FACTORS ASSOCIATED WITH MEASLES OUTBREAK AMONG CHILDREN BELOW 5 YEARS IN OLTEPESI LOCATION IN KAJIADO NORTH SUB COUNTY

EILEEN NAISIANOI SAWANI

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DECLARATION

This research project is my original work and has not been presented for a degree in any other university.

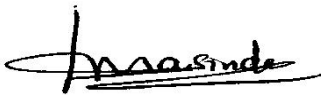
Signature---------- Date----------

Eileen Naisianoi Sawani

PHT-3-4713-3/2012

Supervisor

This research Thesis has been submitted for review with our approval as university supervisor.

Signature-----  Date 26th October 2022

Dr Lily Masinde

Kenya Methodist University

Department of Public health

DEDICATION

This work is dedicated to my beloved husband, Joseph and my three daughters, Naneu, Natasha and Shipae for their patience and moral support.

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I would like to extend my gratitude to Kenya Methodist University for the opportunity to undertake the Masters studies. This proposal would not have been possible without the help, support and patience of my Supervisors, Dr. Lily Masinde for the advice and unsurpassed knowledge. I would like to acknowledge the financial, academic and technical support of the Ministry of Health that provided the necessary financial support for the entire course.

ACRONYMS

AEIs:	Adverse Events of Interest (AEIs)
AFP:	Acute Flaccid Paralysis
BCG:	Bacillus Calmette-Guerin
DHIS:	District Health Information System
DPT	Diphtheria, Pertussis, and Tetanus
FIC:	Fully Immunized Child
GAVI:	Global Alliance for Vaccines and Immunization
GIVS:	Global Immunization Vision and Strategy
GOK:	Government of Kenya
IgM:	Immunoglobulin M
EPI:	Expanded Program on Immunization
KHIS:	Kenya Health Information Systems
LMICs:	Low and Middle-Income Countries
MCV1	Measles-Containing Vaccine
MMR	Measles, Mumps, and Rubella
MOH:	Ministry of Health
NACOSTI	National Commission for Science, Technology and Innovation
NIDs	National Immunization Days
ODK	Open Data Kit

QEs:	Quasi-Experimental Studies
RCTs:	Randomized Control Trial studies
RED:	Reaching Every District
S/CHMT	Sub/County Health Management Team
SIAs:	Supplementary immunization activities
UNICEF:	United Nations International Children's Fund
VMAHS:	Vital Medicines & Health Survey
WHO:	World Health Organization

ABSTRACT

Measles is a viral illness that has been demonstrated to be extremely contagious and to cause morbidity and death in both developing and industrialized nations but also one of the top vaccine-preventable diseases in the world. Kajiado has experienced several measles disease outbreaks before 2012 despite the FIC coverage of 80% slightly below the national coverage of 83% in the same year.

The objectives of this study was to find out the factors contributing to measles outbreak in Oltepesi in Kajiado North Sub County despite the good immunization coverage and an existing cold chain system. The specific objectives of the study included: establishing the role of health worker knowledge on the cold chain management, finding out the contribution of immunization coverage data accuracy, determining the socio-economic & demographic characteristics of the care givers associated with measles outbreak and to ascertain the unvaccinated population factors on measles outbreak.

This was a mixed method design which involved a mixture of retrospective case control study design of caregivers, quantitative, qualitative interview of facility staff and use of secondary data from the Kenya Health Information System (KHIS) for aggregate reporting and analysis, and the health facility records including the registers, tally sheets and reporting tools.

Findings: A quantitative study was conducted to identify factors affecting vaccine cold chain management related to measles outbreak. The health facilities were sampled randomly. Approximately 14.7% had indicated that their child was below 9 months compared to 1.1% of the respondents who indicated that their second child was below the same age limit. Knowledge and awareness of measles was significant [$x^2=7.021,\ p<0.05$] as there were few respondents in Oltepesi who were not aware of the measles vaccine. The results were significant [$x^2=7.72,\ p<0.05$] while on query if child was immunized against measles before the year 2012 [$x^2=6.684,\ p<0.05$] thus knowledge and awareness of measles vaccine is important in eradication of measles as well as adhering to the measles vaccination schedule. Utilization of the growth monitoring services at the two areas was significant. On the coverage of immunization in 2012 and it was established that coverage was low i.e. In January and February 15.8% and 16.7% while in the months of May, June, October and November, there were no data on immunization in Oltepesi and thus coverage was zero. Conclusion: According to the study, there is a knowledge gap and a scarcity of health professionals who work in cold chain management, and mentorship on cold chain management is urgently needed to increase understanding and practice. Recommendations: In accordance with the Kenya Expanded Program on Immunization (KEPI) objectives, the Ministry of Health should keep stepping up immunization efforts nationwide. Data cleaning and audit is necessary as the data in the KHIS might be giving false indicators to the world about health as a whole. This should be done periodically within the health systems. In order to stop any measles outbreaks and advance toward the eradication of the disease, it is imperative that the County implement enhanced ways to increase health workers' awareness of vaccine cold chain management and attain high vaccination coverage nationally.

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OPERATIONAL DEFINITIONS

Clinical case	Anyone who has a fever, a maculopapular rash (non-vesicular), a cough, a runny nose, or conjunctivitis (i.e. red eyes)
Routine measles Immunisations	The two doses of measles vaccine given to infants at 9 months and at 18months
Measles outbreak	This occurs when there are three or more measles suspected cases in a certain location, and these outbreaks occurred between 2011 and 2013.
Confirmed cases	There are probable instances with laboratory confirmation (positive IgM antibody) or epidemiological ties to confirmed patients in an epidemic.
Fully Immunized Child	This is a child who has already had BCG, three doses of the DPT vaccination, three doses of the polio vaccine, and one dose of the measles vaccine during the first year of life.
Measles death	This happens when a probable measles case passes away within 30 days of the rash developing.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Immunization is an available and a known cost-effective intervention that has been effective in reducing morbidity and death that is related to infectious diseases (Gidado et al., 2014).It is also one among many public health interventions that has shown significance outcomes in saving millions of children's lives across the world . The vaccines are known to be responsible for the eradication of many diseases to include measles in the global community (Rogie et al., 2013). In effort to eradicate the preventable infectious diseases, The Global Vaccine Action Plan was approved by the World Health Assembly to be implemented by 2015 in four WHO regions (Dabbagh et al., 2017). However, despite extensive use of measles vaccines, measles cases continued to due to a number of factors, including cold chain management.

Over time, new vaccines have been developed, particularly in the poor countries, but it is still difficult for cold chain systems to support vaccination programs effectively and guarantee the supply of safe and effective vaccines. (Ashok et al., 2017) and this compromises the efforts to eliminate the preventable diseases. Routine vaccination among the worlds' population have had changed as new vaccine regimens have also changed substantially causing new pressure on the already strained systems which has further inhibited the flow of all vaccines (Lee et al., 2016).

Although vaccination rates have increased dramatically in many nations, there are still discrepancies in immunization among the poorest groups, which more frequently face the brunt of the illnesses that can be prevented by vaccines (Sasaki et al., 2019) and this has been associated with existing obstacles to immunization like supply chain, human resources, and service delivery challenges which mostly affect poor rural communities more than the well-off communities.

Measles is known to be a highly contagious viral disease, which affects mostly children under the age of five years(Gupta et al., 2019). The World Health Organisation (WHO, 2015) report indicates that in spite of the fact that a secure and cost-free vaccination is readily available everywhere, measles remains one of the major causes of mortality in young children. Despite the availability of a reliable and efficient measles vaccination, an estimated 800 000 people die from the disease each year, largely children in impoverished nations. (Garly et al., 2003).

Even though vaccines are available, they still need to be stored in spaces that will keep them safe for use but some of the existing storage may compromise the effectiveness of the vaccine and this can lead to unprotected populations. These vaccinations must follow WHO recommendations for vaccine storage and the acceptable temperature range for vaccines in order for them to be safe and effective (Thakker & Woods, 1992).

According to Bogale et al. (2019), One of the most important elements in maintaining the vaccine's potency is the cold chain management system at all stages. Vaccines need

to be handled and stored properly at all times because of their heightened sensitivity to temperature and complex vaccination regimens. The whole process of handling vaccines mostly involves proper management of a cold chain system which requires vaccinations to be handled safely using tools, techniques, and materials that keep them within the appropriate temperature range from the moment they are created until they are given to patients (WHO, 2015). Further, the purpose of the vaccine cold chain is to ensure quality of vaccine from time of manufacturing until the point of administration vaccines by proper storage and transportation within WHO-recommended temperature ranges, (WHO, 2015).As seen overtime, populations and routine childhood vaccine schedules have changed considerably because the existing supply chains are relatively outdated and therefore introducing new vaccines may worsen existing challenges and further inhibiting the flow of all vaccines,(Brown et al., 2014)

Since vaccines are biological products that eventually lose their effectiveness, they must be stored at a temperature that is suitable for both the maker and the recipient (Kawai & Yokoyama, 2010). When combined with advances in storage and

transportation, demand projection systems have the ability to considerably raise vaccination demand while lowering logistical cost per dose (Haidari et al., 2017).

In a study done in Ethiopia, the level of training received, the type of training completed, the cash available for cold chain maintenance and the cold chain itself all indicated a notable correlation with vaccine cold chain management (Feyisa, 2021).

In 2001, the World Health Organization (WHO) estimated that about 30 million morbidity cases and over 700,000 mortalities from measles happen yearly in developing countries.

The Global immunization Vision Strategy(GIVs) had planned to offer vaccinations by keeping the rate of vaccinations coverage high from birth , among the underserved and those with lost chances (Brown et al., 2011) .These obligation of ensuring that vaccination programs are combined with other health treatments contributes to a nation's overall development, particularly in areas relating to health(Brown et al., 2011).Kenya being one of the priority countries for GIVs has a responsibility of ensuring the coverage of measles is sustained.

When immunization coverage is increased, the cases of measles reported reduce. This is evidenced by a study done in Nigeria where proportion of immunised cases with fever and a rash declined from 81% in 2007 to 42% in 2011, while the number of measles cases with laboratory confirmation rose to 53 from two in 2007 (Brown et al., 2011), the study further found that the majority of measles cases occurred in

children between the ages of 9 and 59 months as vaccine coverage declined. The WHO has identified measles as one of its top priority illnesses because reducing measles mortality is crucial to achieving Millennium Development Goal 4. The MDGs targeted to reduce overall under-five childhood mortalities by 2 thirds by 2015 and this was not achieved. Therefore, a crucial indicator for assessing the success of any vaccination objective is the level of routine measles vaccine coverage. According to WHO, (2015) it is noted that worldwide and in the African region, there is rise in premature deaths from the double burden of communicable and non-communicable diseases in this country which remains a major public health concern given that many of the causes are preventable.

Between January 1 and August 24th, 2013, 159 measles cases were recorded in the United States of America, with the majority of cases being detected in unvaccinated people (82%), or in those whose vaccination status was unclear (9%). ("MMR catch-up project launched to prevent further measles outbreaks," 2013). These outbreaks serve as evidence that high vaccination coverage is essential to stop the spread of measles and that unvaccinated individuals put themselves and their communities at risk for the disease. The study also noted that of the 42 recorded importations, 21 (or 50%) were from the European Region of the WHO. In Europe, Although the measles vaccine has been a part of standard paediatric immunization programs for more than 20 years, the disease still exists (Muscat et al., 2009) while in the Netherlands,

vaccination coverage is over 95%, but in spite of this, a measles outbreak are still observed (Fournet et al., 2018).

Despite the cessation of continual cases of measles in the United States, measles infections still arise among vulnerable people in California. According to research, significant measles epidemics can be avoided by conducting contact investigations and using modest contact rates. It was found out that large measles outbreaks can be prevented with contact investigations and moderate contact rates by either ensuring that people under the age of 18 have extremely high vaccination coverage (> 95%) and a moderate to low degree of immunity clustering (0.5), or a low risk of immune clustering for those under the age of 18, a short intervention delay, and a high likelihood that a contact can be tracked (Liu et al., 2015). The highest vaccination coverage with no immunity clustering for individuals under the age of 18 was also advised in order to prevent measles outbreaks with moderate contact rates; however, for individuals with high contact rates, even the highest coverage with no immunity clustering for those under the age of 18 was insufficient to completely prevent measles outbreaks. Three benchmarks for 2015 were also put in place by the World Health Assembly: 1) reach 90% nationwide and 80% in every district for children under 1 years old who are routinely immunized with the first dose of the measles-containing vaccine (MCV1); 2) lower the annual incidence of measles worldwide to

5 cases per million; and 3) reduce the mortality rate of measles worldwide by 95% from the 2000 estimate (Dabbagh et al., 2017).

In order to ensure effective immunization programs around the world, the Expanded Program on Immunization (EPI) was founded in 1974. In 1977, the program's goal was set to provide every child with access to diphtheria, pertussis, tetanus, poliomyelitis, measles, and tuberculosis vaccination by the year 1990 (Keja et al., 1988). Kenya has been implementing a successful routine vaccination over the last 30 years, with achievement of high targets in most of its sub Counties and has been conducting active case based surveillance for measles in an effort to achieve herd immunity for each of the vaccine preventable diseases,(Centers for Disease Control and Prevention [CDC], 2012). This has been possible through the Expanded Program on Immunization (EPI) in Kenya.

