

**DETERMINANTS, PREVALENCE, SPATIAL VARIATION OF PNEUMONIA AND
CONTROL STRATEGIES AMONG CHILDREN AGED UNDER FIVE YEARS IN
KERICHO COUNTY, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements
for the Master of Arts Degree in Geography of Egerton University**

EGERTON UNIVERSITY

OCTOBER, 2025

DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been submitted for the award of a degree or any award in any university.

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DEDICATION

I dedicate this research to the following individuals. First to my dear mum, Hellen Langat, who has supported me throughout this research. Her sacrifice and encouragement gave me energy throughout. I also dedicate thanks to my brothers, David and Japhet; sisters Evaline and Jackline and my mentor Alfayo, whose faith in me never faltered. Their companionship and love have enriched my life. This thesis is their legacy.

ACKNOWLEDGEMENTS

Many thanks to Almighty God for His gift of life and grace. Secondly, I express my deepest gratitude to Egerton University, through the staff in the faculty of Environment and Resource development and Department of Geography for providing the necessary resources to complete the study. I wish to express my sincere gratitude to my supervisors, Prof. Kennedy Ondimu, and Dr. Amon Karanja, for their intellectual guidance and supervision. Their wisdom, support, and integrity have been an unwavering source of inspiration, motivating me to strive for excellence.

Tenwek High School Senior Principal, Mr. Simon Mutali Chesebe for his invaluable support, both morally and financially who enabled me to seamlessly complete this academic journey.

I also thank the lecturers and faculty staff who supported my research from all levels. I would also like to thank the respondents from Ainamoi, Kericho County, field guides and the local administration for the success of fieldwork.

ABSTRACT

Although the government of Kenya is putting efforts to reduce the mortality in children under five years old from pneumonia and related diseases, the prevalence of pneumonia in Kenya remains higher. For example, the incidence of pneumonia grew from 8 in 2008 to 9 in 2014, and 14 in 2020 per live birth. The prevalence of pneumonia in Kenya stands at 16, which is higher than the regional prevalence of 14 found in Africa. The main aim of this research was to evaluate the determinants and prevalence of pneumonia, its spatial distribution, and household response strategies. The research was based on empirical and theoretical literature review. It was guided by germ theory and protective motivation theory. The study utilized descriptive research design involving questionnaires and interviews. The sample frame comprised 391 respondents that arrived using purposive sampling. Data was analyzed using descriptive statistics such as frequencies, percentages, and Chi-square. The results revealed that pneumonia among children under five years of age had a high prevalence of about 36% across various critical indicators. These indicators were cough, respiratory distress, and chest complications. Risk determinants of pneumonia prevalence included hereditary factors, wet cleaning practices, place of residency, and frequency of exposure to congested settings (p -value less than 0.005). Spatial analysis showed a marked spatial variation in pneumonia distribution. Ainamoi Ward with 54%; 469.3 km² was highest and Kipchebor Ward with 32%; 511.8 km² was lowest prevalence. Kipchimchim Ward recorded the lowest incidence at 14%, covering a total area of 164.2 km². Household response strategies were frequently mentioned: wearing warm clothes (31%), eating a balanced diet (11%), improving air circulation in the home (9%), avoiding places where people gather in large groups (11%). The research demonstrated high prevalence and household response methods, as well as other important findings about pneumonia, the leading cause of death among children under the age of five. These outcomes are consistent with 2030 Agenda of Sustainable Development (SDG) which aims to ensure the well-being of children at all age groups globally. The research calls for a concerted effort to overcome pneumonia and highlights the importance of strengthening healthcare infrastructure, tackling underlying risk factors, such as hygiene, improving indoor air quality, and increasing vaccination. Priority areas include the development of tailored approaches to address the specific vulnerabilities of different populations, including improved immunization programs, early detection and treatment through training of community health workers and caregivers, and the implementation of integrated community case management centers and effective referral processes.

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LIST OF ABBREVIATIONS AND ACRONYMS

ALRI	Acute Lower Respiratory Infections
ARI	Acute Respiratory Infections
AURI	Acute Upper Respiratory Infections
BETA	Kenya's bottom-up economic transformation agenda
DALY's	Disability Adjusted Life Years
DHS	Department of Health Services
GAPPD	Global Action Plan for Pneumonia and Diarrhea
GBD	Global Burden of Disease
GIS	Geographic Information Systems
GoK	Government of Kenya
Hib	Hemophilus influenzae type b
KHPF	Kenya Health Policy Framework
KHSSP	Kenya's Health Sector Strategic Plan
KNBS	Kenya National Bureau of Standards
MMR	Measles, Mumps and Rubella
MoH	Ministry of Health
NACOSTI	National Commission for Science, Technology and Innovation
NCDs	Non-Communicable Diseases
SDGs	Sustainable Development Goals
SGCID	Second Generation County Integrated plan
UI	Uncertainty Interval
UNFCCC	United Nation Framework for climate change convention
UNICEF	United Nations International Children's Emergency Fund
UR	Uncertainty Range
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

While preventable infectious diseases remain important, global child mortality rates generally decreased in recent decades. These diseases are still major cause of under-five children's death. This represents roughly 68% of all child deaths (Perin et al., 2022). According to the estimation by the Inter-Agency Group of United Nations identified birth complications, acute respiratory infections, childbirth-related problems, congenital anomalies, and diarrhea as major causes of death in this age group (UN IGME, 2024). Symptoms of pneumonia include coughing and rapid, then shallow breathing and can be fatal if associated with other childhood illnesses (Hanage & Schaffner, 2025).

Young children and premature babies are more prone to serious acute lower respiratory infections (ALRI), often due to a virus called respiratory syncytial virus (RSV). Pneumonia, a form of ARI characterized by lung inflammation, is a leading infectious cause of morbidity and mortality among children worldwide (Ayuk, 2024; Watkins and Sridhar, 2018). In 2019, pneumonia accounted for 740,180 deaths, representing 14% of all deaths in children under age 5. By 2021, combined disease burden of pneumonia and diarrhea led to about 1.17 million deaths, or 23% of all child deaths in this age range (Hanage & Schaffner, 2025). Previous research revealed that pneumonia is a leading cause of death among young children in Eastern Africa (Perin et al., 2022). This includes the 14% of child deaths in Kenya in 2019 alone (Beletew et al., 2020). However (PCVs) pneumococcal conjugate vaccines that was introduced to market in 2011 contributed significantly to reduction of pneumonia prevalence and related mortality. A study conducted in Kericho County in 2014 found a prevalence of pneumonia of 8.3% among children under five (Vandersloot et al., 2022).

Pneumonia not only causes immediate death in children but can have long-term consequences including reduced work capacity and increased risk of developmental disorders and early death in adulthood (Koh et al., 2017). Lower respiratory infections in 2016 alone resulted in more than 652,572 child deaths under the age of 5. It also caused over 1,080,958 total deaths in adults over the age of 70 which all accounted for over 2.37 million deaths globally. Chronic respiratory diseases also contributed 3.8 million deaths, accounting for 9% of the global death toll (WHO, 2016). In developing countries, ARIs contribute as much as 70% to child death-10 to 50 times higher than in developed countries (WHO, 2016). Despite

public health efforts, mortality from pneumonia continues to increase in many developing regions (Liu et al., 2018).

According to the report by Kenya Demographic and Health Survey (KDHS) of 2022, in the two weeks preceding the survey, 2% of children under five exhibited symptoms of ARI, with 82% of these seeking medical attention. However, this survey did not provide data on county-level including the study location of this research in Kericho County (NBS, 2022). The Bottom-Up Economic Transformation Agenda (BETA) highlights the importance of access to affordable and quality healthcare. These are key to economic productivity. The findings indicate that policies that focus on reducing childhood illness through access to better healthcare services will require investments in human capital, increasing labor productivity and fostering more equitable economic growth across counties. This is consistent with the health objectives in the national development plan, which aimed to develop a strong child protection system and a community-based approach to healthcare that involves partnerships between governments and local communities.

Geographic Information Systems (GIS) in health and demographic assessment have proven useful tools for spatial visualization and analysis. This tool enables the identification of trends and relationships (Carballada & Barsa-Barreiro, 2021). However, although GIS is widely adopted in the fields of land-use planning and urban analysis, spatial distribution of pandemic and epidemic remains less utilized in study area (Ahasan et al., 2020). Thus, the purpose of this study was to use GIS tools that can describe the spatial distribution of pneumonia in Kericho County. The use of GIS in tracking disease spread provides a very useful tool which can help in reducing mortality rates and contribute to human capital development. Such initiatives can enable the attainment of inclusive economic growth. This is in line with Kenya's vision of a prosperous future where healthcare interventions are localized to address the specific needs of each county.

1.2 Statement of the problem

Pneumonia is a major basis of child mortality in Kenya particularly among children under five-year-old children. Worldwide, it represents the main cause of death among this age group, and it contributes over 700,000 deaths annually. In Kenya, pneumonia is the leading cause of death in children, and it is responsible for death of over 9,000 children annually. From 1990 to 2019, the national under-five mortality rate declined from 102 to 43 deaths per 1,000 live births. However, pneumonia remains a leading cause of these deaths, with the current mortality rate standing at 6 in 1,000 live births. Pneumonia and Diarrhoea's

Global Action Plan (GAPPD) aim to reduce pneumonia-related deaths to 3 per 1,000 live births by 2025 and as a result Kenya should strengthen intervention strategies. Although the overall prevalence of overall in children under five is a concern, these prevalence rates vary from region to region. This requires the improvement of access to healthcare, vaccination coverage and public health initiatives to lower the pneumonia-related illnesses and deaths among Kenyan children. Moreover, the lack of data on pneumonia, morbidity, prevalence, and preventive measures exist in rural regions such as Ainamoi necessitate this study. Research conducted in Kericho, reported low birth weight, failure to begin breathing at delivery, and neonatal infections. These were the leading causes of neonatal deaths at the Kericho County Referral Hospital (Langat et al., 2021). This when compared with other infectious diseases, pneumonia-related morbidity and mortality in children under five were low. Pneumonia, a common respiratory infection, presents serious health risks and requires precise diagnosis and prompt treatment to improve outcomes (Torres et al., 2021). This is one of the largest prevalence and thus this study aimed to address the knowledge gap by examining the prevalence, determinants of its spread, spatial variations and control measures in Ainamoi Sub-County.

1.3 Research objectives

This section was structured around four main objectives: the prevalence, determinants, variations, and control strategies of pneumonia.

1.3.1 Broad objective

The overall aim of this research was to contribute to the reduction of pneumonia through understanding its prevalence, determinants, control strategies, and spatial variation among children under five years of age.

1.3.2 Specific objectives

- i. To determine the prevalence of pneumonia among children under five in Ainamoi sub-county.
- ii. To assess the pneumonia's determinants among children under five in Ainamoi sub-county.
- iii. To assess spatial variation of pneumonia among households in Ainamoi Sub-County.
- iv. To examine the pneumonia control strategies among households in Ainamoi sub-county.

1.4 Research questions

- i. What is the prevalence of pneumonia among children under five in Ainamoi sub-county?

- ii. What are the determinants of pneumonia among children under five in Ainamoi sub-county?
- iii. How does pneumonia vary among households in Ainamoi sub-county?
- iv. What strategies are used to manage pneumonia among households in Ainamoi sub-county?

1.5 Justification of the study

In recent Additionally, the SDGs aim to prevent avoidable neonatal and under-five deaths. All countries aim for at least 12 neonatal deaths in every 1,000 live births and death of 25 livebirth per 1,000 live births. These efforts include strengthening early warning systems and risk reduction, addressing domestic and global health threats. This research supports Goal 3 of the 2030 SDGs, which seeks to secure universal and equitable access to healthy lives and well-being regardless of age, especially by ending deaths of newborns and children under five years that are preventable (UN, 2018). Achieving this SDG target would require averting 10 million child deaths between 2017 and 2030, with most of these deaths being preventable, across South-East Asia and Sub-Saharan Africa. The health sector has been instrumental in the provision of basic healthcare services, the introduction of waiver of fees, cost-sharing and exemption policies at health centers to promote equity of access (CIDP, 2014-2017).

In Ainamoi, the gap in data related to pneumonia data highlights the need for this study. It requires better surveillance systems, real time data on incidence, mortality, and risk factors. Additionally, the exact cause of pneumonia - whether bacterial, viral, or fungal - is often unknown due to limited access to advanced diagnostic techniques such as PCR or blood cultures, especially in resource-poor settings. The study area was chosen because of the high vulnerability of under-five children who are disproportionately affected by pneumonia (Wang et al., 2024). Pneumonia remains one of the leading causes of childhood death worldwide (Hanage & Schaffner, 2025). Children in this age group are especially vulnerable because their immune systems are not fully developed and their lungs and respiratory systems are still maturing, making them more susceptible to serious infections. The high mortality rate in this population demonstrates the urgent need for research into pediatric pneumonia in Ainamoi Sub-County to address these critical health issues.

