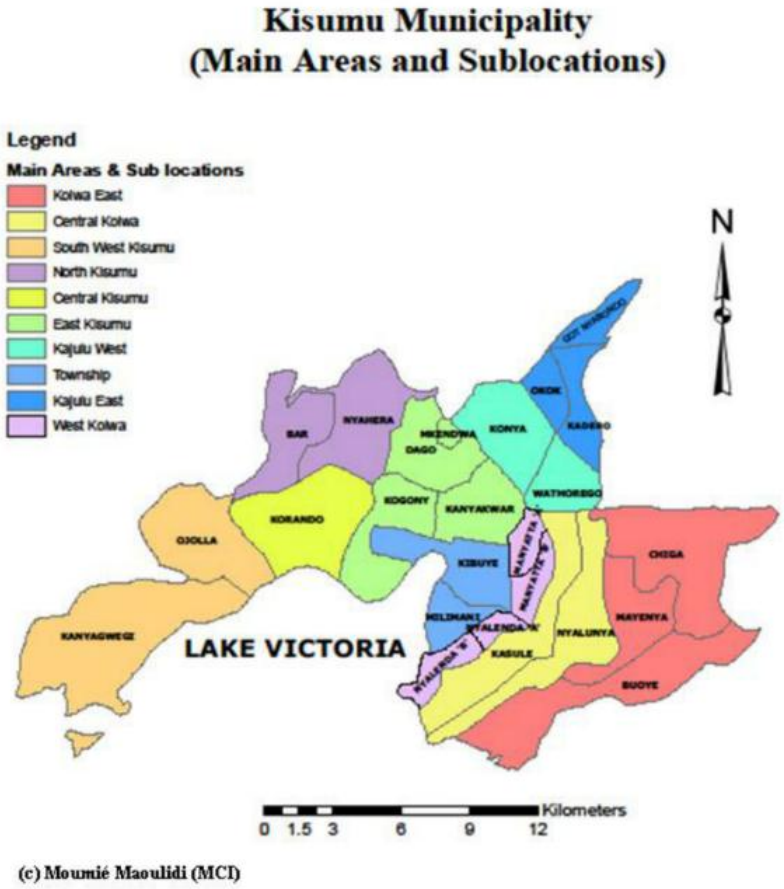
APPENDICES

Appendix 1: Map of Kisumu Municipality



(c) Moumié Maoulidi (MCI)

Appendix 2: Confidentiality consent form

Confidentiality Agreement Form

I _____

(Full Names)

Hereby understand that it is my ethical responsibility to protect the confidentiality of patient health information and further identity. I will abide by quality and security standards of the study patient level data.

I hereby declare that I fully understand the patients or participant's rights to confidentiality with regards to identity and health information and will adhere to this principle as an

Supervisor ☐ **/ Data analyst** ☐ the project at all times. **(Tick as appropriate)**

I shall not disclose patient information to anyone outside the PI either during or after my period of engagement with the study.

If I am in breach of this agreement, I fully understand that the ethics committee has the right to take action against me.

Signature: _____ **Date:** _____

DD/MM/YYYY

Witness: _____

Comments:

_____

_____

QA Review: _____ **Initials:**

Appendix 3: Data Abstraction tool

DATA ABSTRACTION FORM

FOR

CONTRIBUTION OF COVID-19 DEPLOYED PREVENTION & INTERVENTION MEASURES ON THE EPIDEMIOLOGY OF DIARRHEAL DISEASES AMONG THE ADOLESCENT AND ADULT AGE GROUPS 2018-2021 STUDY

Particularly in underdeveloped nations, diarrhea is the second most common cause of morbidity and mortality among children. There are 2.8 billion episodes of diarrhea among older children, adolescents, and adults, making it the third largest cause of death globally. Covid-19 outbreak was declared a public health emergency on 30th January 2020 and a pandemic on 11th March 2020 and a lot of public health preventions and control measures was deployed in attempt to curb the novel SARS-Cov2 transmission from person to person thereby reduce the incidences of the disease. The deployed interventions have not only been helpful in managing Covid-19 transmission rates, but also help reducing the cases of diseases with associated risk factors as personal hygiene, sanitation, contact handshake, movements & travelling restrictions, poor ventilation and overcrowding. This study aims to assess the contribution of the covid-19 deployed prevention & intervention measures on epidemiology of diarrheal diseases among the adolescent and adult population who are well oriented in time, space and place to adhere to covid-19 guidelines and diarrhea prevention before and during the covid-19 pandemic within Kisumu central sub-county, Kenya: from 2018-2021.