Unreliable data may taint the real picture of immunization coverage in any given situation. It was found out that lack of reliable population data in during the surveillance can make it difficult to estimate the attack rates according to a study done in Katanga, Congo (N'goran et al., 2013)

The Kenyan immunization schedule, which had been in place until July 2013, called for giving infants one dose of the measles vaccine at the age of nine months and a second dose through supplemental immunization activities (SIAs). However, this schedule has since been changed to give children two doses of the vaccine on a

regular basis: the first dose is given at the age of nine months, and the second dose is given at the age of eighteen months. According to a research conducted in Kilifi, the Kenyan EPI reaches virtually all of the local children, and this information suggests that there were minimal immunization delays, indicating that vaccinations will have the greatest impact possible on the morbidity and death of young children (Moïsi et al., 2010). In management of the vaccines, it is required that a health worker undergoes a basic training on EPI and it's an assumption that all staff handling the vaccines is knowledgeable about them. Furthermore, a study done in Ethiopia found out that improving knowledge, practice on cold chain management through supportive supervision ,training and provision of equipment is necessary to avoid losing potency of vaccines(Bogale et al., 2019). This is therefore to confirm the need to have a well-managed cold chain system across the health systems.

The World Health Organization and partners launched the RED strategy (Reaching every district) in Kenya in 2002 in an effort to come up with a creative plan to improve the stagnant immunization coverage and effectiveness in Africa. This effort is just one of many that the nation has made to ensure high immunization coverage. But during the last three years, the nation has seen recurrent outbreaks of illnesses that may be prevented by vaccination, primarily measles, polio, and pertussis.

Kenya has been having a measles outbreak since December 2010 and Kajiado North sub County was not left out. In 2011, a total of 665 lab confirmed cases were

reported while 767 have been confirmed in 2012 in Kenya (WHO, 2015). The report further states that in 2012, a total of 45/47 counties and 217/285 Sub Counties have reported cases leading to a total of 31deaths in 2012. Since the beginning of the year 2011 up to the week 37, there were 3,704 confirmed measles cases reported from all the provinces, however the bulk (83% of cases in those 3 provinces) were found in just 8 sub counties in the North Eastern province, Nairobi, and Rift Valley. (Turkana North, Nairobi North, Mandera West, Mandera East, Loitoktok, Lagdera, Kajiado North and Garissa)" (CDC,2012).

Kajiado North has been implementing immunization routinely and also participates in National Immunization Days (NIDs) and the measles vaccine is one of the antigens provided routinely. Between 2010 & 2013, Kajiado North Sub County has had a measles coverage of more than 85%. This coverage under normal circumstances would mean that the sub county has achieved the 90%:80% strategy by WHO in all AFRO countries. In effort to curb the outbreaks the country through EPI conducted a week-long measles mop up immunization in the most affected sub county in September 2012.There were still measles cases that were reported in Kajiado North sub county even after the National immunization campaigns which raises the questions to why this is happening and yet the coverage is high and also the campaigns have been done in the sub county.

With a projected population of 445,570 as of the 2009 census and a growth rate of 3.6%, Kajiado North Sub County has a square area of 6344.9 km2.The populations in the sub county are mostly concentrated in urban parts of the sub county as opposed to the rural areas. The sub county had 143 health facilities of which 36 are GOK while 104 are private facilities (Ministry of Health Kenya,[MoH], 2022). For any of the facilities to qualify as an immunizing facility it should have qualified health workers, a functional cold chain with a vaccine's refrigerator, ice packs, vaccine carriers and reliable source of power which can be electricity, Gas or solar. When a vaccine is shipped, stored, and handled from the producer to the point where it is administered to the customer, the cold chain is employed to guarantee that the vaccine is kept in the best possible circumstances. The equipment and maintenance of the cold chain are essential components of measles vaccination. There are required temperatures that must be maintained throughout the various cold chain systems. The ideal temperature ranges for vaccinations stored in refrigerators is 2°C to 8°C, whereas the ideal range for vaccines stored in freezers is -15°C or below.

The study area has 2 health facilities and these facilities that provide the routine immunization in the Location with health workers allocated duties to provide the vaccines and other services to the catchment populations for both the facilities. The health facilities are provided with the vaccines on monthly basis by the Division of Vaccines and Immunization through the sub county stores during reporting period.

The facilities are expected to do monthly summary reports to present to the sub county stores before they can be allocated vaccines for the month.

The routine immunization at the facilities is part of the KEPI strategies to ensure reaching all the children under one year with vaccines and this is also done through ongoing, fixed and outreach services to specific target groups. This then enables the population to access the measles vaccines from the facilities. Despite this, there have been cases of measles reported in the sub county to include the areas that provide the antigens.

The goal of the study is to determine if improper vaccine cold chain management may be a factor in the periodic measles outbreaks in Kajiado North Sub County, which have persisted despite consistently high rates of measles vaccination with a single dose.

1.2 Statement of the problem

In Kenya, the expanded program on immunization (KEPI) was launched between 1974 and 1980 and this was meant to accelerate the routine immunization in the Country. The Fully Immunised child (FIC) in Kajiado County was 80% in 2012 compared to the National coverage of 83% and this was showed by the (Kenya Health Information System [KHIS], 2012). According to the System, the coverage of measles immunization was above 80%, with a well maintained old chain systems in all facilities but despite this, there are still frequent measles outbreaks in the sub

county. Additionally, in Kajiado North immunization services, like other primary health services, services are given at no cost. This study aims to identify factors that led to measles outbreaks in the area of study despite the favourable indicators.

1.3 Research Objectives

1.3.1 Broad objective

To identify the causes of the measles epidemic in children under the age of five in the Oltepesi and Oloolua sites of the Kajiado north Sub County.

1.3.2 Specific Objectives

1. To ascertain the role that health worker knowledge of cold chain management aspects
2. To find out the influence of accuracy of data on immunization coverage
3. To ascertain the influence of the unvaccinated population on measles outbreak.
4. To determine the socio demographic characteristics of the care givers associated with measles outbreak

1.4 Research Question

1. What were the health worker knowledge on vaccine cold chain management?
2. How accurate were the immunization data in the Kajiado North sub county?
3. Did the unvaccinated population influence the measles outbreaks?
4. What were the socio demographic characteristics of the care givers of the under five children

1.5 Justification of the study

Many studies have been done to establish the factors contributing to increased measles outbreak among children under five years both in Kenya and globally, however these studies have been limited to selected areas in the country and none has been done in Kajiado North. The purpose of this research is to identify the factors contributing to the measles epidemic in Kajiado North. The knowledge and information that will be obtained from the study is of importance to the County as this will enable the County department of health to provide guidance on management of the vaccine cold chain systems, establish the knowledge gap among the health workers providing routine immunisation services in all service delivery points and subsequently be able to prevent future measles out breaks in Kajiado. The results obtained from the study would be disseminated through the County health management team, the Sub county health department and the community leadership. Since there is no such a study done in this area, the study will enable the county health systems to be prepared in the event of new emerging diseases that can be prevented through immunization.

1.6 Significance of the Study

The results of this study have implications for both prevention and control of measles outbreak and prevent re-emergence of communicable diseases in Kajiado, and will be used to educate the community on the factors associated with measles outbreak and

how to prevent at the community levels. These findings should also assist policy makers at the national government, the county government and the Non-Governmental Organisation (NGOs) working within the disease control and prevention spaces in the health systems to improve on the decision making on matters relevant in resource mobilization for immunization. The findings could also help policymakers implement better measles immunization in the county by bridging the knowledge gap among healthcare professionals and enhancing vaccine cold chain management in the basic healthcare institutions that offer routine immunizations by aligning the cold chain systems to the acceptable standards as put by WHO and reaching the hard to reach communities especially with education on immunization. This result will eventually ensure that the clients receive potent vaccines that they need at service delivery points across the County.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter will address the factors associated with measles outbreaks. The study is focused on four main factors: Vaccine Cold chain management factors, the effect of unvaccinated children, Health care knowledge and the data accuracy factors associated with measles outbreak. One of the most important prerequisite in ensuring that immunization is of quality, vaccine efficacy and safety is cold chain monitoring. In this regard, appropriate steps must be taken to guarantee that the nation's vaccination cold chain is being monitored (Ateudjieu et al., 2013). For any country to succeed in elimination of measles disease, there is need for improved implementation of elimination strategies with focus on increasing vaccination coverage, ensuring a working cold chain systems is significant and also by ensuring a continued additional funds in the health system. Strengthening health surveillance systems, use of surveillance data to make decision, advocating for political commitment, and raising the prominence of measles elimination goals has a direct effect on the general running of the health systems and subsequently improves immunization coverage and reduces outbreaks to include measles outbreaks.

Additionally, measles continues to be a serious, vaccine-preventable cause of mortality in underdeveloped countries across the globe despite the fact that immunization is still being conducted in the said countries. It has been determined that the gap in coverage between the hard-to-reach community and the rest of the general population is the cause of the measles outbreaks that are sometimes considered to affect vulnerable populations due to unvaccinated youngsters. The coverage gap was discovered to affect vulnerable populations in difficult-to-reach locations primarily, such as poor rural children or members of underprivileged minorities (Zheng et al., 2015)

The achievement and maintenance of high measles vaccine coverage have proven difficult due to weak health systems, environmental obstacles, cultural obstacles, and economic hurdles in reaching particular population segments, as well as insufficient monitoring and data usage for action. Improved regular and mass vaccination campaign implementation and monitoring are urgently needed in the areas attempting to eradicate measles and manage rubella (Cutts et al., 2013)

Following measles disease outbreak in the tropics with many contributing elements, vaccines failure is an important concern as this may be as a result of contact to natural infections and subsequently recurrent disease outbreaks and not necessarily as a result of lack of immunization (Kizito et al., 2013).

Further, there are four risk events that have the greatest impact on the functionality of the cold chain system which include: transportation, equipment failure, high temperatures and distribution and are the most influential factors of a failed cold chain (Zheng et al., 2021)

By making sure that vaccines are transported and kept within the temperature limits established by the World Health Organization, the vaccine cold chain's goal is to ensure vaccine quality from the point of manufacturing till the site of delivery (WHO, 2015). In order for vaccines to be effective, they must be supplied through a carefully monitored cold chain environment that may provide the user a dose of the vaccine that is at its peak potency, (Zheng et al., 2021)

Management of vaccine cold chain requires a good functionality of cold chain equipment, proper health worker knowledge on management of the systems, good transportation of the vaccines to various levels of care and proper temperature within which the vaccines are to be maintained (van den Ent et al., 2017). The gap in vaccination coverage between hard-to-reach persons and the rest of the general population has been implicated as the cause of the measles outbreaks that are sometimes assumed to affect vulnerable groups, notably impoverished rural children and minority populations (Zheng et al., 2015)

The rapid advancement of vaccine development is a significant milestone in the fight against disease outbreaks, but it may not be feasible given that it depends on the

effectiveness of immunization strategies (Degavi et al., 2021). This is due to the need to address issues with the equipment for vaccine storage and delivery, establishing immunizations programs, and public acceptance of vaccines.

The methodologies of working on the trustworthiness of the immunization cold chain framework incorporate yet not restricted to, eliminate the hindrances in keeping an antibody production network, which can be moved toward by a blend of three techniques: forestalling antibody freezing ,one way being by utilizing cold water packs rather than ice packs for transport; utilization of compelling temperature screens that can go on each vial of immunization from the time it leaves the producer until it arrives at the recipient; and by better control and guideline of the inventory network,(Kartoglu & Milstien, 2014)

A research conducted in Keffa Zone, Ethiopia, revealed that a measles outbreak mostly affected children under the age of five and that poor vaccination rates and inadequate cold storage facilities most likely contributed to the outbreak (Woyessa & Said, 2012), this basically showed that an outbreak can occur as a result of breakdown of a cold chain system.

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In cold chain management, there various factors that affect the running of the cold chain to include, management of stock, delivering of the vaccines to various depots and also looking at the capacity of the fridge to handle the vaccines, whilst this is expected to be done smoothly, in some areas this is not well covered further burdening the situation in the ineffective vaccines emergency-ordering systems (Ngcobo & Kamupira, 2017). The quality of the cold chain and invalid doses of immunization medicines determine the success the incidences of immunization preventable disease cases in a given population (Lusita et al., 2021)

According to Maglasang et al. (2018), appropriate cold chain management is the cornerstone of vaccine safety and quality in any nation's immunization system. Inappropriate handling of vaccines has been acknowledged as one of the major causes for the reduction in potency of vaccine at the time of administration (WHO, 2015). The storage and transportation of vaccines from the principal vaccine stockpile down to the end-user at the health facility, and even farther down at the outreach locations, must be carefully considered in order to maintain the vaccinations' maximum efficacy (Milstien et al., 2006). Access to immunization differs across the world and this dictates how the coverage in the country’s

populations. The only way to boost vaccination coverage is to ensure that the necessary vaccines can reach the population that is being immunized, but it appears that in low- and middle-income nations this is not always the case, this has mainly been a challenge that is yet to be resolved and therefore affecting the immunization coverage in the low and middle-income countries. (De Boeck et al., 2019).