1.6 Scope of the study

The research was carried out in Ainamoi Sub-County under various configurations of urban, peri-urban and rural settlements. The urban component was represented by town

settings with buildings of a formal layout, or in some uniformity of settlement pattern, often with relatively high population density. In contrast, peri-urban was defined by a landscape 'transition zone' of interface between urban (town) and rural (rural-urban transition zone), where urban and rural land uses and functions interact and frequently conflict. The final component is the rural, which exclusively indicates the settlement pattern typified by sparse, clustered, or nucleated patterns dominated by agriculture. Pneumonia prevalence was defined as the number of reported cases in the study household during the two weeks preceding the survey. Characteristics of pneumonia cases were gathered from households, key informants, and health centers. The two-week period prior to data collection for the survey allowed caretakers/guardians and parents to remember the information and prevent repetition.

In terms of the two-week period that was observed prior to the survey date focused on caregivers' socio-demographic facts and child-related risk factors, respiratory infections, mother related risk factors and other such as household-related risk factors. Daycare-related risk factors were collected using a structured registration document distributed at the daycare center to the day care workers in charge of each child. It contained questions on type of premises, room size, household activities, number of children per room, type of ventilation, heating, illumination, existence of an isolating room, hygiene behaviors, disinfection frequency in daycare premises, and hand washing. The epidemiological variability of the cases studied was low, as recommended in Morice et al. (2020) with a one-month survey cycle.

In terms of determinants, the study employed a triple bottom line framework. Thus, the study addressed social, economic and environmental factors influencing pneumonia prevalence and spatial variability. Social conditions such as family structure, housing type, design, occupation, diet, and overcrowding in the household. Economic determinants comprise household structural attributes like construction materials, ventilation, income, education level and environmental analysis, household hygiene, waste disposal practices, indoor pollution that are associated with cigarette smoking and fossil fuel combustion.

1.7 Limitations of the study

The study faced some challenges during field data collection. One key issue was the reliance on symptomatic diagnoses provided by parents, house help, and guardians, which introduced subjectivity into the data. Additionally, some respondents were hesitant to give data about the disease under investigation. The researcher provided preliminary awareness on the goal of the study and its potential benefits in solving household health issues.

1.8 Definition of terms

- Childhood pneumonia** Includes the inflammation of the lungs mostly due to infection or bacteria or inhalation of chemicals. In this study childhood pneumonia would refer to the percentage of children that exhibit symptoms such as rapid breathing, short, and/or difficult breathing which is chest-related among the children of under age 5 of age.
- Determinant** is a factor or causal agent that makes something happen or leads directly to a decision or an element that identifies or determines the nature of something or that fixes or conditions an outcome.
- Determinants** These are personal, socio-economic (education, income, status or rank, social class and environmental variables such as biomass heating, fuels combustions, smoking and, living in crowded homes and parental smoking) which determine the individuals or populations' health.
- Household (HH)** This was the basic unit of inquiry and analysis of main data. For this purpose, HH was defined as people who share meals and live within the same compound, and have a common major source of income, and have shared essentials.
- Housing characteristics** This refers to both size and quality factors of the HH such as ventilation and crowdedness of sleeping conditions that can predispose household members to respiratory infections.
- Prevalence** This is the total number of individuals in a population with health conditions at a specific time.
- Risk factors** The range of biological status, socio-economic or personal and environmental factors which influence individuals' or populations health and are associated with or increased susceptibility to specific ill health or injury or disease.
- Spatial variation** This refers to differences in a measured property, phenomenon, or variable across different locations in space, it describes how a characteristic—such as population density, disease incidence, environmental factors, or genetic traits—changes from one place to another, often due to underlying environmental, biological, or social factors.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter reviews relevant Literature on prevalence and variation of pneumonia, determinant of prevalence of pneumonia and pneumonia response strategy. The theoretical framework and conceptual framework were also presented.

2.2 Influence of geology, drainage, and topography on child pneumonia

The geology of a given area can influence environmental health. These include the quality of soil, the presence of various minerals, and the availability of water, which, in turn, can affect respiratory diseases, such as pneumonia (Bundschuh et al., 2017). The reason is that geology influences hydrology, landforms, and ecosystem diversity, which directly and indirectly affect human health (Walls and McGarvey, 2023). For instance, research indicates that increased landscape biodiversity can have underlying geological features which can contribute to improved respiratory health. This could be due to more diverse microbial exposures that help support the immune system (Liddicoat et al., 2018).

The geology within a given area can make a difference to environmental health. These include the quality of soil, the presence of various minerals, and the availability of water, which, in its turn, may influence respiratory diseases, such as pneumonia (Bundschuh et al., 2017). The reason is that geology affects hydrology, landforms, and ecosystem diversity, which directly and indirectly impact human health (Walls and McGarvey, 2023). For instance, research shows that enhanced biodiversity across landscapes can be accompanied by underlying geological features which can contribute to better respiratory health. This might be due to higher microbial exposures that help support the immune system (Liddicoat et al., 2018).

Climate and geology also influence both air and water quality because these are linked to the incidence of respiratory diseases including pneumonia (Bundschuh et al., 2017). High exposure to dusty and rocky soils also worsens the concentration of particles in the air, and this is predisposing the respiratory conditions. This is common in vulnerable populations, including children. Studies, such as that by Brauer et al. (2016), have linked pneumonia and other respiratory infections with excess exposure to dust, particularly in areas of dryness, where exposure can worsen pre-existing respiratory issues and weaken immune responses in young children. Some topographical features may also contribute to soil contamination, leading to an increased lung disease risk based on a higher pathogen load in the environment.

Drainage is another key environmental health variable. For instance, inefficient drainage systems can lead to stagnant water, which in turn becomes the breeding ground for pathogenic and disease vectors (Liddicoat et al., 2018). In places where there are poor drainage-informal settlements or rural communities, for instance-wet, unsanitary conditions can contribute to spreading infections. Poor water quality and sanitation, according to the World Health Organization (WHO, 2019). These are linked to increased rates of pneumonia as bacteria and viruses can persist in these environments and affect the respiratory function of children. Stagnant water also increases the risk of mosquito-borne illnesses by contributing to health troubles in areas already prone to respiratory infections.

The geographical features like its altitude, hills, and valleys can affect the pneumonia rates. For example, poor ventilation in lower locations may lead to localized contaminants and moisture that facilitates the spread of respiratory infections. Research by Liddicoat et al. (2018) shows that areas with poor air circulation and high pollutant retention correlate with increased risk of respiratory diseases, including pneumonia. High-altitude areas, according to a 2018 study by Liddicoat et al., can cause low oxygen levels, which may adversely affect lung function and susceptibility to pneumonia. In these areas, kids are more likely to struggle with respiratory distress, and the low oxygen levels might make the risk of pneumonia worse. Additionally, geographic barriers, such as hilly or remote terrain, can impede accessibility to healthcare services, making it more difficult for affected populations to receive timely treatment. The failure to provide immediate medical intervention, including the administration of antibiotics and other interventions, can lead to delays in recovery and increase the risk of complications and mortality, especially in young children (Henderson et al., 2014).

2.3 Prevalence of pneumonia

Pneumonia is a frequent public health challenge, as it leads to high deaths and disabilities in children under the age of five. ARIs which pneumonia is a major component of it, are the largest causes of death in children in this age range and this 18% of deaths. Pneumonia is a leading cause of death among children worldwide, with the highest rates occurring in sub-Saharan African and South Asian regions (GBD Chronic Respiratory Disease Collaborators, 2020; WHO and UNICEF, 2013). In developing countries, ARIs rank as the most common cause of childhood illness, making up around 70 percent of childhood diseases.

Pneumonia contributes roughly 3.5% of global burden of disease, representing 30-50 percent of outpatient visits in pediatric populations and up to 30 percent of pediatric hospitalizations in these regions (Adesanya et al., 2016). In 2018, Kenya ranked among the top 15 countries with the highest prevalence of pneumonia, accounting for 74percent of global pneumonia cases. In 2013, pneumonia was the leading cause of death for children in Kenya (UNICEF, 2014).

Respiratory infections account for about 6 percent This is higher than in cancer, diarrheal diseases, HIV, malaria, and ischemic heart diseases (Mizgerd, 2006). Pneumonia, a form of ARI, is a major cause of childhood illness and death globally, with significant demands on health systems and severe economic and psychological burdens on households. Pneumonia causes 94 million DALYs (or 6.3 % of the KH burden), and 1.9 million deaths worldwide each year. In developing nations, mortality rates from pneumonia are 10-50 times higher than in wealthier nations (Broor et al., 2007; Colvin et al., 2013; UNICEF/WHO, 2014; Williams et al., 2002).

Acute Lower Respiratory Infections (ALRIs) composed of bronchitis, bronchiolitis and pneumonia contributed to approximately 20percent of total deaths in children younger than age 5. In this, pneumonia alone accounted for over 90 percent of these deaths. *Streptococcus pneumoniae* is the most common cause of lower respiratory infections worldwide, responsible for more than all other germs combined as of 2016 (WHO, 2016). Pneumonia, characterized by cough and rapid, shallow breathing, can be deadly, particularly when additional health conditions are present (Johnson & Karim, 2013). Studies show that over the past 20 years, the rates of pneumonia have decreased substantially. In 2017, approximately half of these 5.4 million children under the age of five who passed away were in sub-Saharan Africa. This is where ARIs remains the leading cause of death (GBD, 2017). Pneumonia is a leading cause of death among children worldwide, especially across South Asia and sub-Saharan Africa. Disease is preventable with basic measures and treatable with affordable treatments (WHO, 2019).

Maternal mortality rates are high, around 500 deaths per 100,000 births. The perinatal mortality rate is 63 per 1,000, so one in 15 babies dies during delivery or in the first week of life. Child mortality hovers around 55/1000 live births, primarily because of poor living conditions, insufficient immunization, minimal parental education and lack of access to healthcare. In Kericho County, 22 % of the population has at least a secondary level education and 16 % have no formal education. In 2007, the countries with the highest childhood pneumonia rates were in Africa and South-East Asia and. These areas were

responsible for approximately 35 and 61 million cases annually respectively in the under 5 categories alone (Rudan, 2008). By 2010, pneumonia cases in children under five declined to 120 million (including 0.88 million deaths) and then to 102 million in 2015 (with 0.7 million deaths). These improvements are attributed to improved socio-economic conditions, access to healthcare, and preventive measures. Despite these improvements, pneumonia remains a major public health problem in developing countries, with children under five at high risk for morbidity and mortality due to pneumonia (McAllister, 2015).

2.4 Mapping of spatial variation of pneumonia using GIS based technologies

Epstein et al. (2014) and Feemster et al. (2013) surveyed on spatial variation in health, such as poorer health indices and higher respiratory illness as observed in lower-income neighborhoods and communities. The higher population density in areas of lower socioeconomic status has been linked to spatial associations with respiratory tract infections (Han et al., 2104), exposure to environmental particles and pollutants (Tam et al., 2017) and health care access (Hossain et al., 2021). Reported heterogeneity is utilized to calibrate resource-provision, allowing for hospitalization avoidance (Tam et al., 2017).

GIS could aggregate different data sources (spatial, temporal, descriptive) in a single structure (Kiani et al., 2020; Hoseini et al., 2018). Spatial components capture information about the physical location of health events and the geometric shape of objects. Urban, rural and peri-urban are the urban components in our study. GIS offers essential tools for identifying geographical patterns and spatial relationships in distribution of pneumonia as well as potential environmental determinants and settlement characteristics (Goshayeshi et al., 2019; Halimi et al., 2020) with tools for data collection, geo-location, analysis and visualization.

Spatial interpolation methods produce a surface grid or contour map (Kumar et al., 2016). The concentrations of the disease in areas of survey can be approximated using interpolation methods based on known concentrations at a smaller number of points.

GIS is a computerized tool that stores, analyzes, manages, and presents spatial or geographic information in any form, and, when used with the professional judgment of the GIS analyst or user, can be used to solve spatial problems. The main uses of GIS technologies by different researchers have been to examine the spatial and temporal spread of pollutants, the spread of diseases, and environmental variations. (Jensen et al., 2001; Maantay, 2007; Marquez and Smith, 1999; Sohrabinia and Khorshiddoust, 2007; van Westen, 2004).

To understand, and to act on, the epidemic we need to understand the drivers and processes of spatial variation in pneumonia prevalence. An essential tool for this is geospatial analytical methods like remote sensing technology and GIS. However, despite a dramatic increase in the use of such geospatial tools in understanding public health problems and the design and implementation of interventions as well as in the assessment of intervention outcomes, spatially explicit research on pneumonia in sub-Saharan Africa remains extremely limited (Halimi et al., 2020; Tanser et al., 2009).