This is a cross sectional study design with intent to examining the shifting trend of diarrheal disease among adolescent (10-19 years by WHO) and adults (over 19 years) population within the Jaramogi Oginga Odinga Teaching and Referral Hospital in Kisumu central sub-county based on its capacity and services offered. Understanding the causes of diarrhea is crucial for both effective treatment and epidemiological surveillance. The study sets out to:

i. To determine the changes in trends of diarrhea based on the seasonality pre and during covid-19 pandemic in outpatients attending JOOTRH.
ii. To determine the prevalence of diarrhea based on adolescent and adults pre and during covid-19 pandemic in outpatients attending JOOTRH.

iii. To determine the influence of covid-19 containment measures on the changes in diarrhea trends in outpatients attending JOOTRH.

Key outpatient's variables of interest from 2018 to 2021 records include;

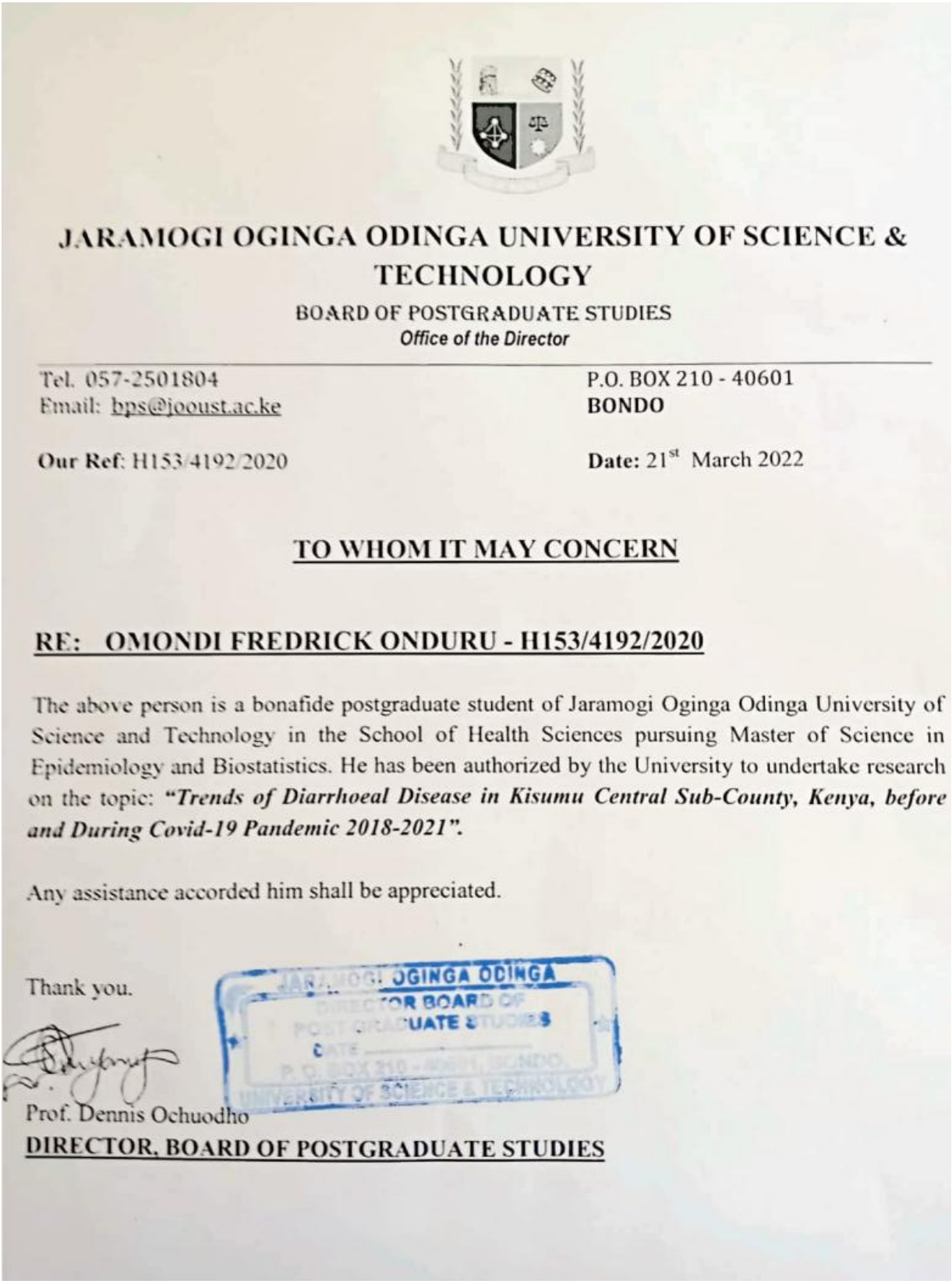
- The Sex/ gender of the outpatients.
- The patients Age or date of birth.
- Dates for visit / date of hospital visit - (which will aid to obtain diarrhea seasonality)
- Patient highest Level of Education
- Marital status of the patients
- Occupation (or source of income)
- Religion
- Diagnosis
- Any comorbidities if there any.
- Residence, i.e. ward, sub-county.