According to Chen et al. (2014), deficiencies in the cold chain supply for the Expanded Program on Immunization (EPI) vaccines are a major concern in a number of developing countries. As a result, there is a major interest in these countries in developing tools to assess and discover methods of how vaccines are distributed.

The measles vaccination is one of several publicly sponsored vaccines and testing solutions that must be maintained between 2°C and 8°C to retain potency, according to Hibbs et al. (2018). Fundamental components of measles vaccination include cold chain maintenance and the associated equipment. In underdeveloped nations with tropical temperatures, the cold chain continues to be a particularly susceptible area for national vaccination efforts.

As per a report from the Center for Disease Control and Prevention (CDC), experts working in clinical placement may not be handling vaccines as per the set standards, which could result in insufficient immunity in those who have received vaccinations (Rogers et al., 2010). This prevents vaccine from being stored and handled in a proper cold chain.

Immunizations are acclaimed as one of the most significant public health measures ever, saving millions of lives each year. High vaccine coverage rates are needed to meet current disease eradication and elimination goals. To guarantee that effective vaccinations reach their intended population in an equal and timely way, a working cold chain is essential (Yakum et al., 2015)

The most frequent causes of vaccine deterioration are vaccinations that are left out of the refrigerator for an extended period of time and refrigerators with extreme temperatures for vaccine storage; transportation of vaccines, equipment functionality and temperatures set on the refrigeration.

The effectiveness of immunization against measles depends on the health worker's knowledge of cold chain maintenance. The study's findings, according to Dairo and Osizimete, (2016) emphasized that in order to maintain the integrity of the vaccine cold chain, it was important to emphasize the need of using general practice nurses in that setting. It was also encouraged for those nurses to become authorized immunizers so they could take part in continuous vaccination education.

Only 16 of the 40 respondents in another study on the cold chain maintenance in relation to staff knowledge were knowledgeable about the ideal storage conditions for vaccines; eight had minimum and maximum thermometers, but only one of these was monitored daily; and in six of the eight practices chosen for monitoring of refrigeration temperatures, only one of these thermometers was used. The

vaccinations were placed in either below freezing temperatures (three freezers) or as high as 16 degrees Celsius (three). Two of them were specialized refrigerators for medication storage that included an internal thermostat and exterior temperature gauges (Thakker & Woods, 1992). This study proves that without clinic employees following the suggested rules, safe vaccination storage cannot be guaranteed.

The measles epidemic in Zimbabwe is mostly caused by the cold chain and this is because it hampers provision of immunization services, (Pomerai et al., 2012). According to Vangroenweghe, (2017) it was found out that most health personnel were not trained on EPI and thus not able to manage the cold chain and this compromises the quality of vaccines.

According to Hanson et al. (2017), it was claimed that there were recurring problems with vaccinations being exposed to temperatures below acceptable ranges during different parts of the cold chain. They attributed these problems to health professionals' ignorance of vaccine freeze damage and how it affects temperature monitoring. More specifically, “The knowledge, mind-set, and behaviour of vaccine administers and handlers will be improved by regularly offering technical assistance and on-the-job training on vaccine cold chain management.”(Mohammed et al., 2021).

2.1.1 Health workers' knowledge on vaccine cold chain management

2.1.1.1 Cold chain management

The term "cold chain vaccine management" refers to the process of making sure that vaccines are safe and that handling procedures are also safe. This process entails materials, tools, and precautions that keep vaccines within the acceptable temperature range from the point at which they are produced to the point at which they are administered to recipients. By ensuring that vaccines are transported and kept within the WHO-recommended temperature limits, the vaccine cold chain also aims to ensure vaccine quality from the point of manufacturing till the site of administration., (WHO, 2015) and vaccinations must be administered through a carefully monitored cold chain environment, which must be able to provide the user with a vaccine that is both safe and effective (Degavi et al., 2021).

Vaccines are to be maintained within certain temperatures which are to be done through a cold chain system. The advent of new, more expensive vaccinations that run the danger of being damaged by heat and/or frost exposure has made it more crucial than ever to find a solution for the difficulty of transporting and storing vaccines at chilled temperatures (2-8 °C) and that all together might be too much for many countries' already inadequate cold-chain systems to handle.(Zaffran et al, 2013).

The newly introduced vaccinations in the cold chain may not be sufficient without competent, well-managed logistics systems that guarantee adequate storage capacity, distribution of sufficient quantities of vaccines, and effective cold storage equipment (Anderson et al., 2014).

For distant sites, where access to electricity, communication, and transportation is difficult and expensive, there are unique difficulties. In order to provide the people who need life-saving vaccinations with them, accurate information regarding immunization programs in low and middle-income countries (LMICs) must overcome a number of obstacles that include transportation among others. (Haidari et al., 2016).

The effectiveness of freeze-sensitive vaccines may be reduced by exposure to temperatures below those suggested for the cold chain, which might result in a loss of vaccination investments and put kids at risk of developing diseases that are preventable by vaccines. Studies have identified that transportation of vaccines has played a major failure in cold chain maintenance. It is in this view that the study would focus on the importance of quality, distribution and storage of the vaccines that are used during the routine immunization and during the national immunizations days. (Gupta et al., 2011) In a study of the causes of measles epidemics in Kangra district of North India found out that health workers can only work effectively if sufficient supplies (vaccines, supplements and medicines) are available when they

need them and therefore transporting the vaccines to place of work is an integral part in cold chain .

In low cost cold chain management systems, adequate cold chain systems with higher storage and transit frequency result in an increase in the number of vaccine doses that are administered successfully and a 34% reduction in the logistical cost per dose, (Haidari et al., 2013). Additionally, a lot of focus is frequently placed on stationary storage of the vaccines at all levels in order to solve the pressing job of enhancing vaccine supply chains, particularly to accommodate the introduction of new vaccinations. There is a knowledge gap among health professionals working in cold chain management, according to a study conducted in Ethiopia. This suggests the need for better supervision and training at various levels of the health care system in order to improve knowledge and practice on cold chain management (Bogale et al., 2019).

2.1.1.1.1 Equipment Functionality

To guarantee that the vaccinations are safe throughout transport and storage, the proper temperatures must be maintained. At the place of storage, freezers and refrigerators are used, as well as refrigeration in trucks and cool boxes while the goods are being transported. A effective vaccination program includes the provision of suitable equipment as well as staff training in maintaining the "cold chain" and the usage and upkeep of equipment (Thakker & Woods, 1992)

A Vital Medicines and Health Survey (VMAHS Round 4) performed in December 2009 in Zimbabwe, which assessed 1286 health facilities that administer vaccination, indicated that over 20% of health facilities do not have working cold chain equipment (refrigerators), which impeded immunization, even though there was 95% vaccination coverage, cold chain was still one of the major factors for the measles outbreak (Yeung et al., 2005). In a study done in India, it was found out that gaps in knowledge of health workers on the management of the equipment with issues related to the beneficiary precipitated outbreaks in India (Gupta et al., 2011).

2.1.1.1.2 Temperatures

The "cold chain" of vaccines works to maintain vaccine quality from the point of manufacturing till the site of administration by ensuring that vaccines are transported and kept within the ranges of temperatures authorized by the World Health Organization (WHO, 2015). According to some studies done, the effectiveness of freeze-sensitive vaccines may be reduced by exposure to temperatures below those suggested for the cold chain, which might result in a loss of vaccination investments and put kids at risk of developing diseases that are preventable by vaccines. (Hanson, et al., 2017). The day to day functioning of a cold chain system has an important effect on the quality of vaccines, but the service delivery process is one that requires monitoring as there are other potential problems such as vaccines loss and irregular

cold storage temperature in the actual operation which affect the potency of the vaccines (Zheng et al., 2021)

The refrigerators are an important aspect of vaccine infrastructure as the vaccines are kept with certain temperatures that are favourable to the vaccines. It has been found out that in many countries, one of the common factors preventing access to effective immunization is the existing cold chain and logistics systems gaps (Anderson et al., 2014). With the introduction of new, more expensive vaccines, it is becoming more crucial than ever to prevent vaccine potency loss during storage and handling, which in at least 1(one) situation necessitates a different storage strategy. The refrigerators used at various levels may run on gas, electricity, or solar power. Large portions of many developing nations lack grid energy, which presents a significant problem that jeopardizes the stability of the vaccination cold chain (McCarney et al., 2013). Other important elements in the cold chain include transportation of vaccines and the dosage given to the clients and proper temperatures need to be maintained throughout.

2.1.2. Coverage of Unvaccinated Children

2.1.23.1 Decreased immunization coverage

Whenever there is decreased measles immunization coverage in any given population, it amounts to an increased number of unvaccinated children, (Pomerai et al., 2012). The unvaccinated population could be as a result of handling the vaccines by the provider, gaps in vaccines potency or an increase in non-vaccinated population. A

study done in Ahmara, Ethopia revealed that there was a knowledge gap and practitioners were significantly associated with vaccine cold chain management practice that may jeopardize maintaining vaccine quality. Of the health care workers, 35 (58.3%) had the necessary skills and knowledge for cold chain management of vaccines, while the remaining 25 (41.7%) did not (Montasser & Helal, 2016). According to the Afro Regional committee, fifty-ninth session, of 2009 even with their SIAs for mopping up and following up, certain nations still have reasonably large outbreaks. It was further noted that Nigeria (2008) reported a total of 9415 confirmed measles cases, and most were unvaccinated young children. These unvaccinated children then create a pool of a population that is susceptible to measles and measles disease tends to spread quickly especially when unvaccinated children come into contact with infected children,(Gao et al., 2013). Similarly, the more people who receive vaccinations, the fewer measles cases are reported; this is demonstrated in Nigeria, where cases with febrile rash and a history of vaccination dropped from 81% in 2007 to 42% in 2011, but laboratory-confirmed cases of measles rose from two in 2007 to 53 in 2011 (Umeh & Ahaneku, 2013). The measles epidemic occurred within the age range when vaccine coverage fell, demonstrating the need for increased vaccination rates for measles in children under the age of five. The attack rates among unprotected and fully vaccinated pupils were 82% and 4.8%, respectively, according to a research that compared the danger of measles in those

who had received vaccinations and those who had not (De Serres et al., 2012). Additionally, it is discovered that, despite widespread vaccination, measles outbreaks can occur among groups of children who have purposefully chosen not to receive the recommended dosage, incurring significant costs for public health organizations, healthcare systems, and families. Additionally, rising rates of purposeful under vaccination can jeopardize the goal of measles eradication (Sugerman et al., 2010).

According to a study conducted in Brazil to find out the causes of Brazil's low measles vaccination, Rocha et al.(2015) found out that after correction for confounding factors, Socioeconomic, maternal, nutritional, and access to healthcare facilities were shown to be significant in 1987 (with a vaccine coverage of 48.2%), whereas nutritional and maternal variables were significant in 2007 (with a vaccination coverage of 96.7%) and due to the low vaccination rates in 1987, there is currently a pool of individuals who were not inoculated as children; this may have led to the start of the current outbreak in Brazil.

According to Girmay and Dadi, (2019) in Ethopia, , the analysis showed that individuals who had received a previous dose of measles vaccination lowered the chances of contracting the measles disease by 83% (AOR, 95%CI = 0.17, 0.05-0.53) and a 3.44-times higher risk of measles infection was associated with previous contact history (AOR, 95%CI = 3.44, 1.26-9.38)", and a similar study done in Indonesia revealed that the two risk factors for measles infection are not having had a

measles vaccine and having a history of contacts (Haidari et al., 2017). According to a study done showed that an increase in the number of measles-susceptible kids who weren't immunized was likely what led to the area's measles outbreaks to resume. The efficiency of the vaccines studied in this study does not support the idea that vaccination failure might be a significant factor (Feyisa., 2021)

A study done in Nigeria Virus Infection among Vaccinated and Unvaccinated Children revealed that a significant number of kids are still contracting measles regardless of their vaccination status, despite the nation's continuous immunization effort (Faneye et al., 2015). Further, a study done in Yemen indicated that the clients that had contact with measles cases in the study areas were found to have been un-vaccinated and this was the probable indication that the infected clients were the potential contributing factors of measles outbreak in Yemen (Hibbs et al., 2018).

According to Sudfeld et al. (2010), The analysis found 3 (three) measles vaccine RCTs and 2 QE studies containing information on measles illness prevention. A meta-analysis of these studies revealed that vaccination was 85% [95% confidence interval (CI) 83-87] successful in avoiding measles illness, which will be used as a proxy for measles mortality in nations that vaccinate children before the age of one Additionally, according to the literature, when immunizing at age 1 or later, a conservative impact estimate of 95% is appropriate to use, and for two doses of the vaccine based on serology studies, a cautious estimate of 98% is suitable.