2.5 Determinants of pneumonia prevalence

In sub-Saharan Africa, the estimated mortality rate for pneumonia in children ranges from 17% to 26% (Konadu et al., 2019). Predictors of higher mortality include low weight-for-age, poor family income, heart disease, and advanced stages of pneumonia, and protective factors include breastfeeding, indoor air pollution, and respiratory syncytial virus (RSV) detection (Fekadu et al., 2014; WHO, 2014). The pediatric pneumonia's key risk factors for include inadequate breastfeeding, low birth weight, malnutrition, indoor air pollution, incomplete vaccination, HIV, family crowding, and underlying conditions such as heart disease (Jackson et al., 2013). However, serious constraints such as insufficient numbers of qualified health care workers, poor health care facilities, poverty, the high incidence of HIV/AIDS, and lack of funds for health sector continue to be widespread. In response to these challenges, the county is working to improve healthcare facilities and promote awareness of healthy behaviors (KCO, 2020).

Children with weakened immune systems, such as those who are malnourished or not exclusively breastfed, are more vulnerable to pneumonia (Chisti, 2009; WHO, 2016). The most vulnerable children are those in the early years of life, with children under five years typically experiencing 4 to 6 episodes of pneumonia annually, resulting in 10-25% mortality in developing countries (WHO, 2006). The under-five mortality rate in Kenya stood at 52 per 1,000 live births in 2014, down from 74 per 1,000 in 2009 (KNBS 2015; Okiro 2019). In Kenya, pneumonia and other lower respiratory infections contribute to substantial health loss in children aged 1 to 5 years. Pneumonia risk factors differ by region, and housing conditions and environmental factors are important for pneumonia transmission in children (Park, 2015).

Evidence from developing countries indicates that severe pneumonia is strongly associated with low birth weight, smoking, formula feeding, early weaning, young maternal age, poor nutrition, indoor air pollution, low parental education, and premature birth (Penner et al., 2003; Pore et al., 2010). Several factors are associated with predisposition to

pneumonia in children under the age of five, such as child-specific factors like age, maternal factors like unemployment, low education level, environmental factors like urban or rural residence (Kumar et al., 2017; Prajapati et al., 2012), seasonal variation (Fienemika et al., 2018), co-existing diseases (Dadi et al., 2014). This research intends to fill the knowledge gap by identifying pneumonia prevalence, variation and mapping of its occurrence and by providing policy recommendations to tackle the issue.

2.5.1 Exposure to indoor air pollution

In many parts of Africa, biomass fuels are major source of energy for most cooking, heating, and lighting. These contribute to indoor air pollution that is a leading cause of respiratory diseases, and it includes pneumonia in children. Open fires are a major source of exposure for women and children due to incomplete fuel combustion and reduced ventilation (Gordon et al., 2014). The World Health Organization (WHO) has recently identified indoor air pollution from solid fuels as the major factor that can be prevented causes of disability-adjusted life lost (Rees et al., 2019). Indoor Solid Fuel Smoke Exposure was also recently classified by the World Health Organization (WHO) as one of the largest preventable risk factors contributing to disability-adjusted life-year (DALY) losses (Rees et al. 2019).

Indoor air pollution doubles the inhibitory effects of pneumonia in children and has resulted in increased pneumonia-related deaths worldwide (UNICEF, 2016). Air pollutants compromise your immune system, rendering your body vulnerable to respiratory illness (Hussey et al., 2017; Smith et al., 2000). Open biomass burning, including products from animals and plants, is recognized as one of the leading preventable causes of pneumonia in young children (Gordon et al., 2014; WHO, 2014). Women and children spend substantial time in kitchens, where cooking fires expose them to smoke. They carry their young onto the shoulders of their mothers, who subsequently subject them to toxic smoke. Due to their vulnerabilities to respiratory suspended particles (RSP) generated by incomplete fuel combustion, women and children are at higher risk of acute respiratory infections (ARI) in these settings (Naz et al., 2020; Tun et al., 2005).

2.5.2 Socio-economic status among household members

The challenge associated with pneumonia is high in low-income countries due to poor access to healthcare, nutrition, and basic sanitation resulting in higher prevalence of the disease. In Kenya, biomass fuels are the major source of energy for cooking and heating in low-income households, causing high levels of particulate matter and carbon monoxide

emissions indoors. Emissions in some households have been found to be up to 1,000 times higher than the acceptable levels, thereby raising health risks (Mwangi, 2017).

2.5.3 Malnutrition

Malnourished children are more susceptible to ARIs because poor nutrition leads to immune system weakness, which in turn makes them more vulnerable to infections (Mirji, 2014). Stunting, which affects lung development, further predisposes children to respiratory failure and reduces their survival chances from pneumonia. Undernourished children who develop pneumonia also have a higher risk of stunting (Batiro et al., 2017).

2.6 Pneumonia response strategies at household level

Millions of children could be saved from pneumonia and diarrhoea. According to the Pneumonia and Diarrhoea Global Action Plan on Prevention and Control (GAPPD) provides a targeted approach to reducing preventable deaths related to these diseases. The plan promotes practices that protect children from disease and combines interventions and services to create healthy environments and contribute to effective prevention and treatment reaching all children. The vision is ambitious but tangible: to eliminate preventable childhood deaths from pneumonia and diarrhoea by 2025. There's already a strong impetus to achieve this goal: much progress has already been made in improving child survival in the past two decades, well ahead of the MDG target of child survival by 2015.

Adopted by the United Nations in 2010, the Global Strategy for Women's and Children's Health emphasize a continuum of care approach with the goal of saving 16 million lives. Every Woman Every Child (EWEC) movement has been actively working to reduce child mortality. As part of the Promise Renewed initiative, the global community committed in 2012 to reduce child mortality to less than 20 deaths in every 1,000 live births global economies by 2035. Other major initiatives that contributing to this effort include the Global Vaccine Action Plan, which aims to prevent childhood disease through vaccination. The WHO-led initiative to improve infants and maternal and the United Nations Sustainable Energy for all initiative. This aims to provide universal access to modern energy services by 2030. Additionally, the United Nations Commission on Life-Saving Commodities has called for action to expand access to life-saving products, such as pneumonia and diarrhea, and the Commission on Information and Accountability has bolstered monitoring of women's and children's health programs.

The GAPPD delivers a portfolio of evidence-based interventions for preventing and treating childhood pneumonia and diarrhoea. While these interventions are well established,

they are not always delivered in concert in a way that maximizes effectiveness. Because prevention and treatment strategies for pneumonia and diarrhoea typically overlap, so do the risk factors, including health-care facilities, family-based approaches, community approaches, and schools. Respiratory diseases remain a major cause of morbidity and mortality among children. The focus has been to prevent early detection, and effective treatment. For instance, the elimination of household air pollution, ambient particulate matter pollution, and improvements in antibiotic use in countries where respiratory infections are common could prevent one death from lower respiratory infection in children under the age of five.

2.7 Summary of knowledge gaps

Although numerous research has been carried out on Acute respiratory infections (ARI), data on prevalence pneumonia in under-five children is limited in Kericho County. Earlier research was centered on the prevalence and distribution of ARI in urban centers with high population density and inadequate social amenities. Thus, to the aimed to bridge the knowledge gap by comparing the prevalence of pneumonia in the under-five children in urban and peri-urban settlement.

GIS and spatial analysis are essential in identifying geographical locations with high burden of disease transmission to inform targeted interventions. Nevertheless, previous research in Kenya has concentrated on prevalence and factors related to the disease. Additionally, the results of these studies are inadequate and restricted to reflect geographic trends of the disease. Thus, the aim of the present research was to investigate the spatial distribution and determinants of pneumonia among under-five children in the selected sub-county in Kericho County through geographic analysis methods.

Although the progress in the characterization of major etiologies, incidence, and factors remains consistent, gaps in knowledge about severe respiratory infections remain (Rudan et al., 2015). Addressing these gaps is essential to make sure that scarce public health resources are optimally directed to viable, effective interventions. In terms of the effectiveness of the response strategies, past research surveyed identified the prevention strategies and government intervention strategies. But there is a gap in the response strategies at the household level.

Table 2.1: Summary of Knowledge Gaps

Objectives	Key findings	Sources	Research gap
Pneumonia prevalence among children	WHO (2013) and UNICEF ranked pneumonia among under-five children at one-fifth cause of mortality globally and they reported that pneumonia remains the main cause of morbidity and mortality. Colvin et al., 2013 identified pneumonia as among the most common causes of both mortality and illness and in young children especially in low-income countries.	WHO (2013) and UNICEF (2013) and Colvin et al., 2013	No recent prevalence analysis (2023) especially in Kericho County.
The determinants of pneumonia among children under five	Fekadu et al. (2014); WHO (2014) and Jackson et al. (2013) identified major risk factors as: Low birth weight, household crowding, incomplete immunization, low family income, under-nutrition, Pré-existing illnesses such as heart diseases, HIV; poor breastfeeding, indoor air pollution and respiratory syncytial virus	Fekadu et al. (2014); WHO (2014) and Jackson et al. (2013)	In location where study was done there are other risk factors that have not been addressed such as types of household energy fuel, ventilation, proximity to health facilities etc.
Spatial variation of pneumonia among household	They identified spatial relationship with respiratory related infections in areas with lower socioeconomic status (population density), increased environmental pollution etc.	Han et al. (2014); Tam et al. (2017) and Hossain et al. (2021)	The studies did not factor in the rural, peri-urban and urban components in spatial variation analysis.
The ARI control strategies among the household	They identified major preventive interventions such as vaccinations, diagnosis and systematization and standard treatment given by primary care health workers.	Obaro and Adegbola (2002),	Household response strategies therefore remain a gap.

2.8 Theoretical framework

Fundamental Cause Theory and Social Determinants of Health (WHO framework) guided this study. Socio-economic determinant pneumonia includes Bacteria, (*streptococcus pneumoniae*, *mycobacterium tuberculosis*), Viral i.e., influenza, Respiratory syncytial Virus (RSV) and Rhinovirus (common cold), Fungal lifestyle risk factors (smoking, excessive alcohol use, malnutrition).

2.8.1 Social determinants of health (WHO framework)

Social Determinants of Health concept has gained prominence as a framework for understanding how socio-economic, cultural, and political factors influence health outcomes. SDH are "the non-medical factors that influence the outcomes of health,". This includes the conditions in which people are born, grow, live, work, and age, and the systems that shape daily life circumstances (WHO, 2008).

The WHO Commission on Social Determinants of Health (CSDH) categorized the determinants into three main elements: the structural determinants, the intermediary determinants, and the socio-political context. Structural determinants are the broader socio-economic and political processes that create social stratification, including governance, policy, and cultural norms. These aspects determine individual socio-economic position (SEP) in terms of education, occupation, income, gender, and ethnicity, which in turn define exposure to risk factors and access to resources (Solar and Irwin, 2010).

Intermediate determinants: material circumstances (housing and neighborhood quality), psychosocial factors (stress), biological and behavioral factors, as well as the health system. These operate at the interface between personal experience and structural realities. Food insecurity and inadequate housing quality have been linked to adverse health outcomes and chronic illnesses (Marmot et al. 2012). Moreover, job insecurity or discrimination, linked to psychosocial stress, could make them even more susceptible to disease (Marmot et al. 2012).

Additionally, social determinants of health / inequalities which cause inequalities The health care system is a social determinant and cause of inequalities. Others are inequitable access, affordability, and quality of care are often a reflection of wider socioeconomic disparities (Braveman and Gottlieb 2014). Health systems in many middle-income and low-countries (LMICs) are insufficient, particularly among marginalized populations. These perpetuates a cycle of poor health and poverty (WHO, 2013). The distribution of power and resources that lead to health disparities are influenced by the socio-political environment,

such as macroeconomic policies, social policies, and governance structures. For example, the neoliberal economic reforms in many countries have led to a decreased state investment in health and social services, worsening inequalities (Navarro, 2007). There is a need to advocate the means of health policies that embody health equity in all realms of government and policymaking (WHO, 2010).

The WHO framework is empirically grounded, with evidence showing that reductions in social inequality can lead to improved population health outcomes. As an example, Scandinavian countries with fairer social policies exhibit better health indicators and decreased health inequalities compared to countries with less redistributive structures (Raphael, 2016). In this regard, it is unlikely that public health interventions focused solely on proximal causes of disease without addressing underlying social inequalities will prove successful in the long-term.

2.8.2 Fundamental cause theory

The Fundamental Cause Theory (FCT) proposed by Bruce and Phelan in 1995 offers a critical lens to explaining the persistent health disparities. As defined in *The Health Status of Populations in Developing Countries* by Link and Phelan, the underpinning factors are social factors, particularly socioeconomic status (SES), which has always influenced various disease outcomes in a multi-factorial way, and most importantly, transcends time despite the varying mechanisms between them and disease (Link and Phelan, 1995).