All Outpatient records for those who are 10 years and above from Jaramogi Oginga Odinga Referral Hospital will be abstracted from the record (2018-2021).

DATA RETRIVAL FORM.

Unique ID	**Sex**	**Date of Birth(Age)**	**Date of hospital visit**	**Level of Education**	**Marital status**	**Occupation**	**Religion**	**Diagnosis**	**Any comorbidity**	**Residence**

Appendix 4: School/Board of Post graduate approval



JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY

BOARD OF POSTGRADUATE STUDIES
Office of the Director

Tel. 057-2501804
Email: bps@jooust.ac.ke

P.O. BOX 210 - 40601
BONDO

Our Ref: H153/4192/2020

Date: 21st March 2022

TO WHOM IT MAY CONCERN

RE: OMONDI FREDRICK ONDURU - H153/4192/2020

The above person is a bonafide postgraduate student of Jaramogi Oginga Odinga University of Science and Technology in the School of Health Sciences pursuing Master of Science in Epidemiology and Biostatistics. He has been authorized by the University to undertake research on the topic: ***"Trends of Diarrhoeal Disease in Kisumu Central Sub-County, Kenya, before and During Covid-19 Pandemic 2018-2021".***

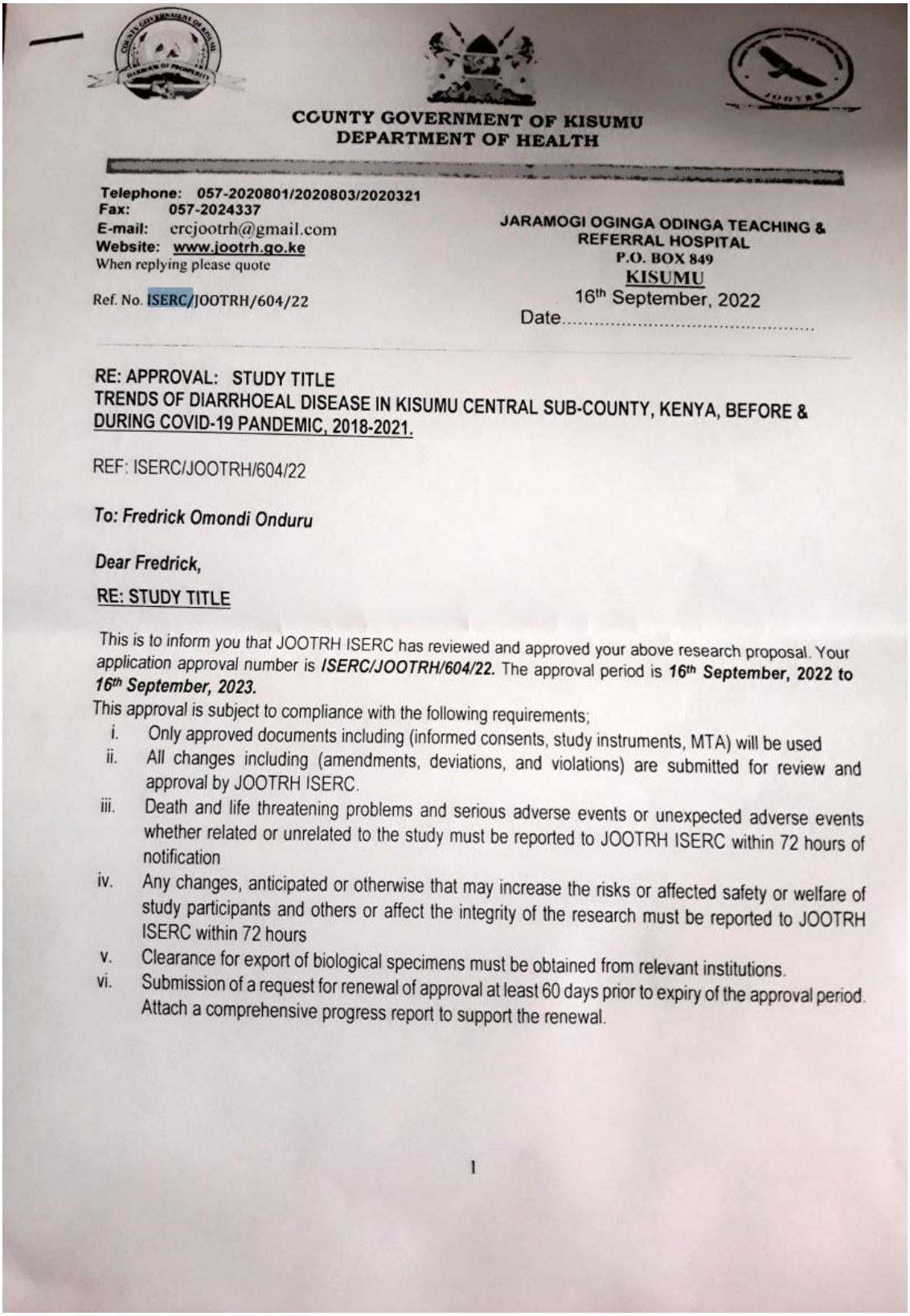
Any assistance accorded him shall be appreciated.