To counteract the increase in unvaccinated children within a population, it is necessary to have an alternative intervention in the immunization areas. According to Vijayaraghavan et al. (2007), In Kenya, SIAs enhanced both coverage and equity, obtaining considerably greater coverage in all areas with regular measles vaccination coverage lower than 80%, reaching a significant portion of zero-dose children in these provinces, and reaching more kids from the poorest families, Additionally, the same research revealed that generally according to a 2002 SIA, Kenya's measles vaccination coverage and equity increased, reducing the immunity gap between families from both affluent and underprivileged backgrounds .Measles SIAs offer a perfect setting for implementing additional child health treatments that can save lives. This is also corroborated by research by Braeye et al. (2013), which indicated that vaccination campaigns restricted the transmission of the measles within schools where there are concentrated populations but were unable to stop it from spreading to family members who have not received vaccinations. It's also crucial to keep in mind that the effectiveness of national measles vaccination campaigns is strongly correlated with the overall impact of the disease (Colzani et al., 2014). In addition, Patients who were either vaccinated or unvaccinated were mixed together in congested health facilities, which contributed to the spread of the measles during the epidemic in Uganda (Nsubuga et al., 2018)

Children who weren't vaccinated had a higher prevalence of dehydration and were more likely to be stunted, underweight, and wasted (some or severe dehydration) (28% vs 22%, p<0.001), required lengthier period of time (>72 h) of hospitalization (15% vs 10%, p<0.001), had more frequently abnormal lung sounds that were suggestive of lower respiratory tract infections (8% vs 5%, p<0.001)",(Chowdhury et al., 2006) and that low routine Immunization coverage do result in a wide-spread measles outbreak (Girmay & Dadi, ,2019)

In study conducted in Zaka, Masvingo Province, Zimbabwe Umeh and Ahaneku,(2013), found out that being unprotected against the measles (AOR= 3.96, 95% CI (2.58-6.08)), having contact with a measles case (AOR= 41.14, 95% CI (7.47-226.5), and not obtaining further doses of the measles vaccination (AOR 5.48, 95% CI (2.16-11.08)) were all independent risk factors for catching the disease. The Zaka district had a 75% immunization rate against the measles, indicating that a significant number of unvaccinated kids were the cause of the epidemic.

Another factor in the increased number of unvaccinated children is an issue in clustering especially in areas where there are high populations like schools. The concentration of unvaccinated people in groups, such as in schools, promotes measles outbreaks and is a significant barrier to the eradication of measles (Braeye et al., 2013). A vaccination program controlled the measles outbreak in schools but was unable to stop it from spreading to unprotected family members. Among the health

care workers providing immunization, knowledge on preparation of the vaccines determines the efficacy of the vaccine by the time the vaccine is given to the client. At nine months old, the first dose of the measles vaccine has an effectiveness rate of 85%. Over time, a small number of community members who are susceptible to the disease gradually increase. Since not all children receive the measles vaccine, such accumulations are often brought about by the combination of this and the recurrent outbreaks that result from the disease. Dairo and Osizimete, (2016) indicated that one of the main causes of the vaccine's potency waning when given to recipients has been shown to be improper handling of vaccinations along the cold chain, additionally, the study found that measles vaccinations are not exempt from this phenomenon because potency loss is also visible in immunized people who contract the measles infections that the immunizations were designed to prevent.

Depending on cold chain management and maintenance the vaccine efficacy may differ. In a study done in India it was found out that the vaccine efficacy was 84% in Himachal Pradesh, in West Bengal, it was 66% in 2005 and 81% (95% CI, 67%-89%) in 2006 (Murhekar et al., 2011)

The effectiveness of the vaccinations can be impacted by many factors in addition to their 85% efficacy. The majority of cases of measles occurred in children between the ages of 9 and 59 months as vaccine coverage declined. Accordingly, efforts

should be made to enhance measles immunization in this age range (Umeh & Ahaneku, 2013).

Vitamin A is an essential nutrient needed in smaller amounts for normal visual and immune functions, the maintenance of epithelial cellular integrity, growth, and development. Recent studies show that vitamin A levels decrease during measles and that vitamin A therapy can improve measles outcome in children in the developing world and as a result child with low vitamin A levels had lower measles-specific antibody levels (Frieden et al., 1992). The data gathered from a study on Vitamin A level and severity of measles in New York City showed that many children younger than 2 years, had low vitamin A levels when ill with measles, and that such children seem to have lower measles-specific antibody levels and increased morbidity (Frieden et al., 1992).

The current strategy utilized by WHO/United Nations Children's Fund (UNICEF) to reach the Global Immunization Vision and Strategy 2010 measles reduction goal includes increasing coverage of measles vaccine, vitamin A treatment and supplementation in addition to offering two doses of vaccine to all children and that Measles vaccine and vitamin A treatment are effective interventions to prevent measles mortality in children. It is noted that Measles is associated with severe complications and contributes to a bigger rate of childhood morbidity and mortality this according to Mishra (2012).

Vitamin A deficiency is a recognized risk factor for severe measles infections. The World Health Organization (WHO) recommends administration of an oral dose of vitamin A (200,000 international units (IU), or 100,000 IU in infants) each day for two days to children with measles when they live in areas where vitamin A deficiency may be present, (Yang et al., 2005)

According to Benn et al., (2002), “Children who received vitamin A supplements had lower levels of non-protective antibodies (p=0.0095), and those who had protective antibody levels tended to have higher geometric mean antibody titres (p=0.09).)”. Therefore, early vitamin A delivery and measles vaccination at age 9 months have proven long-term effects on measles-specific antibody levels and may help improve measles control in underdeveloped nations. This investigation examined how vitamin A supplementation affected the levels of measles-specific antibodies in Guinea-Bissau. The number of measles mortality and the severity of the illness are both impacted by vitamin A deficiency. In children, it is known to cause severe measles-related problems that can lead to blindness, corneal ulcers, exophthalmia, and delay recovery.

2.1.3 Socio-demographic characteristics of the care giver of the children under five years

The adoption of vaccination services by a community might be impacted by the impact of socio-cultural variables on caregivers' health-seeking behaviour. The Oltepesi area has rural set up and some communities in the area are hard to reach. A study done in Nigeria found out that there was disparity especially in accessing available services by different communities (Eboreime et al., 2015). To boost the vaccination coverage of children, it was advised to improve mothers' health-seeking behaviours and understanding of child immunization, promote outreach programs, community participation, and actively work with local communities (Girmay & Dadi, 2019b). An assessment done to ascertain the effects of literacy level to immunization found out that there was higher immunization completion among children whose parents had some form of education. While socioeconomic position was seen to also promote uptake regardless of the degree of education, maternal education was associated with the acquisition of literacy skills and better health-seeking behaviour, which in turn increased vaccine uptake for their children (Balogun et al., 2017) .

2.1.4 Data management and accuracy

Data is needed to define the general need for health services, the efficiency of existing services, as well as their impact on morbidity and mortality. Accuracy of data on immunization coverage in the health care facilities source documents as

compared to the KHIS is an integral part in assessing the factors associated with measles outbreaks. The unexpected occurrence of significant and protracted measles outbreaks in nations reporting high measles vaccine coverage levels points to issues with the quality of immunization monitoring data, according to the WHO, Afro Region minutes 2010 on eliminating measles. This is a result of underestimating target populations and inadequacies in the coverage monitoring mechanism in a number of nations.

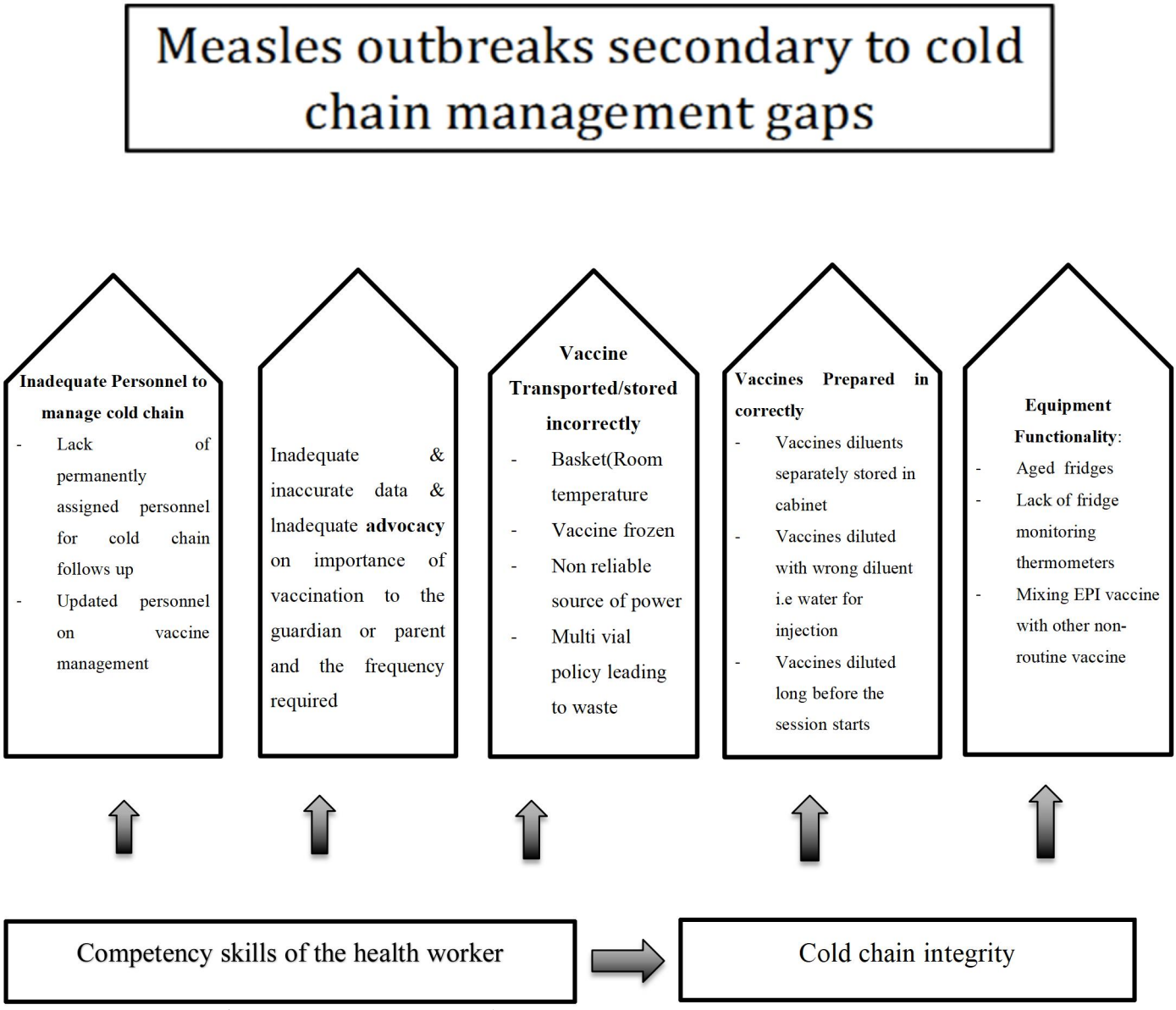
A study on the analysis of a three-month measles outbreak in western Liguria, Italy, identified areas for intervention, one of which is to enhance the timeliness and comprehensiveness of surveillance systems. There is also a need to ensure the security of the hospital and the dependability of the medical staff (Baccolini et al., 2020).