Among the most important lessons of FCT is that stretchy resources that comprise of prestige, power, knowledge, money, and beneficial social networks allow people to escape risks and implement protective measures regardless of how the nature of health threats change. Therefore, the health outcomes of people with more resources are always better than the health outcomes of people with less resources (Phelan et al., 2010). FCT has concerns about the persistence of health disparities despite medical progress. As an example, when new health technologies or treatments are developed, health disparities are prone to grow rather than diminish because people with higher socioeconomic statuses are more likely to access and use these new technologies (Link et al., 2015). This trend has been shown in contexts as diverse as heart disease interventions and cancer screening programs.

Additional empirical research has substantiated the theory's propositions. Luftey and Freese (2005) showed how unequal access to and utilization of information on health risks can contribute to SES-based variability in the management of diabetes. On the same note, Krieger et al. (2008) found that even with universal health coverage, racial and

socioeconomic inequalities in mortality remained, indicating that structural social forces were operating beyond the health care system itself.

Critiques of FCT have pointed out that while it emphasizes enduring inequalities, it may under-theorize the mechanisms by which resources are mobilized or contested (Hatzenbuehler et al., 2013). Nevertheless, Link and Phelan's later work expanded the theory to incorporate the role of stigma as a fundamental cause of health inequalities, particularly in contexts such as mental health and HIV/AIDS (Phelan et al., 2008). Among the trends emerging in the use of FCT is the interplay with policy discourse. According to Link and Phelan (2005), effective health equity initiatives must not only focus on addressing the immediate causes of disease but also involve allocating resources that are flexible. Such a view locates structural interventions such as education reform, wealth redistribution, and anti-discrimination policies on an equal footing with more traditional health promotion initiatives.

2.9 Conceptual framework

The conceptual framework presented in Figure 2.1 emphasizes the relations between the factors determining occurrence and spatial variability of pneumonia in children under five years of age. The framework identifies 2 dependent variables. These are prevalence of pneumonia in children and geographical variation in pneumonia rates. The independent variables encompass both determinants of childhood pneumonia and the control measures undertaken by households. These variables determine the outcomes of the dependent variables. Under the following framework the interplay between different factors and their impact on pneumonia rates are illustrated.

The independent variables influenced pneumonia prevalence and risk in children were measured at individual, household, and community levels. At the individual level it included personal hygiene practices, handwashing, cleanliness, and good sanitation. Additionally, underlying health issues such as asthma and malnutrition can predispose children to pneumonia. The role of the immune system is also key, as the immune system is the body's first line of defense against infections, including pneumonia. A strong immune system can mean the difference between a mild illness and a life-threatening condition. At the household level, structural and socio-economic factors exert a profound impact. Settlement patterns-urban, rural, or peri-urban-affect access to healthcare, exposure to environmental pollutants, and living conditions. Housing conditions also matter; overcrowding, poor ventilation, mold, or poor sanitary conditions can create an environment favoring respiratory infections. Socio-economic factors such as parental education, household income, and access to healthcare also serve as risk factors of pneumonia. Families with poor

financial resources delay access to medical care or struggle to create a healthy living environment. This makes them more vulnerable to infections, such as pneumonia.

Environmental conditions such as poor air quality, inadequate sanitation facilities, and disease vectors influence the prevalence of pneumonia. The responsiveness of health agencies is also critical. Through community-wide immunization, standardized treatment guidelines, and education of the population about health to improve understanding and reduction of protective behaviors, Intervening variables include government policies (e.g., Public Health Act CAP 242) and public health sanitation guidelines that influence the overall health environment and approaches adopted at household and community levels. These factors collectively affect the prevalence and geographic distribution of pneumonia in young children and the effectiveness of control strategies.

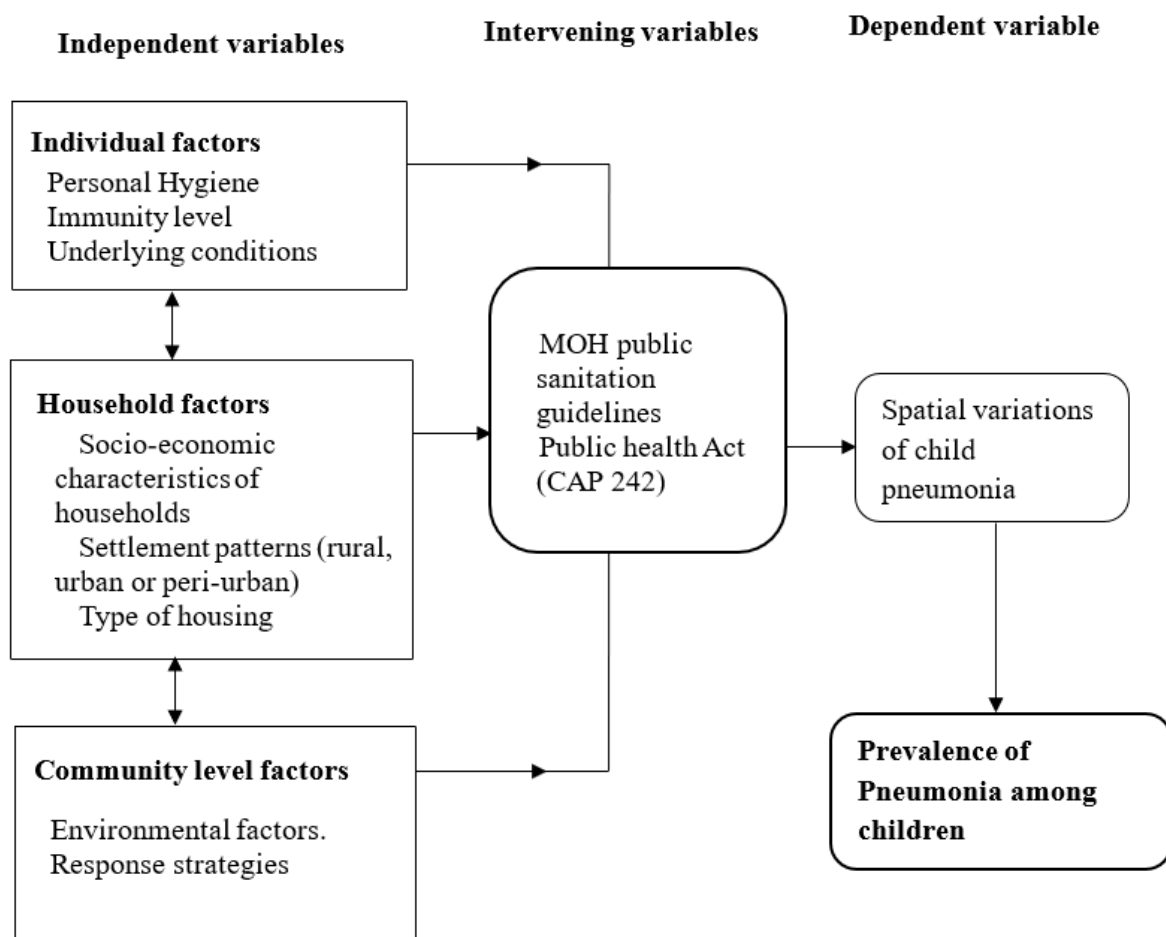


Figure 2.1: Conceptual framework

Source: Adopted from Lanks et al. (2019)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter gives a brief overview of the methods used, the description of study area, research design, and sample size and sampling procedure. It also outlines the data collection protocols as well as ethical consideration and data analysis.

3.2 Study area

The study took place in Ainamoi sub-county, Kericho County. Ainamoi is one of the six sub-counties within Kericho County, with its county administrative headquarters in Kericho Town. It covers approximately 239.9 square kilometers of the Earth's surface, extending from latitude 0deg13'30"S to 0deg22'30"S and from longitude 35deg15'0"E to 35deg19'30"E. The sub-county is further subdivided into eleven localities and twenty-four sub-locities. According to 2019 Kenya Population and Housing Census (KPHC), Ainamoi has a population of 170,625 people, out of which 86,671 are male, 83,947 are female, and 7 are intersex. There are 44,246 households and the average household size is 3.8. Administratively, the sub-county is divided into six wards: Kapsoit, Ainamoi, Kapkugerwet, Kipchebor, Kipchimchim, Kapsaos.

Residents of Ainamoi are youthful, with children aged 0-14 years accounting for 44% of total population, equating to 354,800 persons (KNBS, 2019). However, over 55% of households lack access to safe water, and as many as 80% lack latrines. Degraded environment (due to the escalating growth of tea and coffee factories, population pressure on tracts of land including water catchments and hill-tops, urbanization and migration from rural areas, unplanned settlements, weak enforcement of environmental policies, poor solid waste management and lack of awareness about environment). The issue of waste remains a significant constraint in urban centres in Kericho County (Kericho County Strategic Plan 2019-2020; SGCIDP 2018-2022).

Kericho Town generates an estimated 90 tons of garbage daily, while Litein Town generates more than 6.4 tons per day. In 2014, the morbidity rate of pneumonia in children under 5 years in Ainamoi Sub-County was 1,881 outpatients, representing 6.524% of total cases. The sub-county is served by a number of health facilities: 10 hospitals, 4 sub-district hospitals, 12 health centres, 133 dispensaries, 15 private clinics, and 1 nursing home (Ainamoi in Ainamoi Constituency), Kericho County Strategic Plan 2014-2017. Regarding human resource personnel, the county has 43 nurses, 8 doctors, and 16 clinical officers per

100,000 residents (KDHS, 2014). Pneumonia was the leading cause of under-5 mortality worldwide, causing 1,755,000 deaths in 2000, with that figure declining to 802,000 by 2018 (UNICEF, 2019).

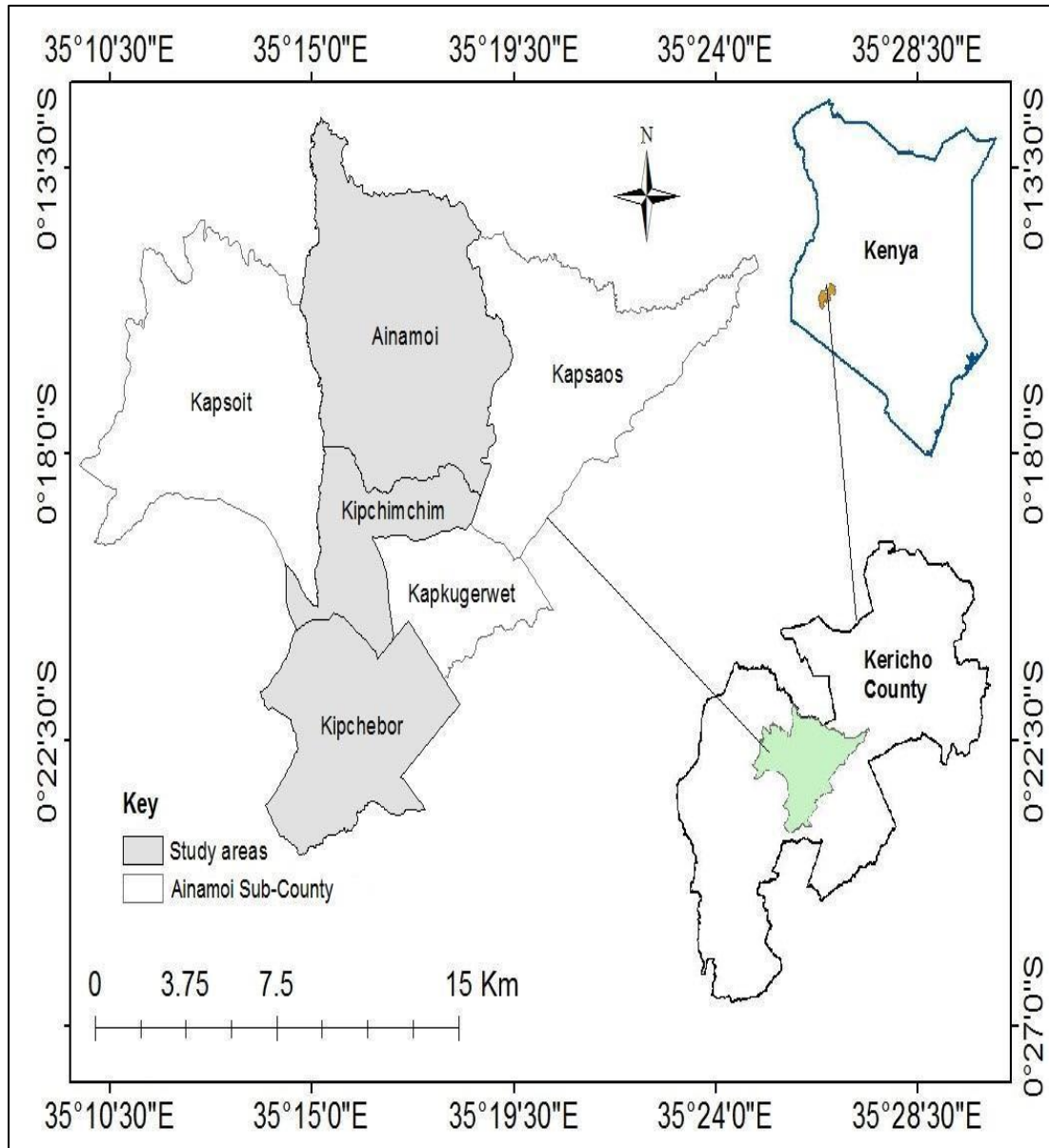


Figure 3.1: Map of the study area showing study sites

3.3 Research design

Descriptive research design was used to assess the determinants and distribution of pneumonia cases in the study area. Household questionnaires were used to collect quantitative data and this tool was administered through face-to-face interviews in selected households. In addition, qualitative data was collected through semi-structured

interviews. Key informants were drawn from health facilities and other stakeholders (e.g., public health department). This data enabled an understanding of the context and determinants of pneumonia cases. Trends and patterns were characterized by the number of pneumonia cases reported during the survey period.