Thank you.

JARAMOGI OGINGA ODINGA
DIRECTOR BOARD OF
POST GRADUATE STUDIES
DATE
P. O. BOX 210 - 40601, BONDO
UNIVERSITY OF SCIENCE & TECHNOLOGY

Prof. Dennis Ochuodho
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

Appendix 5: Ethical approval from jootrh ISERC



COUNTY GOVERNMENT OF KISUMU
DEPARTMENT OF HEALTH

Telephone: 057-2020801/2020803/2020321
Fax: 057-2024337
E-mail: ercjootrh@gmail.com
Website: www.jootrh.go.ke
When replying please quote

JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL
P.O. BOX 849
KISUMU

Ref. No. ISERC/JOOTRH/604/22

Date 16th September, 2022

RE: APPROVAL: STUDY TITLE
TRENDS OF DIARRHOEAL DISEASE IN KISUMU CENTRAL SUB-COUNTY, KENYA, BEFORE & DURING COVID-19 PANDEMIC, 2018-2021.

REF: ISERC/JOOTRH/604/22

To: Fredrick Omondi Onduru

Dear Fredrick,

RE: STUDY TITLE

This is to inform you that JOOTRH ISERC has reviewed and approved your above research proposal. Your *application approval number is* ***ISERC/JOOTRH/604/22.*** The approval period is ***16th September, 2022 to 16th September, 2023.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by JOOTRH ISERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to JOOTRH ISERC within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to JOOTRH ISERC within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

1

vii. Submission of an executive summary report within 90 days upon completion of the study to JOOTRH ISERC.

viii. In case the study site is JOOTRH, kindly report to Chief Executive Officer before commencement of data collection.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

JOOTRH ETHICS & REVIEW COMMITTEE
P. O. Box 849 - 40100
KISUMU

ANTONY AYORA
SECRETARY – ISERC
JOOTRH - KISUMU

Appendix 6: NACOSTI Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **755658**

Date of Issue: **13/October/2022**

RESEARCH LICENSE

This is to Certify that Mr.. Fredrick Omondi Onduru of Jaramogi Oginga Odinga University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kisumu on the topic: TREND DIARRHOEAL DISEASES IN KISUMU CENTRAL SUB-COUNTY, KENYA, BEFORE for the period ending : 13/October/2023.