The data provided from the facilities usually is reconciled together to make up the sub county coverage and if this data is not accurate then there shall be a difficulty in the generated data. According to a survey done on accuracy of data it indicated that 94.6% of the population received one shot, 75.2% received two doses, and 8.1% were susceptible to measles, according to routine statistics. According to the records survey, estimates for one- and two-dose population coverage were 97.4% (+2.8%) and 78.9% (+3.7%), respectively, and a revised susceptibility estimate of 5.2%, or a 36% decrease in the susceptibility percentage, was made. Regular health facility

statistics may somewhat exaggerate measles susceptibility while underestimating vaccination coverage (Lyratzopoulos et al., 2002)

Figure 2. 1

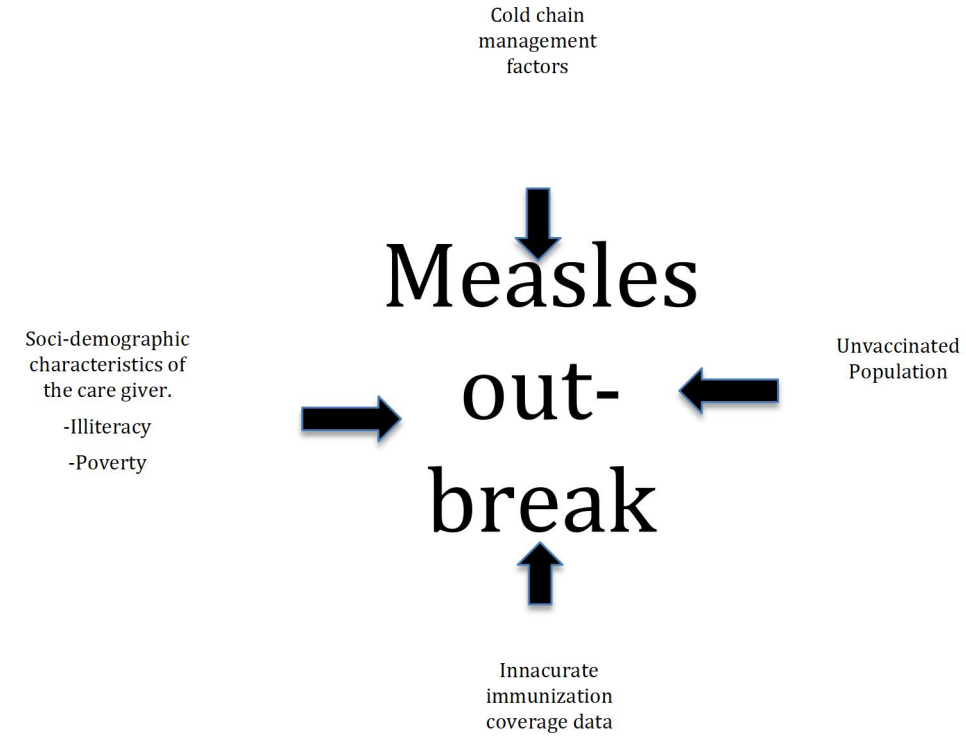
Theoretical Framework



Source :(Mohammed et al., 2021)

Figure 2. 2

Conceptual Framework



Source: Researcher (2022)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The study was conducted in Kajiado County in Keekonyokie Division of Kajiado North Sub County. Kajiado North Sub County which covers an area of 6344.9km square with a population of 445,570 projected from 2009 census with growth rate of 3.6%. The study was conducted in two locations within this sub-county: Oltepesi and Oloolua. Oloolua dispensary has an average patient flow of 100 per day while Oltepesi has at most 50 patients per day.

3.2 Study Design

This study used a mixed-method approach that included retrospective case-control design, quantitative and qualitative staff interviews, use of secondary data from the Kenya Health Information System (KHIS) for summary of reports, analysis, and records from the health facility, such as registers, tally sheets, and reporting tools. The case-control data involved households with children under 5 and sought to address community related objectives. The secondary data from health facilities aimed at assessing the accuracy of reporting from the medical centre. The qualitative assessment at the medical centre aimed at assessing the vaccine cold chain capacity of the two facilities as well as the health worker maintaining the vaccine cold chain.

The cases here are classified as children in households located in Oltepesi where there was an outbreak of measles in 2012 and the control refers to the households in Oloolua which did not experience any measles cases during the same period. It is a retrospective case control study design which was carried out in the areas most affected in the sub county by measles outbreak between 2012 and 2013. Children exposed to measles would be associated with those who were never exposed to measles.

3.3 Target Population

The target population consisted of moms or guardians, exposed and non-exposed children from the exposed and non-exposed areas and health workers from the same areas.

3.4 Sampling Procedures

In the 2 divisions, health facilities were sampled randomly and the participants were sampled by cluster sampling where the cohorts being studied should consist of individuals with similar characteristics to include age, Sex, Socio-economic status, Cultural practices, Literacy levels and management practices.

Every woman or guardian with a previously exposed child under 5 years visiting the oltepesi health facility would be sampled in the exposed area and all visiting the non-exposed facility. The child welfare registers, immunization registers, reporting tools and the KHIS was reviewed for the year 2012 and 2013 by month. The health

facilities in the study both had one health care who were to provide health services in the health facilities to include cold chain and immunization services.

3.5 Sample Size Determination

The catchment population for Oloolua dispensary is 12,605 while Oltepesi had a population of 7,107. The children under five year's proportion in the areas is 16.5% (Kenya National Bureau is Statistics, 2010). The target population of the two locations is 2,858 .The below formula was used to compute the population sample.

$$n = \frac{Z^2 pa}{2} \qquad n = \frac{Z^2 p(1-p)}{d^2}$$

Where *n*= Desired sample size for one population. *P* =is the estimate of the prevalence of measles in the study area. Since this is unknown, we will use the 50%. *∂* = estimated percentage of the real value's margin of error, or the desired degree of accuracy. Z = Critical value of the standard normal deviation's confidence interval. This was 1.96 at the 95% confidence range. Consequently, the estimated sample size was:$n = \frac{1.96^2 x 0.5 x 0.5}{0.05^2} = 384$

The needed sample size was adjusted using a finite population correction factor formula.

$$nf = \frac{n}{1 + \frac{n}{N}}$$

$$nf = \frac{384}{1+\frac{384}{2,858}} = 338$$

The sample size of 338 was distributed into the two locations based on the proportion of the population in each location.

Oloolua = $\frac{12,605}{19,712} * 338 =$ 0.63*261= 213

Oltepesi = $\frac{7,107}{19,712}$ = 0.37*338 =125

3.6 Exclusion and Inclusion Criteria

Inclusion

- The participants were from the area of study during the period in question
- Children less than five years old were residing in the area in the participant's family throughout the relevant time period.
- The individual was either a member of the exposed group or not, and health professionals
- A health worker providing immunization services at the health facility

Exclusion

- Any caregivers or guardian were not visit the health facility during the period of data collection
- A care or guardian visiting the health facilities and having children under five years of age.
- Excluded if participants refuse to give consent

3.7 Methods and Data Collection Tools

Check List

Through observational visits utilizing a checklist, cold chain maintenance in both case and control regions is to be assessed. The checklist may also be used to assess the availability of vaccine supplies. The checklist would measure the kind of equipment, the practices against the standard operations given. The checklist would also be used in the retrospective review of the data existing in the health facilities' source documents in comparison to what is entered in the KHIS.

Standardized Interview Schedules

In-depth interviews were used to evaluate a number of variables, including socioeconomic status, knowledge, attitude, traditional beliefs, vitamin A supplementation, distance to a health facility, and how this is related to the health-seeking behaviour of mothers of cases and mothers of age- and sex-matched controls.

3.8 Data Management Procedures

An enumerator was engaged and trained on the data collection tool which was administered in English. Data collected from the field was captured electronically on ODK collect using smart phones and did not require a separate data entry/Coding, the data was then downloaded in a format compatible with SPSS statistical software which was then used for analysis. To minimize errors logic checks including skips and range limits were included in the electronic data collection tool.

3.9 Data Analysis

Although we had included logical checks in the electronic data collection tool, the collected data was still checked for any inconsistencies on SPSS and minimal errors were found which could affect the final results. The data was then subjected to both descriptive and inferential analysis as described below.

Descriptive Analysis

The data collected from the respondents was mostly categorical, hence for descriptive analysis it was mostly analysed using frequencies and proportions. The frequencies/proportion between groups were also cross tabulated to assess the variation in proportions/frequencies among groups.

a) Inferential Statistics

This study had mostly categorical variables; the most appropriate inferential analysis which was used was the Chi-square test.

4.0 Ethical Considerations

The Kenya Methodist University's postgraduate studies program, as well as the Kenya Methodist University Ethics Committee, were consulted for approval before the study could be conducted. The Ministry of Education and the National Commission for Science, Technology, and Innovation were asked for authorization to conduct the study with these two endorsements (NACOSTI).

A signed informed permission was acquired once the study's goal was communicated to the county government's ministry of health. The participants and dispensaries both received the identical presentation. Both the participants and the personnel at the dispensaries received an explanation of the study's goal. The research was optional, and participants were informed that their ability to get dispensary medical care would not be impacted by their decision not to participate.

The participants were assured of their confidentiality and that they would be identified by a randomly assigned number that would not be traceable to them. They were also informed that there would be no physically intrusive procedures and no monetary gain would be provided from taking part in the study.

3.10 Data Quality Control (validity and reliability)

1. Quality assessment instruments are typically included in the study to ensure randomization is done.
2. Quality assurance using quality scales and checklists that offer quantitative assessments of the general research quality.
3. Training of interviewers' prior the study

3.11 Study Limitations

1. The study being retrospective may lead to unreliable data since we can only rely on existing data without manipulating the data

2. The study may limit the information as it shall rely on recall from the guardian

3.11.2 Study Delimitations

1. Randomization was done to ensure participants have an equal chance of participating in the study as long as they are in the eligible population.
2. Subjects were put on a comparable educational status
3. Limitations of the study already listed and source documents identified prior the study

CHAPTER FOUR

FINDINGS AND DISCUSSION

4.1 Introduction

In this chapter statistical summaries, results from empirical analysis, and interpretations of the statistical conclusions drawn from the gathered data are discussed. Discussion of the study's findings will also be included. Mugenda and Mugenda (2003) state that a response rate of 50% is sufficient for analysis and reporting, a response rate of 60% is acceptable, and a response rate of 70% or above is great. As a result, the average response rate of 73.1% for this study is viewed good enough to draw findings from.

The study focused on three primary elements to determine the causes of measles epidemics in the Oloolua and Oltepesi districts; Cold chain factors, coverage of unvaccinated children, and the data accuracy factors. The discussion is guided by the study objectives as discussed in the study.

This study targeted 338 children under five whose parents or guardians were to be participants but only 335 of the children were found and their 213 guardians appropriately respondent and this translated to a response rate of 99.1% in the two locations of the study.

4.1.1 Socio Demographic Characteristics of the Participants

Table 4. 1

Socio Demographic Characteristics of the Parents /Guardians

	Name of Location	Oltepesi		Oloolua		Average	
		n	%	n	%	N	%
Sex	Female	97	74	67	81.7	164	77
	Male	34	26	15	18.3	49	23
Age in Years	20-30	78	59	45	55	123	58
	31-40	53	40	37	45.1	90	42
Marital status	Married	84	64	41	50	125	59
	Single	47	35	41	50.1	88	41
Children aged less than 5 years	Under 1 year	78	59	49	59.8	127	60
	over 1 year	53	40	33	40.2	86	40

Source: Research Data (2022)

The table above presents the socio demographic details of the study participant's areas of Oltepesi and Oloolua. The study mainly targeted caregivers of children who are more likely to have more accurate information on the children's immunization history. Most of the participants were female (77%). Oloolua had a higher percentage of respondents who were female (81.7%) while Oltepesi had 74% female respondents. The participants were of different age groups varying from 20 to 40 years. Those 20- 30 years 59%, and 40 31-40 years were 40%.

Probing if they had children less than five years under their care, all of them indicated so and this included 59 % with a child less than five years41% with a child between 1 yr and 59 months.

Table 4. 2

Socio Demographic Characteristics of the Parents /Guardians

		Name of Location					
		Oltepesi		Oloolua		Average	
		n	%	n	%	N	%
Attended School	No	17	13%	6	7%	23	11%
	Yes	114	87%	76	93%	190	89%
Highest education level completed	None	17	13%	6	7%	23	11%
	Primary	69	53%	32	39%	101	47%
	Secondary	35	27%	17	21%	52	24%
	Post-secondary	10	8%	27	33%	37	17%
Occupation	Formal employment	42	32%	30	37%	72	34%
	Casual employment	32	24%	24	29%	56	26%
	Self-employment	33	25%	12	15%	45	21%
	Unemployed	24	18%	16	20%	40	19%
Religious affiliation of the household head	Christian	67	51%	36	44%	103	48.4
	Muslim	29	22%	15	18%	44	20.7
	Others	35	27%	31	38%	66	31%

Source: Research Data (2022)

As indicated in Table 4.2 majority of the study participants stated that they were Christians (48.4%), followed by Muslim (20.7%) with 0.31% for others. By education, most of the respondents (89.2%) had at least a primary level of education with most of the participants only having completed primary level of education (47.4%) as compared to secondary (24.4%) or any other post-secondary (17.4%).

Some of the participants still indicated not to have completed any level of education (10.8%). Oltepesi had a higher percentage of respondents who had not completed any level of formal education (13%) as compared to Oloolua which only had 7.3%. It is of importance to note that the level of education affects immunization. This was also shown in a study where maternal awareness, understanding and educational attainment were the main drivers of vaccine coverage, and it was discovered that improving maternal literacy and knowledge levels are crucial for boosting immunization coverage in this group (Gidado et al., 2014)

Additionally, the study aimed to pinpoint the time frame during which the responders under five years had stayed in the region and their responses are provided and summarized in the subsequent. The research showed that the majority of participants knew about measles vaccinations at 154[95.3%] compared with a small number of those respondents in Oloolua dispensary.