3.4 Target population

The target population of the study were parents, guardians and caregivers within all households in Ainamoi Sub-County who had children under five years of age. The study also targeted health care facilities.

3.5 Sampling procedure and sample size

Yamane formula (1967) was used to determine the sample size of the study. In the three selected wards— Ainamoi, Kipchimchim and Kipchebor, the estimated population size was 63,743 which forms the sampling frame (KNBS, 2019). Since the average household size was 3.8, the target households were 16774. In each ward one location was sampled. According to Yamane (1967) a sample size n can be determined as follows.

$$n = \frac{N}{1+e^2N}$$

(1)

Where:

n - sample size

N - Target population = 16774

e - error term = 0.05

$$n = \frac{16774}{1 + (0.05^2 * 16774)}$$

$n = \mathbf{391}$

The study area was selected since Ainamoi sub-county had aspect of urban and rural settlement types which highlight the variation in pneumonia prevalence and potential conclusive evaluation of the causative factors. In sampling, three aspects of demographic were observed. The first aspect is the urban component which represents a setting with exclusive town setting characterized by planned buildings, or with some uniformity in settlement pattern and often densely populated. Based on these characteristics, Kipchebor ward was classified as urban. The second component is the peri-urban which represents the landscape interface between urban (town) and rural (countryside), and in the study area, Kipchimchim ward was delineated as rural—urban transition zone where urban and rural uses and functions mix and often clash. The last component is the rural area, which exclusively

represents the settlement patterns characterized by sparse or clustered or nucleated patterns with no major town setting and is dominated by agricultural activities.

Sampling was done at household level and health facilities level because the pneumonia determinants is best evaluated at household level while the prevalence rates can be available at health facilities. For the administration of survey questionnaires to households, the participants were identified using multistage and stratified. Multistage sample design techniques were administered in three stages. Stage 1 was stratification i.e., rural, urban or peri urban. Stratified sampling protocol was used to select the study locations. Stage two was giving proportions thus providing clusters. Proportional sampling was used to select households from each stratum. Each of the six wards was treated as unique strata. Three administrative wards were selected based on nature and type of settlement, Kipchebor ward (urban) with four locations namely, Kapsuser, Kakiptui, Township and peri-urban wards of Motobo, Kipchimchim ward has three locations Kichimchim, Chepkolon, Taiywet and Ainamoi ward represents rural classification, and it has three locations; Poiywek, Laliat and Ainamoi. In each ward, two locations were selected as representative samples. Stage three involved the identification of households by using purposive sampling which relied on community health promoters and area chiefs to get households with children under five.

A total of eight health facilities were visited and medical practitioners were interviewed because health data records were inaccessible. This qualitative data was used to triangulate the quantitative data and provided comparison of both sets of data. Additionally, the qualitative data were used to identify the common pneumonia response strategies based on morbidity cases in health facilities.

3.6 Data collection

Structured household questionnaires were used to collect information for the study. In addition, the interview schedule was used to validate the data on prevalence of pneumonia by collecting information on the morbidity rates, infant mortality and etiological information. The information collected in household questionnaire included household characteristics that includes; levels of household hygiene, type of housing, type of fuel used, parental occupations, literacy levels among the parents, income levels, food profile, population density, general household lifestyles, ventilation status; individual factors that includes presence or absence of underlying conditions, prevalence of pneumonia, immunity levels, determinants of pneumonia prevalence, spatial variation of pneumonia that includes the rural and urban based component, effectiveness of household strategies such as enhanced level of

awareness, following the MOH guidelines, hygiene, improved housing structure, promoting child immunization.

3.6.1 Household surveys

Structured questionnaires were used to collect quantitative data. The questionnaire tool was administered to the respondents using face-to-face interviews with the sampled respondents.

3.6.2 Key informant interview

The interview schedule was used to collect qualitative data from key informants. The researcher made appointments with key informants for the scheduled interviews. The interviews were guided by lead questions formulated from the objectives of the study.

3.7 Validity and reliability test

The tool was piloted in Mogogosiek Ward of Bomet County to test its reliability. This was done to see if the instrument requires any corrections before actual data collection, with a lesser sample size of around 10 households as advised by Creswell and Creswell (2017). Traditionally, quality can be defined in terms of reliability, which is the degree to which an instrument is expected to yield consistent results when measurements are repeated (Taber, 2018). To verify the reliability of the questionnaires, 10 respondents from rural areas and 10 respondents from urban areas were randomly chosen to answer the questionnaires during piloting. The people who took the pilot were not included in the study population to prevent biases. Cronbach's alpha coefficient was then computed. The instrument's coefficient is 0.7 and above, which is considered reliable and acceptable for the study (Creswell & Creswell, 2017).

The findings from the pilot survey were used to restructure the questionnaires by adding missing information, removing questions that are not relevant and rephrasing questions that might be ambiguous to the respondents.

Validation refers to a collection of facts to support the inferences drawn from scores derived from measurement activities (Creswell & Creswell, 2017). Validity is established by generating a hypothesis about how a test or instrument should work if it is functioning properly and then testing that hypothesis for evidence. Content validity was established through extensive reading and dialogue with peers and project supervisors. Experts were consulted to provide feedback on the quality of the tools to ensure all study goals were met. The instruments' construction was inspected to ensure that the questions are not

misinterpreted, and only correct information is acquired. The researcher took care to ensure that all questions were presented correctly to the respondents and that clarifications were provided where necessary to avoid misinterpretation of any sort.

3.8 Data analysis

Table 3.1: Summary of data analysis

Research Question	Data Tool	Data Analysis Approach
i) What is the prevalence of pneumonia among children under five in Ainamoi sub-county?	Descriptive statistics	This includes the analysis of frequencies, percentages, and measures of central tendency.
ii) What are the determinants of pneumonia among children under five in Ainamoi sub-county?	Chi-square test	The Chi-square test was used to assess the relationship between pneumonia and its determinants.
iii) How does pneumonia vary among households in Ainamoi sub-county?	Thematic maps, Kernel density	Thematic maps with kernel density smoothing were used to assess the spatial variation of pneumonia, with denser color schemes indicating higher prevalence.
iv) What strategies are used to manage pneumonia among households in Ainamoi sub-county?	Descriptive statistics	Descriptive statistics (frequencies and percentages) were used to identify pneumonia control strategies among households.

3.9 Ethical considerations

To ensure ethical procedures were followed, the researcher obtained ethical clearance from Egerton University Ethics committee. An introductory letter from the Graduate School, Egerton University, was obtained to assist in the application of a research permit from the National Council for Science and Technology and Innovations (NACOSTI). Moreover, the researcher obtained a letter from the department of public health and sanitation, Kericho County acknowledging the data collection exercise in their jurisdiction. The researcher also informed the office of provision administration on the data collection activities.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter reports on the results of the study. The first section describes the demographic profile of respondents, giving a basic understanding of the study population. Part 2 describes the pneumonia burden among children under 5 years of age in the study area and the major determinants of that prevalence. The third section outlines the spatial distribution of pneumonia in the region. Finally, the chapter ends with a discussion of household control strategies for pneumonia in the study area.

4.2 Demographic characteristics of respondents

Demographic characteristics represent the features of population that are measurable. In this study, variables such as age, gender and socio-economic indicators including income, education and occupation were measured. Additionally, the study assessed the respondents' localities including rural and urban components. These factors determine the accessibility to resources and services. As a result, they may lead to disparities in health, education, and overall well-being.

4.2.1 Gender of the respondent

Results in Figure 4.1 show that female respondents represented 54% while male 46%. The higher percentage of female-headed households suggests a deviation from traditional patriarchal household structures. There may be implications for childcare, eldercare, and other social support systems based on this gender distribution. The World Bank and various demographic studies typically report global averages of female-headed households ranging from 20-30%, though with significant regional variations. As compared to previous study by Cheruiyot (2024), higher proportion of households' head were male (59.3%) while the female headed households were 40.7%. In the current study, the higher proportion of female headed household is attributed to particular demographic subset being studied and possible influence of nature of study where female was mainly found at home during the survey and qualified as head of household in absence of the male patriarch.

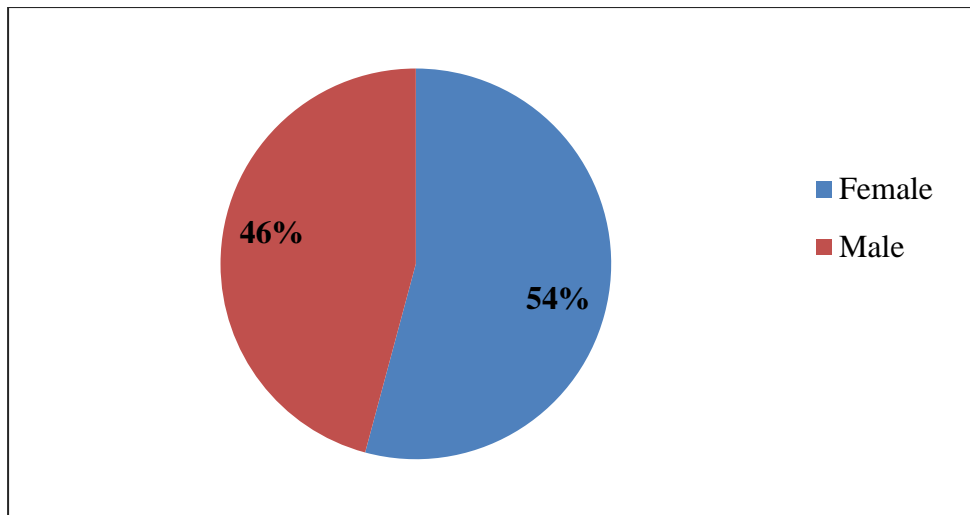


Figure 4.1: Gender of respondents

4.2.2 Occupation of the Respondents

The findings in Figure 4.2 indicate that most respondents are involved in farming (52%), indicating that most participants were from rural and peri-urban areas where farming is the dominant activity. Other significant occupations include teachers (21%), casual workers (17%) and other professionals (19%). Furthermore, the significant share of teachers (21%) reflects a relatively high degree of education sector presence, which is remarkable for a farming-dominant population. A small proportion of medical professionals (3%) were able to point to potential barriers to healthcare access. The relatively low proportions in other professions (6%) and other occupations (1%) reflect the limited economic diversification outside agriculture and education.

The finding reveals that 52% of respondents are engaged in farming. This contrasts with Anne et al. (2022), who reported that farmers made up 20.3 percent of the workforce in the same study area. This distribution, however, aligns with data from the World Bank's Rural Development Strategy (2021). This strategy points out that agriculture is a leading employment source in many developing regions and is responsible for 50-70% of rural jobs. The role of casual labor as a means of diversifying income in agriculture-based communities is emphasized by the International Labor Organization (ILO, 2022). These findings are indicative of a rural area in transition where agriculture is the dominant economic activity. Education is taking on increasing importance (Rahman et al., 2022).

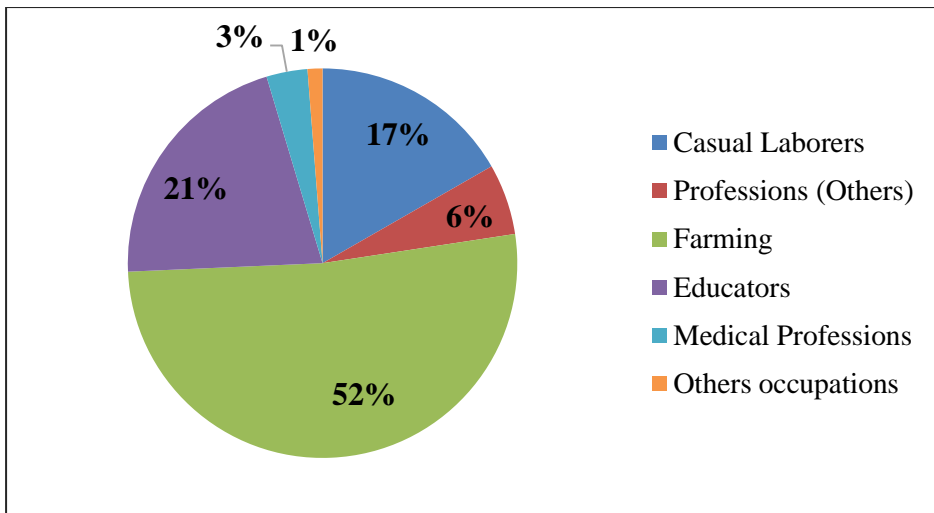


Figure 4.2: Occupations of the respondents

4.2.3 Level of education of the household head

Results in Figure 4.3 show that many respondents attained a secondary education level (38%) and tertiary education (42%). Others had no formal education (20%). The relatively low percentage of university-educated respondents (10%) compared to previous generations could indicate barriers to higher education access. The substantial proportion without higher education (58% with high school or less) indicates a need for accessible education programs. The findings show lower university attainment which compares favorably with a study by Cheruiyot (2024) who also reported relatively low rate of tertiary education (23.8%).