License No: **NACOSTI/P/22/20543**

755658

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)

Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

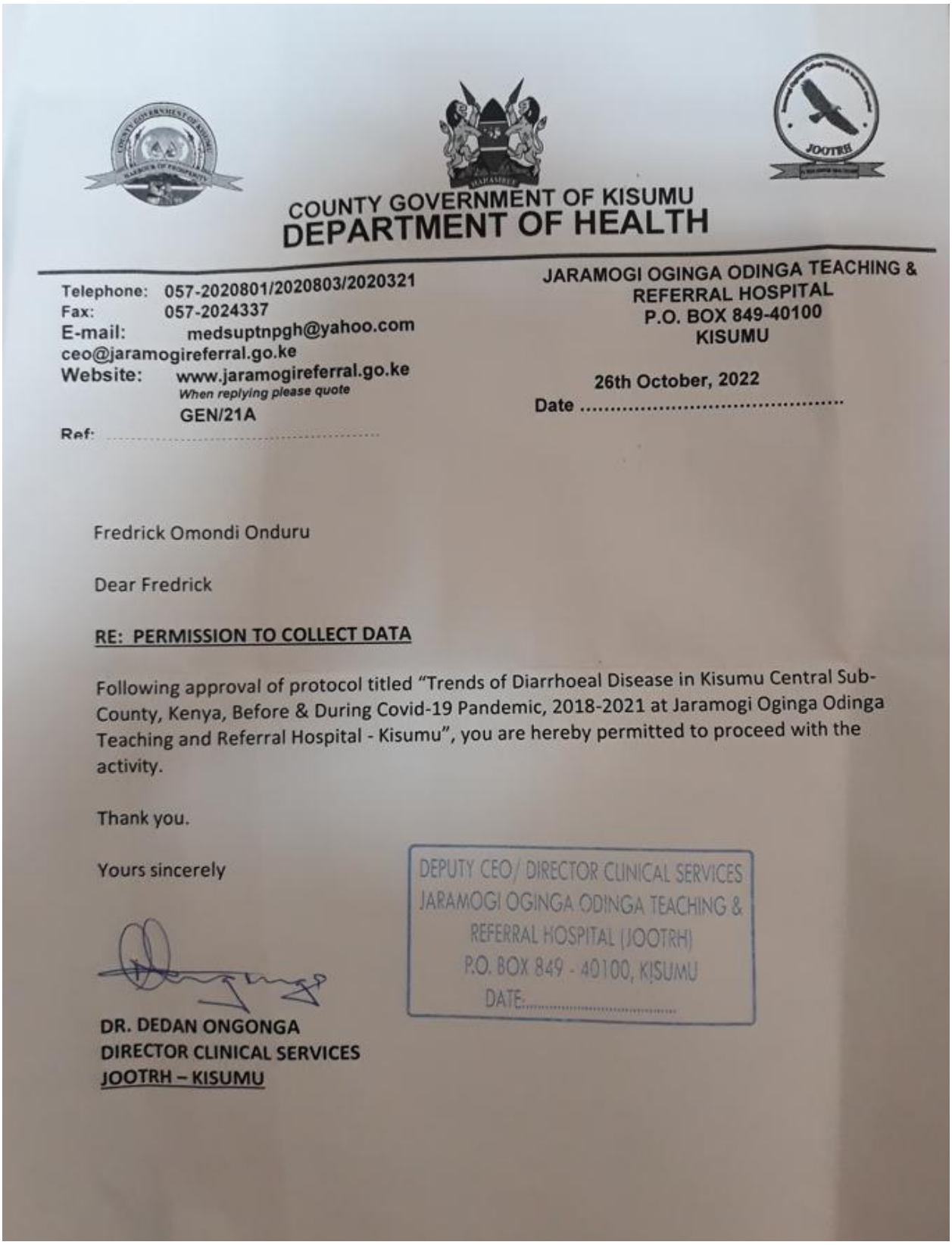
The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
    i. Endanger national security
    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
    vii. Endanger public safety and national cohesion
    viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix 7: Permission to Data Collection



COUNTY GOVERNMENT OF KISUMU
DEPARTMENT OF HEALTH

Telephone: 057-2020801/2020803/2020321
Fax: 057-2024337
E-mail: medsuptnpgh@yahoo.com
ceo@jaramogireferral.go.ke
Website: www.jaramogireferral.go.ke
When replying please quote
GEN/21A
Ref: .....

JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL
P.O. BOX 849-40100
KISUMU

26th October, 2022
Date .....

Fredrick Omondi Onduru

Dear Fredrick

RE: PERMISSION TO COLLECT DATA

Following approval of protocol titled "Trends of Diarrhoeal Disease in Kisumu Central Sub-County, Kenya, Before & During Covid-19 Pandemic, 2018-2021 at Jaramogi Oginga Odinga Teaching and Referral Hospital - Kisumu", you are hereby permitted to proceed with the activity.