Parental education has an influence on their children's health especially in making sure the child visits for vaccinations. This is according to the level of education of a guardian or parents determines the decision they will make towards immunization of the children. According to a research conducted in Northern Nigeria, where mothers and children were on average 27 years old (standard error (SE): 0.27 years) and 17 months old (SE: 0.8 months) correspondingly, 79% of mothers had no formal education, and 84% had insufficient understanding about immunizations. Children

who had all recommended vaccinations made up just 7.6% of the population. Logistic analysis revealed a substantial correlation between complete vaccination and having at least a secondary education (Adjusted OR=3.6, 95% CI=1.2-10.6) and sufficient knowledge (Adjusted OR=18.4, 95% CI=3.6-94.7) (Gidado et al., 2014) .This indicated that parental awareness and educational status were the main factors

		Facility Catchment Area					
		Oltepesi		Oloolua		Overall	
		n	%	n	%	n	%
Order of child from last	1	131	63.0%	82	64.6%	213	63.6%
	2	54	26.0%	33	26.0%	87	26.0%
	3	23	11.1%	12	9.4%	35	10.4%
Sex of child	Female	107	51.4%	74	58.3%	181	54.0%
	Male	101	48.6%	53	41.7%	154	46.0%
Age of child(In years)	1	51	24.5%	36	28.3%	87	26.0%
	2	45	21.6%	27	21.3%	72	21.5%
	3	51	24.5%	33	26.0%	84	25.1%
	4	61	29.3%	31	24.4%	92	27.5%
Duration of Stay in area(in years)	1	62	29.8%	45	35.4%	107	32.0%
	2	70	33.7%	34	26.8%	104	31.0%
	3	52	25.0%	32	25.2%	84	25.1%
	4	24	11.5%	16	12.6%	40	11.9%

influencing vaccination coverage. To boost vaccination coverage in this population, it is crucial to increase mother literacy and maternal awareness. Moreover, results showed variation in families' responses based on the parents' educational attainment,

demonstrating that parents with higher levels of education assimilate new knowledge more quickly."(Schober, 2020).

Table 4. 3

Socio-Demographic Characteristics of Children

Source: Research Data (2022)

A total of 335 children participated in the survey of whom close to two thirds (63.6%) were the last child in the homes with an almost similar percentage in the two facility catchment areas. 46% of respondents were men, compared to 54% of respondents who identified as female. In Oltepesi (n=208) the female (51.4%) were slightly more than the male (48.6%) as compared to Oloolua (n=128) which had 58.3% female and male formed only 41.7% of the participating children.

The researcher only focused on the last three children in the selected family who were within the catchment area during the year of the outbreak and aged below five years. More than half of the respondents (52.6%) were three or more years older than Oloolua (53.8%) and Oltepesi (50.4%). The respondents were asked how long the children had stayed in the catchment area when the measles epidemic occurred. Most of the children had stayed in the catchment area for most of their life and this ranged between zero (incomplete year) and four years.

Only 20.7% of the participants stated that the nearest public facility is less than 30 minutes' walk away from their home, 29.6% stated that they must walk about 30

minutes to 1 hour to reach the closest health institution while 27.7% stated that they take between an hour and two and 22.1% take more than two hours. Oloolua had a slightly higher proportion (23.2%) of respondents who take less than 30 minutes to walk to the nearest health facility as compared to Oltepesi (19.1%). Oltepesi had a slightly higher percentage (51.1%) of participants who walk more than one hour to get to the nearest health facility as compared to Oloolua (47.6%) which agreed with a study done in Ethiopia that indicated that associated the above with the measles outbreak (Tsegaye et al., 2022)

4. 1.2 Influence of Unvaccinated Children

4.1.1.1 Knowledge of Importance of immunization and vaccination of children

The participants were assessed on their general knowledge of vaccination and the measles vaccine in specific; below are results from the questions assessing their knowledge.

Table 4. 4

Community Knowledge on Measles and Importance of Vaccination

		Facility Catchment Area					
		Oltepesi		Oloolua		Overall	
		n	%	n	%	N	%
Main benefit/effect of vaccination	Build immunity	76	58.0%	50	61.0%	126	59.2%
	Prevents spread of diseases	35	26.7%	24	29.3%	59	27.7%
	Make children sick	11	8.4%	4	4.9%	15	7.0%
	Don't know	9	6.9%	4	4.9%	13	6.1%
Important to vaccinate children?	Yes	100	76.3%	73	89.0%	173	81.2%
	No	28	21.4%	4	4.9%	32	15.0%
	Not sure	3	2.3%	5	6.1%	8	3.8%
Ever heard about measles vaccine	Yes	105	80.2%	66	80.5%	171	80.3%
	No	26	19.8%	16	19.5%	42	19.7%
	Not sure	0	0.0%	0	0.0%	0	0.0%

Source: Research Data

Most participants (59.2%) when asked what the biggest advantage or result of vaccinations was said that the main benefit of vaccination was to help one build immunity against diseases. This was followed by those who stated that vaccination helps to prevent the spread of diseases (27.7%) then about 7% believed that vaccines make children sick while others (6.1%) stated they do not know the main benefit of vaccinating children. Oloolua had a slightly higher percentage (61%) of participants stating that the main benefit of vaccination is to help the body build immunity as

compared to Oltepesi (58%). Oltepesi had a slightly higher proportion of respondents who stated they did not know any benefits of vaccination (6.9%) and that vaccines mainly make children sick (8.4%) as compared to Oloolua with 4.9% stated that vaccines mainly make children sick and that a similar percentage stating that they didn't know the benefits of vaccination.

Overall more than three quarters stated that it is important to vaccinate children (81.2%) while 15% stated that it may not be important and 3.8% stating that they were not sure that it is important. In Oloolua, 89% stated that vaccination is important, and only 4.9% stated that they do not see the importance in vaccinating children while 6.1% were not sure. In Oletepesi, only about three quarters stated that it is important to vaccinate children (76.3%), 21.4% stating that they did not see the importance in vaccinating children while only 2.3% stated that they were not sure. Most of the participants 80% stated that they've heard about the measles vaccine, the same percentage cutting across the two facilities.

The findings of the knowledge survey indicate that factors related to the household and children have an impact on whether people choose to receive measles vaccinations, particularly on the level of parental awareness (LYIMO, 2012). The study which was done in Tanzania also revealed that there are various social factors that affect the uptake of both routine and supplemental uptake of vaccines among

under-fives. When the guardian lacks knowledge on the measles vaccines, there is a tendency of non-compliance in the uptake of the vaccine (Phimmasane,et al.,2010) According to Gidado et al. (2014) it was discovered that mother awareness and educational status were the main factors of vaccination coverage in Nigeria. To boost vaccination coverage among the under-five population, it was crucial to raise guardian awareness and educational levels. In order to improve vaccination handling and storage procedures, regular training is advised. It is crucial that the health professional dispensing vaccination advice be fully informed, and frequent training is advised to improve vaccine handling and storage standards (Dairo & Osizimete, 2016)

4.1.2.1 Measles Vaccination Coverage

Does the proportion of unvaccinated children vary by the two dispensaries catchment areas? The researcher also assessed the measles vaccination coverage among the children whose parents participated in the study. Among the information of interest collected included whether the child was vaccinated, number of doses given if the child was vaccinated and if the child was infected with measles during the outbreak. Table 4.4 below highlights the results.

Table 4. 5

Immunization coverage against incidence of Measles by Facility

		Facility							
		Oltepesi		Oloolua		Overall		Chi-Square	
		n	%	n	%	n	%	df	p-value
Child immunized against measles	**No**	43	20.7%	22	17.3%	65	19.4%	1	0.452
	Yes	165	79.3%	105	82.7%	270	80.6%		
Immunized before the year 2012	**No**	151	72.6%	101	79.5%	252	75.2%	1	0.078
	Yes	57	27.4%	26	20.5%	83	24.8%		
No. of doses of measles vaccine	**0**	43	20.7%	22	17.3%	43	20.7%	3	0.585
	1	76	36.5%	56	44.1%	76	36.5%		
	2	53	25.5%	29	22.8%	53	25.5%		
	3	36	17.3%	20	15.7%	36	17.3%		
Infected by measles	**No**	199	95.7%	127	100%	326	97.3%	1	**0.017***
	Yes	9	4.3%	0	0.0%	9	2.7%		

Source: Research Data (2022)

The researcher compared the characteristics of the children across the two dispensaries catchment area to assess whether there was any variation. Overall, 19.4% of the children among the respondents stated they were not vaccinated against measles. Oltepesi (20.7%) had a somewhat greater percentage of children who were not immunized as compared to Oloolua dispensary (17.3%) though not significantly different ($p > 0.05$). Oltepesi also had a slightly higher percentage of children who were vaccinated against measles before the start of 2012 (27.8%) as compared to Oloolua (20.5%) also not significantly different ($p > 0.05$). There was also no

significant difference in the number of measles vaccine doses administered on children (p>0.05) though Oloolua had a high proportion of children with at least one dose of the measles vaccine.

Measles cases by Household Socio-Demographic Characteristics

Below are the highlights a statistical comparison of measles cases by the household and household head socio-demographic characteristics in the assessed households.

Table 4. 6

Household Socio-Demographic Characteristics and Measles cases

Household head characteristics		***Measles infection***				***Total***			
		Not infected		Infected			Chi-square		
		N	%	N	%	N	Df	P-value	
Marital status of the household head	Single	59.0	98.3%	1	1.7%	60.0	4.0	1.0	
	Married	193.0	97.0%	6	3.0%	199.0			
	Single	74	98.0%	2	6.1%	76			
Religious affiliation of the household head	Christian	158.0	96.3%	6	3.7%	164.0	4.0	0.7	
	Muslim	66.0	97.1%	2	2.9%	68.0			
	Others	102	99.4%	1	1.9%	103			
Ever attended school	No	32.0	100.0%	0	0.0%	32.0	1.0	0.3	
	Yes	294.0	97.0%	9	1.0%	101.0			
Walking distance to nearest facility	<0.5 hours	64	97.0%	2	3.0%	66	3.0	0.4	
	0.5 - 1 hours	95	96.0%	4	4.0%	99			
	1 - 2 hours	89	96.7%	3	3.3%	92			
	2+ hours	78	100.0%	0	0.0%	78			

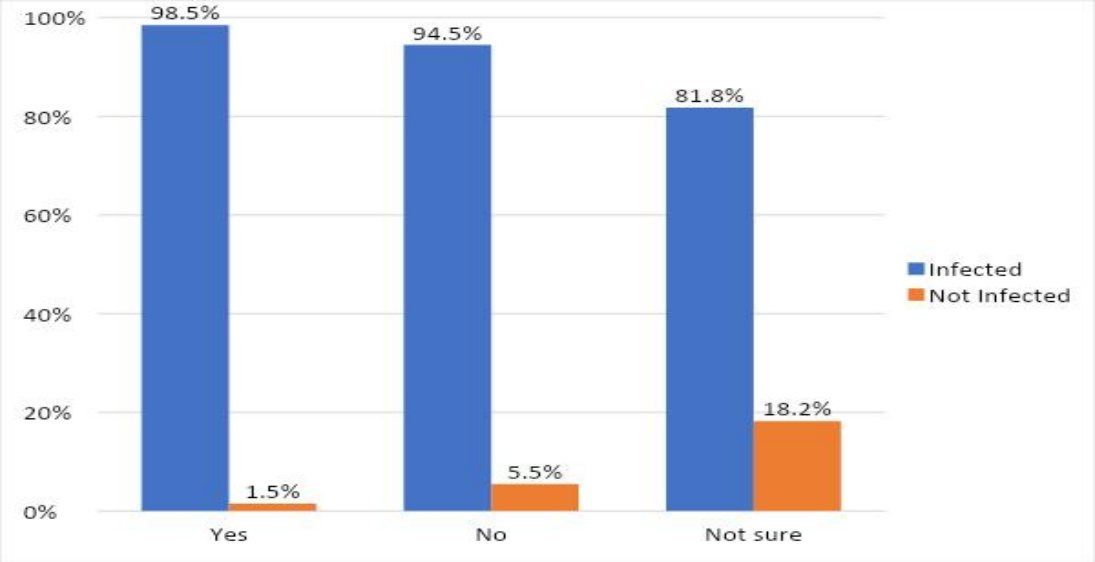
Source: Research Data (2022)

To determine whether there was any variance in the measles epidemic by the demographics of the family and household head, a Chi-Square test was used. There were some observations of interest like those households closest to the facility i.e. walking distance to facility less than two hours having higher cases of measles than those who live more than two hours away who did not report any case of measles. The socio-demographic features of the households did not, however, show any discernible significant variation in the reported measles cases. The percentage of measles cases were quite comparable across household heads.

Figure 4.1

Measles Cases by Household Attitudes towards Vaccinations

Measles Cases by Household Head Attitudes tow



Source: Research Data (2022)

There was a total of 269 children from caregivers who stated that it was important to vaccinate children while 55 felt that it was not important and 11 stated they were not sure. By attitude toward vaccination, there was a substantial variation in the number of measles cases. The attitude of the caregivers regarding immunization and measles patients differed significantly. Among those who felt it was important to vaccinate, there were 4 cases (1.5%) of measles, those who felt it was not important there were three cases (5.5%) and two cases (18.2%) among those who were not sure. This was the only household and household head characteristics which was significantly varying among the households who reported to have had children who got a measles infection during the outbreak

The use of immunization services depends on a number of factors, including the parents' knowledge and attitudes towards immunizations, in addition to how well the

immunization services are provided or performed (Gidado et al., 2014) . According to this survey, just 10% of parents delayed immunizing their children, and no one objected to the practice. Certain parents might put off being vaccinated, although this is primarily due to inadequate information about the necessity of vaccination in the first place, certain childhood illnesses, a lack of awareness about vaccinations, and vaccine deficiencies, according to (Mohammed et al., 2021).