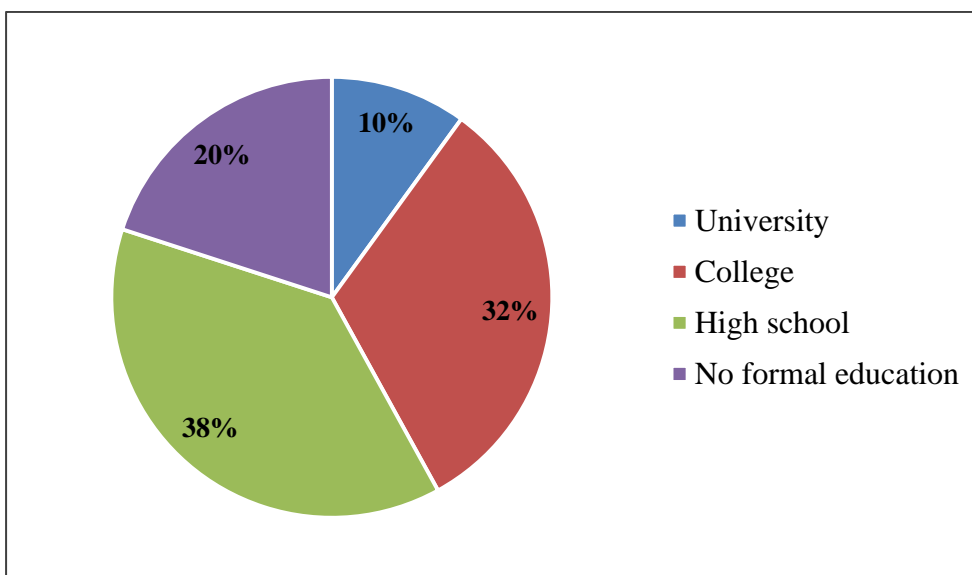


Figure 4.3: Shows level of education of respondents

4.2.4 Gender of children under five

Results in Figure 4.4 show the gender of children under five in a household. The results shows that higher proportion of the children under five who were covered in the study were male representing 65% while females were 35%. This represents a significant gender imbalance, with nearly twice as many male children as female children. The typical biological birth ratio is approximately 105 males to 100 females (or about 51% male to 49% female). This result shows a much more extreme imbalance (65% male to 35% female). Such a skewed ratio may indicate gender-selective practices or social instability. This finding differs from report given by UNFPA (2020) which indicate natural sex ratios globally range between 103-107 male births per 100 female births (approximately 50.7-51.7% male). Das Gupta et al. (2020) noted that in contexts with strong son preference, under-five sex ratios can become more imbalanced than birth ratios due to gender-differentiated care practices and resource allocation leading to higher female mortality. The World Health Organization's studies (WHO, 2022) on gender-biased sex selection have identified regions with male-to-female ratios among young children exceeding 110:100, but rarely approaching the 186:100 ratio (65:35) shown in this survey.

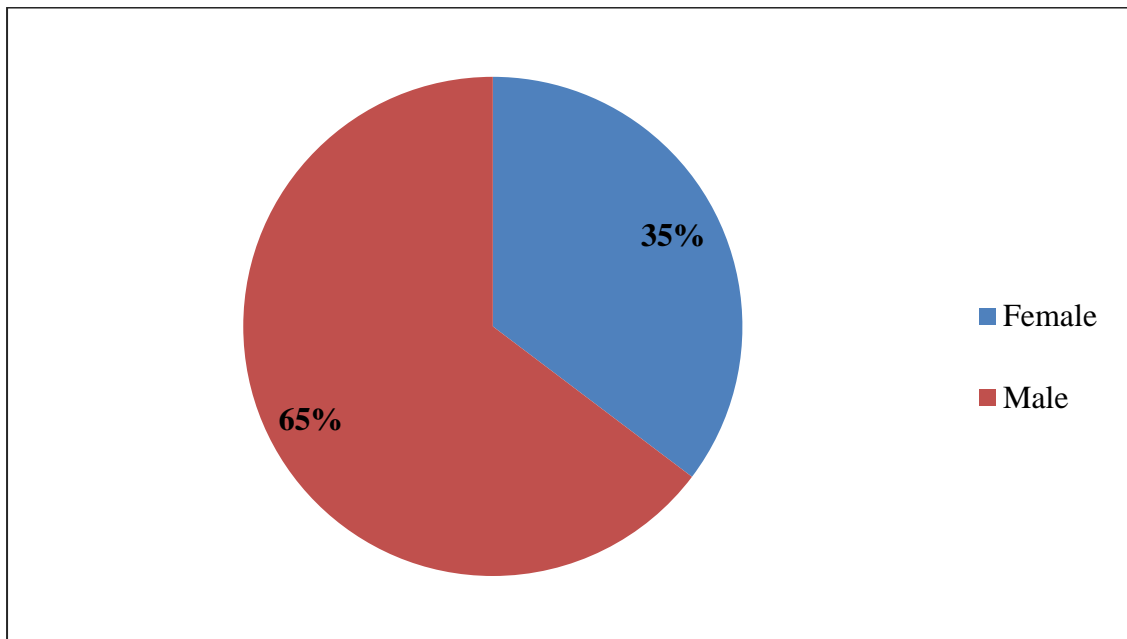


Figure 4.4: Gender of children under five

4.2.5 Daily activities of the child

As seen in Figure 4.5, the daily care of children under five in households shows a largely informal and home-based childcare system, with two-thirds of children either in informal playgroups (33%) or in the care of caregivers (33%). Only 14% attend formal early

education (kindergarten), and 20% stay at home with parents or other family members. With 66% of children in non-family care, there is some reliance on childcare arrangements beyond the immediate family. On the other hand, the low attendance in kindergarten (14%) indicates potentially limited access to structured early learning opportunities, which could affect school readiness. This distribution may reflect a need for improved access to formal early childhood education, quality control in informal care environments, and caregiver support.

The OECD (2023) reports that in developed countries, formal preschool participation rates for children 3-5 years average 87%, are substantially higher than the 14% kindergarten attendance shown here. However, UNESCO's Global Education Monitoring Report (2022) notes that in low-income countries, formal pre-primary enrollment averages only 22%, closer to this finding of 14% kindergarten rate. The World Bank's Early Learning Partnership (2021) found similar patterns in rural areas and low-resource settings, where informal care networks and extended family arrangements predominate over institutional early education. Richter et al. (2019) support the findings where most households rely on care givers (33%). According to Cheruiyot (2024), non-maternal caregiving arrangements have become increasingly common in Kericho amid increasing economic pressures which require parental employment in settings without affordable formal childcare.

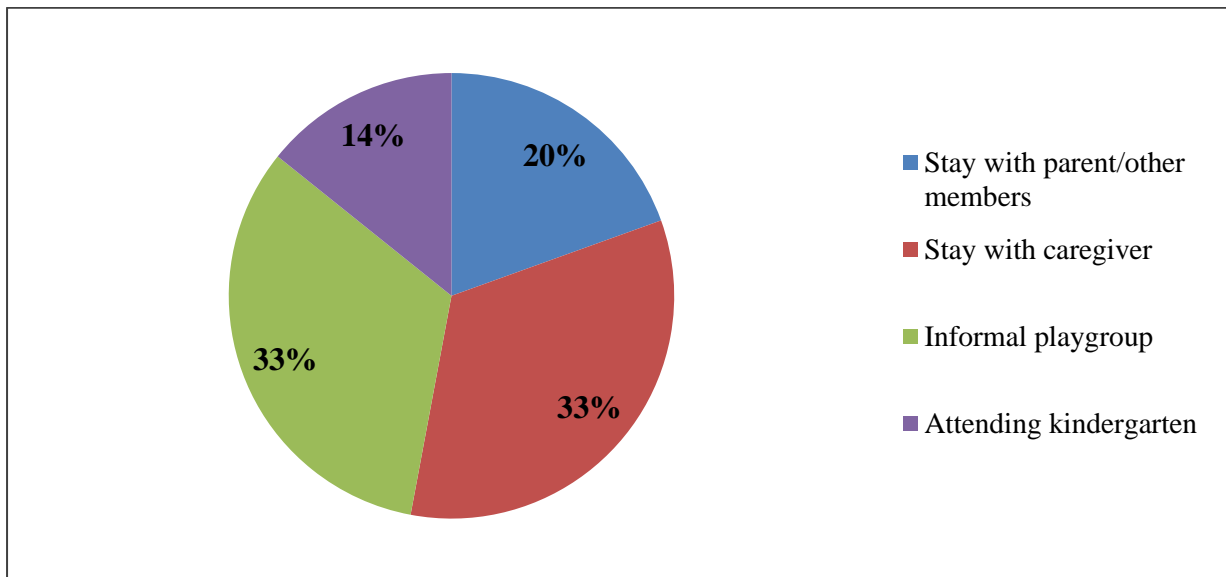


Figure 4.5: Daily activity of children under five

4.2.6 Other demographic characteristics of respondents

The results in Table 4.1 shows other demographic characteristics of the respondents such as average number of children under five, the number of dependents in Household (HH) and the age of respondents. The findings showed that the average number of children under five were 1.21 children which illustrates that on average, households in this finding have

about 1-2 children under the age of five. The low standard deviation (0.45) suggests that most households are clustered close to this average. In terms of the average number of dependents in Household, the results revealed that the average dependency rate of households is 5.39 dependents. This implies that the average household in the study area has around 5-6 dependents. The standard deviation of 2.20 indicates more variability in household size compared to the number of young children, meaning some households have significantly more or fewer dependents than the average.

Additionally, the mean age of the respondents was 40.45 years. In support to previous finding Adawe et al. (2023) highlighted the following risk factors for pneumonia among children aged under 5 years were age, level of education, income, birth weight, exclusive breast feeding, pneumonia vaccination, postnatal care, and history of acute respiratory tract infection in Banadir Hospital, Mogadishu, Somalia in 2022.

Table 4.1: Other demographic characteristics of respondents

Demographic factor	N	Mean	Std. Dev
Average number of children under five	323	1.21	0.45
Number of dependents in HH	323	5.39	2.20
Age of respondents	323	40.45	12.50

4.3 Child pneumonia prevalence in Ainamoi sub-county

Figure 4.6 displays the three symptoms associated with pneumonia: cough, breathing, and chest symptoms. The findings showed that the symptomatic prevalence of pneumonia depends on cough as a symptom, which was 36 percent. Cough is a common symptom of several respiratory conditions such as pneumonia. While cough alone is not a direct marker for pneumonia, it is a common symptom among pneumonia patients. The prevalence associated with breathing-related complications was also 36 percent, while the prevalence associated with chest symptoms was 37 percent, suggesting that pneumonia is an infection that inflames the air sacs in one or both lungs, which can fill with fluid or pus, causing breathing difficulties and chest congestion. The three symptoms that are used to determine whether you have pneumonia are reliable indicators. This means that these symptoms are evenly distributed in the population studied, with roughly one third of people experiencing each symptom and two thirds NOT experiencing them.

The study has important epidemiologic implications regarding pneumonia in Ainamoi. Hospitalized pneumonia was widespread, and frequently fatal. The study on cough

as a precursor to pneumonia was also reported in Sharan et al. (2023) who suggest that cough, along with other symptoms like fever and shortness of breath, is used in clinical settings to screen for pneumonia. However, cough by itself is not a reliable indicator of pneumonia, as it also occurs in other respiratory diseases. Atoloye et al. (2023) in support of the recent finding reiterated that cough is a common symptom in respiratory illnesses, including community-acquired pneumonia (CAP), bronchitis, and lower respiratory tract infections (LRTI). In children, pneumonia is a common cause of cough, with other symptoms such as fever and fast breathing.