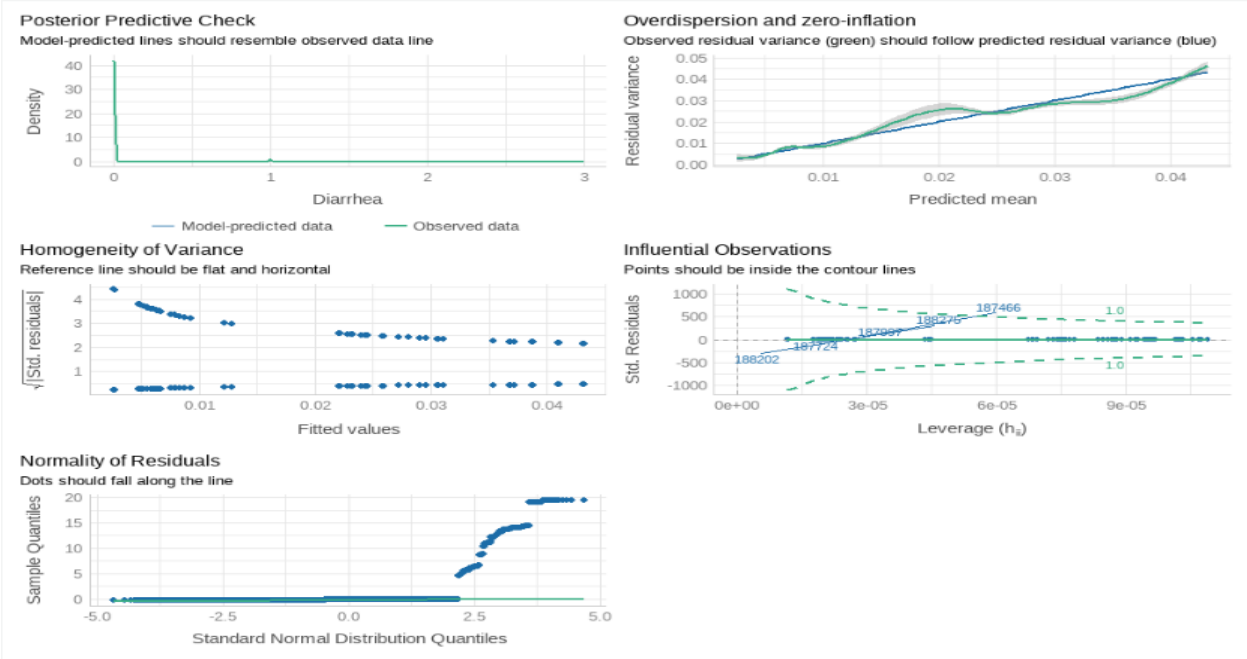
Thank you.

Yours sincerely

DEPUTY CEO/ DIRECTOR CLINICAL SERVICES
JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL (JOOTRH)
P.O. BOX 849 - 40100, KISUMU
DATE:.....

DR. DEDAN ONGONGA
DIRECTOR CLINICAL SERVICES
JOOTRH – KISUMU

Appendix 8: GLMM Poisson log link Assumption Check



Appendix 9: Bivariate analysis

Risk factors	IRR[1]	95% CI[1]	p-value
Covid			
During Covid	0.24	0.19, 0.30	<0.001
Age category			
Adults	1.00	0.94, 1.05	>0.9
Gender			
Male	0.93	0.88, 0.98	0.011
Months			
April	—	—	
January	1.38	1.24, 1.53	<0.001
February	1.09	0.97, 1.23	0.2
March	0.95	0.85, 1.07	0.4
May	1.05	0.94, 1.18	0.4
June	0.35	0.31, 0.40	<0.001
July	0.83	0.73, 0.93	0.002
August	0.80	0.70, 0.91	<0.001
September	0.73	0.65, 0.83	<0.001
October	1.18	1.06, 1.32	0.003
November	0.78	0.69, 0.89	<0.001
December	0.70	0.62, 0.79	<0.001
Years			
2018	—	—	
2019	0.46	0.43, 0.49	<0.001
2020	0.21	0.19, 0.23	<0.001
2021	0.13	0.11, 0.14	<0.001

[1]**IRR = Incidence Rate Ratio, CI = Confidence Interval**

Generalize Linear Mixed Effect Models-: Poisson regression (link = log).