4.1.2.3 Measles Cases by Child's Characteristics

A comparison was also conducted based on the child's characteristics and the results are highlighted in table 4.7

Table 4. 7

Measles Cases by Child's Characteristics

Child Characteristics		Measles Infection				Chi-Square	
		n	%	n	%	df	p-value
Immunized against measles	**No**	63	96.9%	2	3.1%	1	0.828
	Yes	263	97.4%	7	2.6%		
No of Doses	**0**	63	96.9%	2	3.1%	3	0.962
	1	128	97.0%	4	3.0%		
	2	80	97.6%	2	2.4%		
	3	55	98.2%	1	1.8%		
Child's age	**0**	26	100.0%	0	0.0%	4	0.653
	1	60	98.4%	1	1.6%		
	2	70	97.2%	2	2.8%		
	3	80	95.2%	4	4.8%		
	4	90	97.8%	2	2.2%		

Source: Research Data (2022)

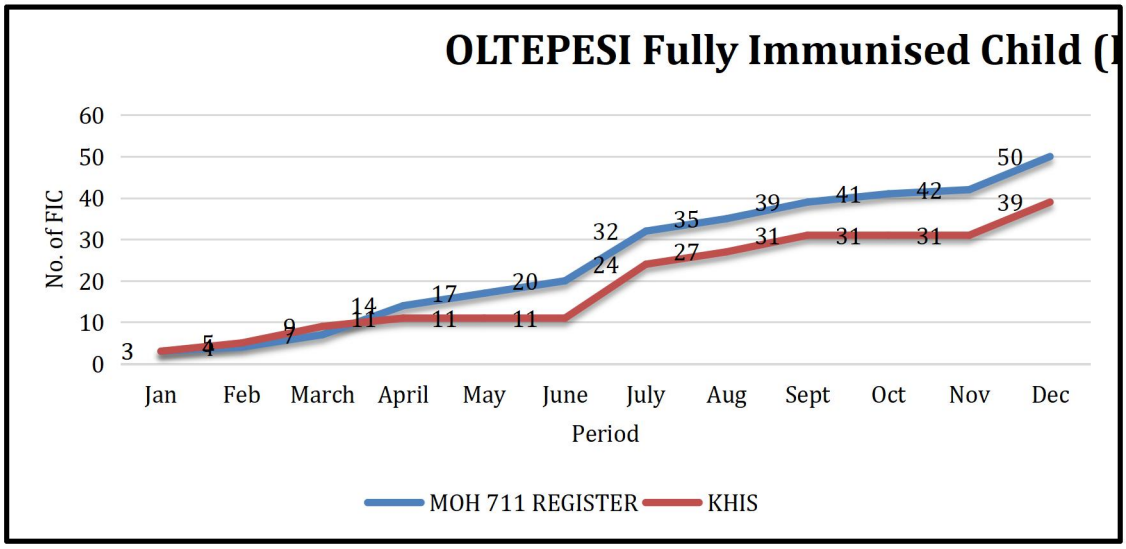
The characteristics of the children did not show any significant variation in the measles infection rates. Among those children indicating they were not vaccinated

during the outbreak, 96.9% did not get infected with measles during the outbreak, a near similar percentage (97.4%) among the infected did not also get infected.

4.1.3 Immunization coverage data Accuracy

Figure 4. 1

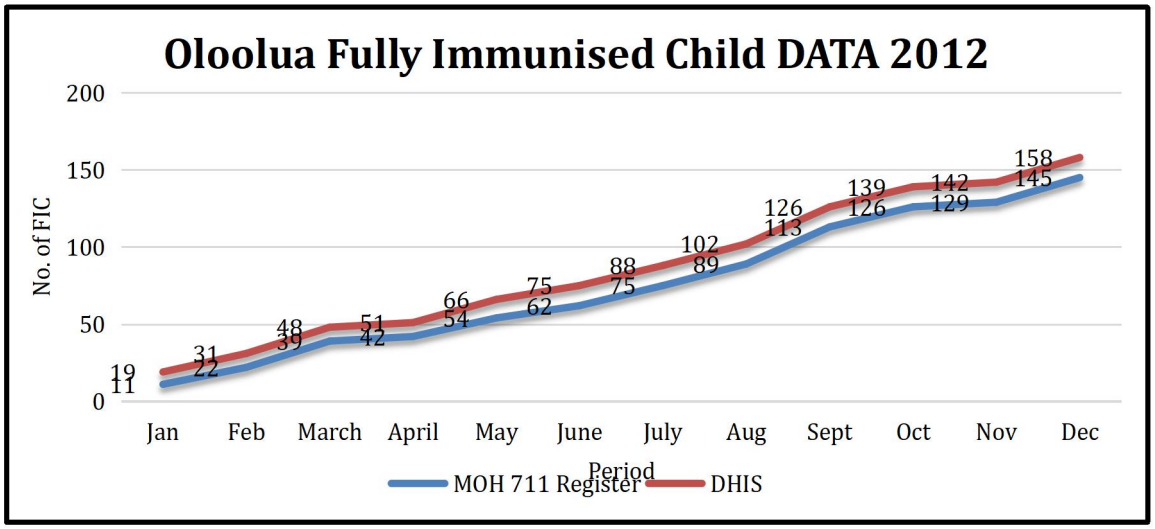
No. of Children Fully immunised at 1 year in Oltepesi Dispensary in 2012



Source: Research Data (2012)

Figure 4. 2

No. of children fully immunised at 1 year in Oloolua Dispensary



Source: Research Data (2012)

4.3: Fully Immunized Children in 2012, MOH711 vs KHIS2 Reporting

From the previous cross tabulation, the study used Oloolua as the control group as they were no incidence of measles during the study period and in the Figure 4.3, they present the coverage of immunization in 2012 and it was established that coverage was low i.e. In January and February 15.8% and 16.7% while in the months of May, June, October and November, there was no data on immunization in Oltepesi and thus coverage was zero. The data is also indicating that it is not reliable as there was no Concordance. As observed in the figure above, there is a higher level of data discrepancy from what has been reported by Oltepesi on KHIS2 as compared to the data at the health facility. Oloolua only missed reporting during one month during the year 2012 while Oltepesi did not report in three out the twelve months in the year and an additional five months varied by more than 20% between what was reported on KHIS2 and the facility report. There were only two months that the reports at the facility matched what was on KHIS2. Oloolua only had one month (October 2012) that didn't have any numbers reported on KHIS2 and only one month (Jan 2012) that the reported numbers in the facility varied from the numbers reported on KHIS2 by more than 20%.

Data accuracy can mean that the measles vaccine coverage is accurate or not accurate. The data available in the KHIS for 2012 for the two study areas is not agreeing with data obtained from the source documents in the facilities. For instance, some months

indicated no children were immunized against measles on KHIS while data in the source document was indicated more than one, this shows that the data is not reliable. This is in line with the WHO Africa Region Minutes 2010 on Measles Elimination, where it was noted that unexpectedly large and protracted measles outbreaks have occurred in nations with high measles vaccine coverage rates, which suggests an issue with the data monitoring of immunizations. This is associated with the underestimating of target populations and holes in the coverage monitoring mechanisms in certain nations. Therefore, the coverage is not as high as what the KHIS indicates for the said period and according to Muscat et al 2009, The pillars of the measles eradication effort are the attainment and maintenance of optimal vaccination coverage and enhanced surveillance.

According to this study, there were significantly more children who had had a measles vaccination in KHIS than there were in the institutions. Therefore, it is hard to determine the real vaccination coverage in the two locations due to a lack of trustworthy data and the surveillance system's insufficient coverage. As a result, the monitoring system must continue to be improved if the measles outbreak is to be effectively controlled(Nmor et al., 2011)

The study identified inconsistent and unreliable data from the health facilities in Kajiado and thus there is a need to improve the existing monitoring system. Further studies would be recommended to better understand why the data accuracy is an

issue in the facilities. “The degree of vaccination coverage among children in any particular nation is significantly influenced by the accessibility of health facilities and information, education, and communication initiatives”,(Sahu et al., 2010) . Additionally, even though the model includes community-level factors, individual-level variables, such as parent education levels, a child's birth order, and the frequency of prenatal care visits, continue to play a predictive role for the likelihood of vaccination coverage.

Accuracy of data affects the appearance and interpretation of any given information as it was found out by Lyratzopoulos, et al. (2002) where the study showed that routine data may modestly underestimate vaccination coverage and significantly overestimate measles susceptibility. Despite the fact that the measles vaccination rate for the aforementioned time was high, it is crucial to remember that high vaccination rates with just one dose may not be enough to protect the general population and stop measles outbreaks (Bose et al., 2014). An efficient measles and rubella surveillance system offers crucial data for planning, implementing, and assessing measles vaccination efforts as well as tracking the progression toward measles eradication.

4.1.4 Health Worker Knowledge and vaccine Cold chain management

The assessment of the cold chain knowledge and practice by facility staff from Oloolua and Oltepesi facilities was summarised in the table below to ascertain the knowledge on cold chain management.

Table 4. 8

Health worker knowledge on cold chain and infrastructure availability

Observed infrastructure & Practice of cold chain system		Oltepesi	Oloolua	
Ideal Number for dispensary				
Type of cold chain equipment	Iced lined refrigerator	1	1	1
	Deep freezer	0	0	1
	Cold box	0	0	1
	Domestic refrigerator	0	0	1
	Vaccine carrier	1	1	1
Availability of at least one functional refrigerator for EPI vaccines		1	1	1
Access to power supply	At least one source	1	1	1

Source: Research Data (2022)

Table 4. 9

Infrastructure of the cold chain equipment and Human resources

S. no	Observed infrastructure & Practice of cold chain system		Oltepesi	Oloolua	Ideal Number for dispensary
1	Source of power	Electricity as main source	X 0(Don't have)	✓	✓(Have)
		Solar as main source	✓		✓(Have)
		Gas as main source	✓	✓	✓(Have)
2	Availability of sufficient frozen ice parks		✓	✓	✓(Have)
3	Availability of functional generator		X(Don't have)	X (Don't have)	✓(Have)
4	Availability of functional thermometer		✓	✓	✓(Have)
5	Availability of spare parts for minor maintenance		X (Don't have)	X(Don't have)	✓(Have)
6	Availability of personnel assigned Permanently for cold chain management throughout		X(Don't have)	X(Don't have)	✓(Have)

Table 4.8 above showed that had the same source of power but Oltepesi had no electricity as an alternative source encase there was electricity failure. The findings of this study also showed that the degree of vaccination knowledge and practice among the medical staff in both hospitals was essentially the same. Both facilities lacked adequate back up for power failure as expected for maintenance of cold chain. There was a noted difference in the management of the measles diluent by the health care worker where in Oltepesi facility staff indicated that they store the diluents in the cabinets (room temperature) as compared to Oloolua who store their diluent in the fridge. All the refrigerators were indicated to be more than 10 years' old which

could comprise the potency of the vaccines they store. When older refrigerators are used to store vaccines, there is a higher chance of the refrigerator malfunctioning since all refrigerators used to store vaccines require regular maintenance cleaning and inspections in accordance with a maintenance plan.

A refrigerator maintenance equipment log should be kept for all refrigerators used for the storage of vaccines which in this case did not appear in the old fridges available in Oltepesi dispensary.

According to Maglasang et al. (2018), To maintain the cold chain and guarantee that it is maintained throughout the vaccination sessions, the employees handling vaccines must be trained in the correct handling, storage, and transportation of immunization supplies, such as the use of cold boxes and ice packs.

4.1.4.1 Equipment Functionality

From the results it is illustrated that the cold chain maintenance in both health facilities were deficient in terms of cold chain management. The age of the fridges which were older than 10 years in use and this affects the temperatures and refrigerators are an important aspect of vaccine infrastructure where the vaccines are kept with certain temperatures, this may affect the potency of vaccines. According to, Hibbs et al. (2018), Vaccine safety when stored below or above the advised temperature increases chances of Adverse Events of Interest (AEIs).

The safe storage of vaccinations in healthcare institutions cannot be guaranteed without the most up-to-date technology on immunization storage since vaccines may lose some of their efficacy when exposed to extreme temperatures. An effective immunization program requires the provision of suitable equipment and training for employees in maintaining the "cold chain" and the usage and upkeep of equipment.

In the study, it was found out that the health workers were well versed with knowledge needed for vaccine management in and out of the health facilities and according to Gupta et al. (2011) In a study of the factors causing measles epidemics in the Kangra district of North India, it was discovered that health workers can only work effectively if sufficient supplies (vaccines, supplements and medicines) are available when they need them and therefore transporting the vaccines to place of work is an integral part in cold chain management .