Pneumonia prevalence is defined as the proportion of people in each population with pneumonia at a point in time (Beletew et al., 2020). Pneumonia is a major disease worldwide, affecting approximately 450 million people each year and causing about 4 million deaths per year. The incidence is particularly high in children under five years old and adults over 75 years of age. As illustrated in the present study, the prevalence rate in the study area is high, which supports the finding of UNICEF (2024) that developing countries bear a disproportionate burden, with pneumonia occurring about five times more frequently than in developed countries. In East Africa, studies have documented the wide prevalence of pneumonia in children under five, ranging from 5.5% to 89.8%, illustrating the heterogeneity and magnitude of the problem across different settings (Beletew et al., 2020).

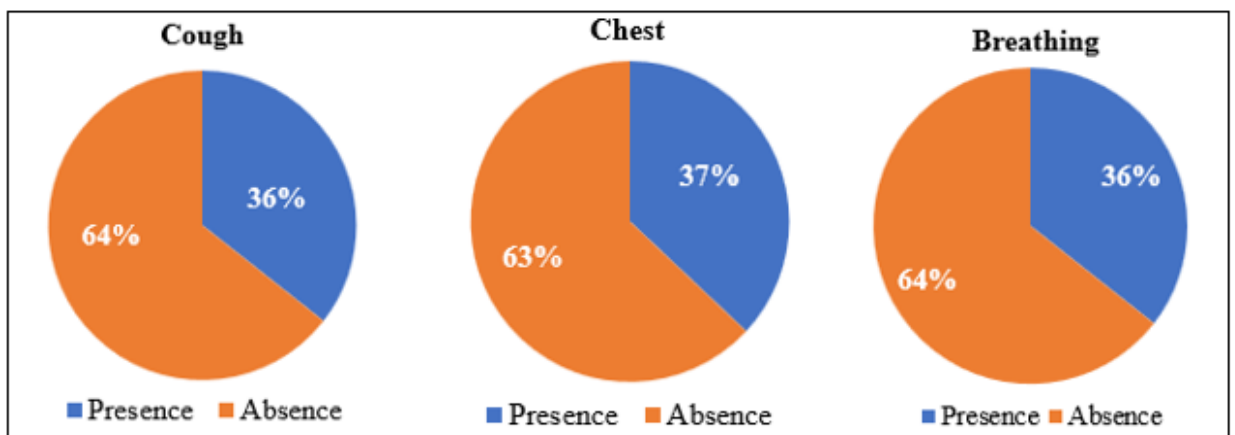


Figure 4.6: Shows the prevalence of indicators of pneumonia

The results from qualitative interviews supported the quantitative results on pneumonia prevalence. One of the key informants reported that:

“Many children under five years old patronage our health facility many times a week for treatment of cases related to pneumonia and this peaks during cold and rainy

seasons. I can point out this week alone, that I have attended to over four cases of children with breathing difficulties and running nose” [Participant 1: Male, Nurse]

4.3.1 Cross-tabulation of energy sources and symptoms of pneumonia prevalence

Results in Table 4.2 presents the cross-tabulation between prevalence of pneumonia and the energy sources used by surveyed households. Wood/Charcoal is the most common energy source used (85.7%), and other minor sources include the electricity/Solar (5.9%), Biogas/Gas (4.7%), Fossil fuel (3.4%), and Other (0.3%). This result provides evidence of positive relationship between the energy sources and prevalence as seen in wood sources which resulted in prevalence rate of 33.7% and moderate 27.5%. This finding suggests a possible association between energy sources and pneumonia symptoms, with wood/charcoal (a source that typically produces indoor air pollution) being both the most common energy source and having a substantial proportion of cases with "Very high" prevalence of pneumonia symptoms (Beletew et al., 2020). However, the small sample sizes for the cleaner energy sources make it difficult to draw definitive conclusions about whether they are associated with lower pneumonia symptom prevalence. The relationship between pneumonia prevalence and energy sources was not significant as shown by chi-square test (See Table 4.2).

Table 4.2: Cross-tabulation of energy sources and prevalence rate of pneumonia symptoms

Source of energy	Stat	Very low	Low	Moderate	High	Very high	Total
Wood/Charcoal	Freq	52	32	76	23	93	276
	(%)	19	12	8	8	34	100
Electricity/Solar	Freq	2	1	7	3	6	19
	(%)	11	5	37	6	32	100
Biogas/Gas	Freq	3	2	4	2	4	15
	(%)	20	13	27	13	27	100
Fossil fuel	Freq	2	0	3	1	5	11
	(%)	18	0	27	9	46	100
Other	Freq	0	0	0	0	1	1
	(%)	0	0	0	0	100	100
Total		59	35	90	29	109	322

4.3.2 Cross-tabulation of pneumonia prevalence and the type of housing

Results on Table 4.3 presents the cross-tabulation between pneumonia prevalence and the type of family housing/material. The results showed that mud walled and iron sheet-roofed housing were the most common type (35.4%). Additionally, traditional grass-thatched houses were the second most common (22.7%). Other significant types were timber-walled and iron sheet roofed houses (19.6%), and fully furnished apartment (8.1%). There were strong association between timber/Wooded house with pneumonia prevalence with 36.5% of houses made of timber reporting having "Very high" prevalence. Similarly, mud walled housing had high association with pneumonia prevalence with 33.3% showing "Very high" prevalence. This was similar to traditional grass-thatched houses, of which 32.9% show "Very high" prevalence.

Table 4.3: Cross-tabulations of prevalence of pneumonia and type of housing

Type of house	Stat.	V. low	Low	Moderate	High	V. high	Total
Mud Walled	Freq	22	9	36	9	38	114
	(%)	19	8	32	8	26	100
Traditional Grass-Thatched	Freq	12	13	18	6	24	73
	(%)	16	18	25	8	33	100
Timber/Wooded House	Freq	9	5	16	10	23	63
	(%)	14	8	25	17	37	100
Fully Furnished Apartment	Freq	9	3	7	1	6	26
	(%)	35	12	27	4	23	100
Unfurnished Apartment	Freq	3	1	4	1	7	16
	(%)	19	6	25	6	44	100
Iron Sheet-Walled	Freq	3	3	3	0	2	11
	(%)	27	27	27	0	19	100
Permanent Housing	Freq	1	1	6	2	8	18
	(%)	6	6	33	11	44	100
Other Housing	Freq	0	0	0	0	1	1
	(%)	0	0	0	0	100	100
Total		59	35	90	29	109	322

More modern housing shows a lower percentage of pneumonia prevalence (23.1%). However, permanent housing shows a high percentage (44.4%) of "Very high" prevalence

cases, which is somewhat unexpected. The findings suggest some potential relationships between housing type and pneumonia symptom prevalence. There appears to be variation in pneumonia prevalence across different housing types, with some modern housing types showing lower rates of "Very high" prevalence. Traditional housing types (Mud walled, grass-thatched, and timber/wooded) generally show higher rates of "Very high" prevalence cases.

The unexpectedly high rate of "Very high" prevalence in permanent housing and unfurnished apartments suggests that housing type alone may not determine pneumonia risk - other factors like ventilation, crowding, or specific construction details might play important roles. The chi-square test showed that there was no statistically significant relationship between type of housing and the pneumonia prevalence ($P=0.682$).

4.3.3 Qualitative results on pneumonia prevalence and risk factors

The prevalence is determined by the exposure to indoor air pollution, which is largely driven by the low-income levels of the majority of families. In response to these risk factors, some families have turned to biomass-fuel stoves to help reduce the levels of exposure. A Pediatrician in an interview says:

“Household air pollution is linked to a higher risk of pneumonia in children in this region, particularly in low-income households. Many of the families who are at risk for pneumonia are using biomass-fueled cookstoves as a means to mitigate these exposures.”

[Participant 5: Male Pediatrician]

The recorded prevalence of 36% was comparable to that of ARI in rural areas of Western Kenya. For instance, in a nationwide survey, Bigogo et al. 2019 reported an ARI prevalence of 39% in the general population studied. Nokes et al. (2009) also reported a prevalence of 20% in infants and 32% during epidemics for severe RSV in rural areas. Nokes et al. (2009) reported that severe to very severe pneumonia affected 7359 (29%) of 25,149 patients admitted to hospital in Kenya.

4.4 Determinants of pneumonia prevalence in Ainamoi sub-county

This subsection explores factors that contribute to the high prevalence of pneumonia in Ainamoi sub-county. It provides an analysis of risk factors for the disease, such as the prevalence of household use of humid cleaning practices, the effect of household size on child pneumonia rates, and the impact of residential risk factors.

4.4.1 Analysis of pneumonia risk factors

Findings in Table 4.4 highlights selected determinants of pneumonia prevalence in the study area. Chi-square association tests between risk factors and prevalence. The findings indicated that four factors were statistically significantly related to pneumonia prevalence: hereditary factors, humid cleaning, places of residence, and overcrowding households.

Hereditary had a statistical relationship with pneumonia prevalence ($p = 0.000$). The hereditary factor was assessed using the history of occurrence of the pneumonia among any household member under study. Family history indicates strong statistical evidence that genetic factors are highly correlated with pneumonia risk due to inherited immune system characteristics and familial genetic vulnerabilities to respiratory infections. In support of these findings, Campos et al. (2021) have shown that genetic variations contribute to individual differences in susceptibility to pneumonia. Specific genetic loci and genes, such as those on chromosomes 15, 16, and 9, have been associated with pneumonia risk.

Table 4.4: Determinants of pneumonia prevalence

Risk Factor/Determinants	N	Chi-square	df	Sig.
Hereditary	322	23.814 ^a	5	0.000
Type of family house/building materials	322	30.572 ^a	35	0.682
Type of fuel/source of energy	322	8.839 ^a	20	0.985
Major HH food profile	322	34.467 ^a	30	0.263
HH income levels	322	19.021 ^a	20	0.52
Locality (E.g. Rural, Urban, Peri-urban)	322	21.517 ^a	10	0.018
Proximity to industrial plant/Factory/Mining	322	20.821 ^a	15	0.143
Overcrowded houses	322	25.329 ^a	15	0.046
Seasonality	318	2.738 ^a	5	0.740
Air ventilation in your house	322	17.209 ^a	20	0.639
Method of waste/garbage disposal applied	322	5.521 ^a	10	0.854
Frequency Humid cleaning in HH	322	37.969 ^a	25	0.047

In addition, the degree of household overcrowding was statistically linked to pneumonia prevalence ($p = 0.046$). This makes household size a major pneumonia risk factor. This result is consistent with Naz and Ghimire (2020) who claimed that children living in overcrowded homes are at higher risk of pneumonia. Similarly, crowding has been

recognized as a risk factor for pneumonia in children in urban Dhaka, Bangladesh (Ram et al., 2014). Moreover, in support of these findings, Naz et al. (2020) posited that overcrowded living conditions are a significant risk factor for pneumonia in children. Studies in Pakistan and Gambia found that children who lived in overcrowded homes were at greater risk of pneumonia. Similarly, crowded living conditions, such as refugee camps, were associated with increased incidence of pneumonia in humanitarian settings.

Household damp cleaning was also a significant factor in pneumonia incidence ($p = 0.047$). Exposure variable (humid cleaning) was measured as the number of times a household humid cleansed per month. This variable is negatively associated with the prevalence of pneumonia; the more the households do humid cleaning the less likely they are to experience pneumonia prevalence. These findings are consistent with prior evidence, such as that reported by Liu et al. (2024), that frequent cleaning and ventilation (which includes opening windows and exposing bedding to sunlight) reduce the risk of childhood pneumonia associated with indoor dampness. Conversely, risk is enhanced by air humidifiers and air conditioning, and dampness in the home, such as damp clothing, bedding, and visible mould, is significantly linked with increased risk of childhood pneumonia. Ensuring proper ventilation and hygiene might help reduce these risks, and the use of household humidifiers, especially disinfectant-containing humidifiers, has been associated with lung injury and the possibility of interstitial pneumonia (Lamichhane T et al. 2019). This indicates that while humidifiers can be a valuable asset for air quality, they should be utilized with caution to avoid any unintended adverse outcomes. While humidifiers can be an effective tool for improving air quality, they come with potential drawbacks that must be carefully managed to prevent negative health effects.

Other covariates such as type of family house/residence, seasonality, fuel/energy source, household food profile, household income levels, presence of industrial plants/factories/mining, ventilation of air, and mode of waste/garbage disposal were important, though statistically non-significant. While seasonality was not statistically significant in the current study, Lu et al. (2023) suggest seasonality is a key risk factor for childhood pneumonia, driven by climatic and environmental conditions. Muthumbi et al. (2017) additionally reported that out of many air-pollution variables, only two were significant in the univariate analyses; cooking in a room with only one exit for ventilation (the door) was more frequent among cases.

In the study, the type of fuel used didn't show a significant association with pneumonia in children. This is consistent with the evidence presented in Muthumbi et al.