At all stages of service delivery, careful consideration of handling procedures is required to guarantee the vaccines' maximum efficacy. Milstien (2006). The storage and delivery of vaccines from the major vaccine stockpile to the final user at the healthcare institution, as well as farther down at the outreach locations, are examples of these. The ideal storage conditions for vaccines used in vaccination

4.1.4.2 Transportation and Temperatures of vaccines

A functional vaccine storage system, suitable vaccine management protocols, and well-trained vaccine cold chain health personnel are the very minimum requirements for any efficient cold chain management of vaccines (Feyisa et al., 2022). The

storage and transportation of vaccines from the primary vaccine store down to the end-user at the health facility, and further down at the outreach sites, are among the handling practices that must be taken into account to ensure the optimal potency of vaccines, according to Milstien et al. (2006).

Vaccination exposure to temperatures below recommended ranges occurred during shipping was 38% from higher income nations and in 19.3% of those from lower income countries but according to this study the transportation of vaccine to and from the health facility was efficient as the required means of transporting the vaccine was properly followed. The table below shows the management of vaccines.

Table 4.10

Vaccine Management

Vaccine temperature monitoring	**Oltepesi**	**Oloolua**

Sno	Vaccine Storage temperatures monitoring	Normal /Ideal	Frequency-Practice	
1	Availability of daily temperature chart	**Daily**	Week day	Week day
2	Temperature record charts correct and updated	**Updated daily**	Week day	Week day
3	Thermometer placed in correct position within the fridge	**Away from freezing compartment**	OK	OK
4	Refrigerator within the recommended temperature range	**Between** + 2 °C to + 8 °C	+10°C	+ 2 °C to + 8 °C
5	Emergency repairs are conducted in a timely manner	**Yes**	NO	NO

Source: Research Data (2022)

The table above shows the management of vaccines.

The results indicate that the vaccines are only monitored during working days and not monitored during the weekend in both health facilities. The findings show that 25% of medical institutions handle the vaccine cold chain based on the recommended vaccine storage temperature range (+ 2 °C to + 8 °C), but in Oltepesi dispensary, the vaccine diluent was stored outside the refrigerator. Storage of vaccine diluents at room temperatures and diluting a vaccine that is in the fridge can reduce the vaccine titres. This then affects the immunity which causes the temporal changes in vaccine-induced IgG antibody titters and the consequent susceptibility to infection (Sasaki et al., 2019). The health workers indicated that they cannot tell the temperature over the weekend s and holidays since the thermometer does not keep the records throughout.

This points to a problem with temperature monitoring as thermometers have been proven to be insufficient in giving accurate temperature information for refrigerators since they don't save the memory of low and high alerts. When there are variations in refrigerator temperature, thermometers may not be as useful as Fridge-tags in giving health professionals the knowledge they need to take appropriate action. (Kartoğlu et al., 2010)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

The chapter presents the conclusions arrived at and gives recommendations and the suggestions

5.1 Conclusion

There was error in the data as the data entered in KHIS is not same as the data in the source documents and therefore inaccurate immunization data gives a false “high immunization coverage” in the sub county

The study concluded that there was insufficient understanding of cold chain services among medical practitioners and other providers. As a result, "improving knowledge and practice on cold chain management" is necessary”. Enhanced guidance and mentoring on cold chain management at all levels of service provision will help bridge that gap. The vaccine storage equipment and maintenance of the same equipment had gaps in the two study areas.

5.2 Recommendation

In accordance with the Kenya Expanded Programme on Vaccination, the Ministry of Health and county departments of health shall continue to intensify immunization efforts nationwide through national policy makers and county implementers.

The Kenyan government in conjunction with MoH and county governments should implement a strategy that would help improve coverage in the county. When

considering communication, it is important to have a wide view that includes community mobilization through community health assistance programs and advocacy by county health promotion officers.

Data cleaning and audit is necessary as the data in the KHIS might be giving false indicators to the world about health as a whole. This should be done periodically within the health systems.

To avoid any measles outbreaks and sustain progress toward measles eradication, the County needs stronger strategies to strengthen the health professionals' expertise of vaccine cold chain management and achieve high vaccination coverage nationwide.

Suggestion for further study

Further, a study should be done in the county to determine the efficacy and potency of vaccines stored at both health facilities and a study to be done on the already immunised children on the level of acquired immunity after vaccination with the two doses of Measles Vaccine

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APPENDICES

Appendix I: Consent

My Name is Eileen N. Sawani, an Master of Science Public Health student at the department of health science in Kenya Methodist University. I am carrying out a study on Factors associated with measles outbreak in Kajiado West and North sub counties at Oloolua and Oltepesi dispensaries. This is part of fulfilment for the degree award. I am being supervised by

Dr Lily Masinde

I am going to give you information and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research.

There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain.

This Informed Consent Form is for men and women who are guardians of children under 5 years who were exposed/Not exposed to measles in 2012/2013, and who we are inviting to participate in research on measles outbreak. The title of our research project is Factors associated with measles outbreaks among children below5 years in Kajiado North Sub County.

Questionnaire number _____

*Name of location*_____

*Name of facility*_____

*Name of Interviewer*_____

Date of interview _____

Appendix II: Information on health worker on cold chain management and records

Part A. Cold chain related factors checklist

I. Health worker

Questions	**Choices**	**Tick (✓) where appropriate**
What type of cold chain equipment do you have?	a) Iced lined refrigerator	
	b) Deep freezer	
	c) Cold box	
	d) Domestic refrigerator	
	e) Vaccine carrier	
Do you have a functional refrigerator for keeping vaccines?	a) Yes	
	b) No	
What's your main source of power	a)Electricity as main source	
	b)Solar as main source	
	c)Gas as main source	
Do you have an alternative back-up power-Generator	a) Yes	
	b) No	
Do you have frozen icepacks	a) Yes	
	b) No	
Does the facility have spare parts for minor maintenance of refrigerator	a) Yes	
	b) No	
How old is the refrigerator?	a) Less than 5 years	
	b) More than 10 years	
	c) Don't know	
Have you been trained on vaccine management for the last 1 year?	a) Yes	
	b) No	
Is there a personel assigned Permanently for cold chain management throughout	a) Yes	
	b) No	
At what temperatures do you store your measles vaccines?	a)0-8 degrees Celsius	
	b) Below 0 degrees Celsius	
	c)Any other, Specify----------	
Where do you store your measles diluent?	a) In the fridge throughout between 0-8 degrees Celsius	
	b) Freeze with vaccine	

	c) At the cabinet	
	d) Other, (Specify_____)	

Part B. : Data review to determine accuracy of data on immunization

Oloolua Dispensary			**Oltepesi Dispensary**		
Months of the year	2012 Fully Immunized Children data		Months of the year	2012 Fully Immunized Children data	
	MOH 711 Register	KHIS		MOH 711 Register	KHIS
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Totals					

Appendix III. : Household Socio-Demographic and Immunization Knowledge, Practice and Coverage Tool

Section A: Consent

This Informed Consent Form is for men and women who are guardians of children under 5 years who were exposed/Not exposed to measles in 2012/2013, and who we are inviting to participate in research on measles outbreak. The title of our research project is Factors associated with measles outbreak among children below5 years in Kajiado North Sub County.

Questionnaire number _____

*Name of location*_____

*Name of Interviewer*_____

Date of interview _____

Section B: Information

Greetings,

I am ----------, from Kenya Methodist University. We are doing research on measles disease, which is very common in this County.

Section C: Respondent/Household Head Information

1) Relationship of respondent to household head
   a. Household head b. Spouse
   c. Sibling (brother/sister) d. Other _____
   e. Child
2) Sex of the respondent
   a. Female b. Male
3) What is your age in completed years? ☐☐
4) What is your marital status?
   a. Single b. Married
   c. Engaged d. Divorced
   e. Widowed f. Other _____
5) Religious affiliation of the household head?
   a. Christian b. Muslim
   c. Traditional d. No religious affiliation
   e. Other (specify) _____
6) Are you a resident of this home that we are in now?
   a. Yes b. No
7) Have you ever attended school?
   a. Yes b. No
8) (If Yes in 8) What is your highest level of education you have completed?
   a. None b. Primary
   c. Secondary d. University or other post-secondary education
9) What is the occupation of the household head? (If employed)?
   a. Formal employment b. Casual employment
   c. Self-employment/Business d. Unemployed
10) How long does it take you to walk from your home to the nearest health facility?
   a. <30 minutes b. 1 – 2 Hours
   c. 30 minutes – 1 Hour d. 2+ Hours

Section D: Immunization Knowledge and Practices

1. List any benefits or effects of immunization?
   a. Help body build immunity ag
   b. Prevents spread of diseases
   c. Vaccines make children sick
   d. Don't know any
2. Do you think it is important to vaccinate your children?
   a. Yes b. No c. Not sure
3. Have you ever heard about measles vaccine?
   a. Yes b. No c. Not sure

4. Do you think it is important to have your children vaccinated against measles?

   a. Yes b. No c. Not sure

5. How many children do you have that are aged below 5 years?

   _____

Section E: Prevalence of unvaccinated children checklist

Children Information and vaccination history

I would like to get some details about your last three children at most who are below 5 years. Let me begin by asking you some questions about the children who are under 5 years

4. Demographic characteristics of children under 5 years

	Name of Child(optional)	Child 1 _____	Child 2 _____	Child 3 _____
1.	Sex	a) Male b) Female	a) Male b) Female	a) Male b) Female
2.	How old is the child	_____	_____	_____
3.	How long has the child lived here	_____	_____	_____

2. Immunization history

4.	Is the child immunized against measles	a) Yes b) No	a) Yes b) No	a) Yes b) No
4a.	Was the child immunized against measles before the year 2012	a) Yes b) No	a) Yes b) No	a) Yes b) No
5.	Was the 3rd child immunized against measles before the year 2012 (*Confirm with vaccination card)*	a) Yes b) No	a) Yes b) No	a) Yes b) No
6.	If not for 1st child, why?	_____	_____	_____
7.	Was the 3rd child infected by measles during the outbreak in 2012 and 2013	_____	_____	_____
8.	Did you take the 1st child to the health facility to be checked			
9.	How many doses of measles vaccine did the child receive?			

Appendix IV: Approval Letters

KENYA METHODIST UNIVERSITY
Department of Health Systems Management

P. O. Box 45240-00100, NAIROBI, KENYA
Tel: 020-2247987, 020-2248172
Fax: 02-248160

Mobile: 0725-751878
0735 - 372326
E-mail nairobicampus@kemu.ac.ke

6th May 2014

Kajiado County Department of Health

Thru:

Kajiado North Sub County Health Management Team

Attn: Sub County Medical Officer

Approved

Ministry Of Public Health & ...
DISTRICT MEDICAL OFFICER OF HEALTH
KAJIADO NORTH
P. O. Box 99 - 00208
NGONG HILLS
Date.....

Dear Sir/Madam

RE: SAWANI NAISIANOI EILEEN (PHT-3-4713-3/2013)

The above named student is pursuing Master of Science in Public Health degree currently a finalist. As a partial fulfillment for graduation she is required to undertake a research for learning purposes.

She has been approved to undertake a research titled **"Factors associated with measles outbreak among children below 5 years in Oloolua and Oltepesi in Kajiado North Subcounty".**

We request that you grant her permission to conduct the study in your centre.

Any assistance accorded to her will be highly appreciated.

Thank you.

Yours faithfully,

KENYA METHODIST UNIVERSITY
DEPARTMENT OF PUBLIC HEALTH
- 9 MAY 2014
Sign
NAIROBI CAMPUS
P.O. Box 45240-00100, NAIROBI

Dr. Naftal Oirere

Chairman of Department

Public Health

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 13562

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MS. EILEEN NAISIANOI SAWANI
of KENYA METHODIST UNIVERSITY,
31-1100 kajiado,has been permitted to
conduct research in *Kajiado County*

on the topic: *FACTORS ASSOCIATED WITH MEASLES OUTBREAK AMONG CHILDREN BELOW 5 YEARS IN OLTEPESI AND OLOOLUA LOCATIONS IN KAJIADO NORTH SUB COUNTY*

for the period ending:
30th March,2018

.....
Applicant's
Signature

Permit No : NACOSTI/P/17/85257/16320
Date Of Issue : 31st March,2017
Fee Recieved :Ksh 1000

.....
Director General
National Commission for Science,
Technology & Innovation

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone: +254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O.Box 30623-00100
NAIROBI-KENYA

Ref: No **NACOSTI/P/17/85257/16320** Date **31st March, 2017**

Eileen Naisianoi Sawani
Kenya Methodist University
P.O. Box 267- 60200
MERU.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Factors associated with measles outbreak among children below 5 years in Oltepesi and Oloolua locations in Kajiado North Sub County,"*** I am pleased to inform you that you have been authorized to undertake research in **Kajiado County** for the period ending **30th March, 2018.**

You are advised to report to **the County Commissioner, the County Director of Education and County Director of Health Services, Kajiado County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kajiado County.

The County Director of Education
Kajiado County.