(2017), where indoor cooking, sleeping in the cooking room, and fuel type for cooking were not linked to pneumonia. However, a study by Budhathoki et al. (2020) suggested that household air pollution, mainly due to cooking with polluting fuels, is a major risk factor for childhood pneumonia. Additionally, using dampness, cooking with solid fuels or natural gas, and exposure to new building materials are risk factors for childhood pneumonia, as argued by Zhuge et al. (2018). Natural gas and solid cooking fuels were positively associated with pneumonia, compared with electricity. Although the results show no significant statistical association between types of houses or building materials with pneumonia incidences, Zhuge et al. (2018) found a positive association between cement, construction materials including synthetic fiber, laminated wood, paint, emulsion paint and wallpaper with pneumonia.

4.4.2 Analysis of the frequency of humid cleaning among the households

Table 4.5 reveals that 67 percent of respondents never clean with a humid cloth, indicating crucial hygiene and household maintenance issues. According to Muthumbi et al. (2017) humid cleaning is a method that involves using moisture, such as water, steam, or damp cloths, to remove dirt, dust, and contaminants from surfaces. Moreover, 19 percent of respondents maintain relatively regular cleaning, representing a minority of households with consistent cleaning practices. On the other hand, 6 percent, 4 percent and 3 percent reported infrequent cleaning categories which include less than once a month, once a month, a few times a month and only 1 percent perform humid cleaning daily. This highlights the potential of high risk of dust accumulation thus increased vulnerability to respiratory diseases such as pneumonia due to limited humid cleaning practices in the area.

The findings were in contrary to assertion by Carrión et al. (2019) who posit that the exposure to household air pollution is associated with an increased carriage of bacterial pathogens in the nasal passages of infants as opposed to dusty environment, which can lead to bacterial pneumonia. This association is more pronounced in children exposed to traditional cooking methods compared to those using improved biomass or LPG stoves and the household hygiene practices. Nkwopara et al. (2019) who emphasized that Lilongwe, Malawi, areas with higher rates of poverty, informal settlements, and poor sanitation had higher than expected enrollment in a fast-breathing child pneumonia clinical trial.

Table 4.5: Frequency of humid cleaning in your house

Variable	Frequency	Number of respondents (%)
Daily	5	1

A few times a week	60	19
A few times a month	10	3
Once a month	12	4
Less than once a month	19	6
Never	217	67
Total	323	100

4.4.3 Effect of household size on the prevalence of child pneumonia

Table 4.6 presents a crosstabulation of household crowdedness (measured by the number of people per household) and the prevalence of child pneumonia categorized into five levels (Very Low, Low, Moderate, High, Very High). The results shows that there is positive association between household size and the pneumonia prevalence. Pneumonia prevalence appears to increase as household crowdedness increases, with higher crowdedness levels (4+ members) associated with a greater number of cases ranked as high and very high prevalence categories. For example, among households with 12 members, all 5 cases show "Very high" pneumonia prevalence. Similarly, household with 10 members shows predominantly "High" or "Very high" prevalence. On the other hand, the smaller households (1-3 members) account for only 16.5% prevalence rate. Medium households (4-6 members) account for 55.3% of the pneumonia cases. The Chi-Square tests further revealed a significant positive correlation between household size and the pneumonia prevalence ($p = 0.046$).

This finding means overcrowding is a significant risk for childhood pneumonia. This support Cardoso et al. (2019) who posits that children in overcrowded households were 1.5 to 3 times more likely to develop pneumonia compared to those in less crowded conditions. Sonogo et al., (2015) reported similar results in Sub-Saharan Africa where households with more than 4-5 people per sleeping area were strongly associated with increased pneumonia.

The results show a sharp increase in pneumonia prevalence when household size exceeds 4 members, aligning with research suggesting that the threshold for increased risk is around 4-5 people per household (Dagvadorj et al., 2020). According to Dagvadorj et al. (2020) large households are likely to increase pathogen exposure, limited ventilation, and cross-infection risk, contributing to a higher pneumonia burden. They also highlight that household air pollution and poor ventilation exacerbate pneumonia risks in crowded settings.

Table 4.6: Crosstabulation of level of HH crowdedness and the prevalence

Size of HH	V. low	Low	Moderate	High	V. high	Total
1	1	1	4	0	3	9
2	0	0	10	2	9	21
3	4	0	6	3	10	23
4	11	11	12	8	23	65
5	16	7	20	5	17	65
6	8	7	14	4	15	48
7	9	4	8	3	10	34
8	6	3	9	2	9	29
9	4	2	5	1	7	19
10	0	0	0	1	1	2
11	0	0	2	0	0	2
12	0	0	0	0	5	5
Total	59	35	90	29	109	322

4.4.4 Relationship between residential risk factors and child pneumonia prevalence

Results in Table 4.7 indicates the locales in the study area in terms of stratification which include rural/Countryside, Peri-urban Setting and Urban Setting. Rural/Countryside was one distribution of residential settings where 52 percent showed significant variation in living conditions which indicates a predominantly rural population therefore this suggests agricultural or remote community characteristics with potential implications for access to healthcare, infrastructure and services. Peri-urban setting is the second largest cohort, transitional areas between urban and rural zones representing 34 percent of the respondents and it's characterized by mixed land use and developing infrastructure. Urban Setting suggests limited concentration in the study area and are likely direct exposure to environmental and health risks due to waste disposal and industrial pollution. This result corroborates with Zhuge et al. (2018) who posit that Urban children had more pneumonia

than suburban (29.9%) and rural children (24.9%), with more residential risk factors found in urban dwellings.

Table 4.7: Locality classification

Variable	Frequency	Number of respondents (%)
Urban setting	45	14
Peri-urban setting	110	34
Rural/Countryside	168	52
Total	323	100

4.5 Spatial variation of pneumonia in Ainamoi Sub-County

The results in Figure 4.7 show spatial analysis of pneumonia. The spatial variation analysis of pneumonia cases was done across three wards: Kipchimchim, Kipchebor, and Ainamoi which entirely covers about 1,145.3 square kilometers. Within the entire study area, the total cases of child pneumonia were 166. The pneumonia cases were concentrated in areas with higher population density and unique residential settings such as urban and small centers in rural settings. In most remotely located wards such as Kipchimchim and Ainamoi, the spatial variation was high revealing few cases. Although Ainamoi Ward has the highest number of cases (54%) the total area is larger than the other rural based ward of Kipchimchim (469.3km²) which had the lowest number of cases (14%). Kipchebor Ward, which lies in urban and peri-urban areas represent the higher prevalence cases also (32%). Peri-urban is characterized by affects like overcrowded, unhygienic conditions and poor housing structures that characterize many peri-urban areas where many children are being raised in. Such conditions facilitate the transmission of pneumonia, hence driving up child mortality due to pneumonia.

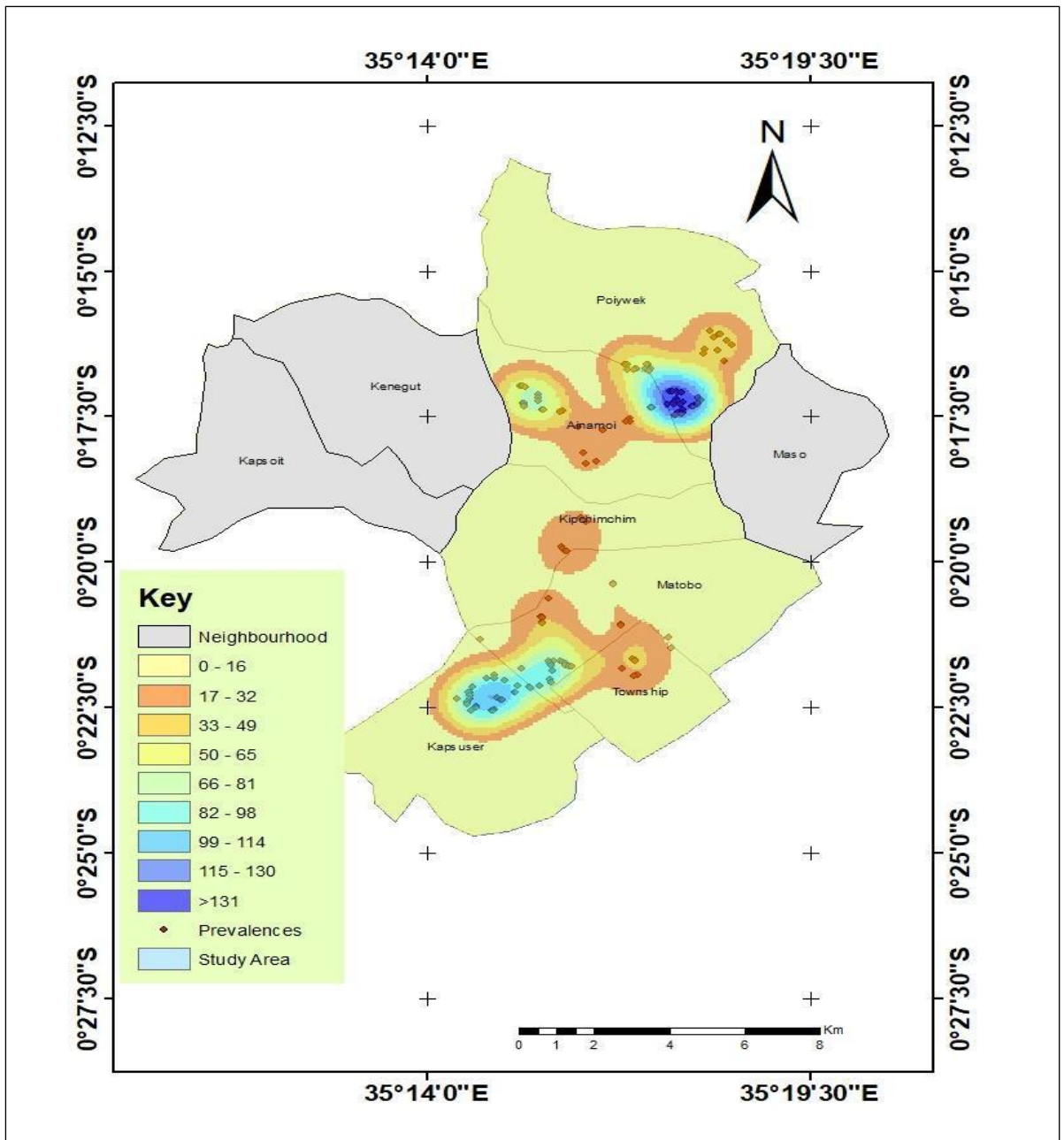


Figure 4.7: Spatial variation of pneumonia in study area

The results in Table 4.8 shows the prevalence and sizes of the three selected wards namely: Kipchimchim 164.2 Km² with 14 percent, Kipchebor 511.8 Km² 32 percent and Ainamoi ward 469.3 Km² with 54 percent this indicates that Ainamoi ward has the highest number of cases due to the previous findings which indicate that rural based pneumonia is due to various socioeconomic factors which include: the educational status of parents, smoking habits of any member of the household, nutritional status, age and sex of the child.

Table 4.8: Spatial variation of pneumonia cases in study area

Ward	Cases	Area (Km²)	Prevalence Rate (%)
Kipchimchim	24	164	14
Kipchebor	53	512	32
Ainamoi	89	469	54
Total	166	1,145	100

4.5.1 Relationship between pneumonia prevalence and topography of the area

Elevation and topography map of the study area shows that childhood pneumonia is predominantly found in areas located at elevations from 1700 - 1890 meters (m) above sea level and 1800 - 2013 meters (m) above sea level with a lower prevalence in low altitude areas from 1350 - 1550 m and 1550 - 1734 m (See Figure 4.8). The data suggests that regions at higher to mid-altitudes (above 1700 m) might be at a higher risk of pneumonia-related health impacts, while areas at lower altitudes (below 1550 m) generally show lower rates of the disease. Environmental factors like reduced oxygen content, lower temperatures, and increased humidity can also make you more susceptible to respiratory infections at higher altitudes. Research suggests that higher elevations and lower atmospheric pressure can have consequences for respiratory function; decreased availability of oxygen may place further stress on the respiratory system and make individuals more susceptible to infectious diseases such as pneumonia (Martinez et al., 2020). These regions are also known to experience significant daily temperature variations, which can induce additional stress on the immune system (Tse et al., 2019).

In children, risk factors for pneumonia in mid-elevation areas such as 1800m - 2013m include things such as pollution, terrible housing conditions and lack of access to healthcare in rural as well as highland regions. These pollutants in the air or unsanitary living conditions can contribute to higher rates of respiratory infections among these communities (Muller et al., 2020). On the other hand, low-elevation (1350m - 1550m) and mid-elevation (1550m - 1734m) may experience a lower incidence of pneumonia due to more favorable environmental conditions, such as warmer temperatures and increased oxygen levels, which reduce strain on the respiratory system. Warmer climates are generally less conducive to the proliferation of respiratory pathogens than colder, high-altitude areas (Barouki et al., 2021). There is also good infrastructure and access to healthcare available at lower altitudes and this

may help to reduce pneumonia rates, as these communities tend to have better access to medical services, vaccinations, and sanitation.

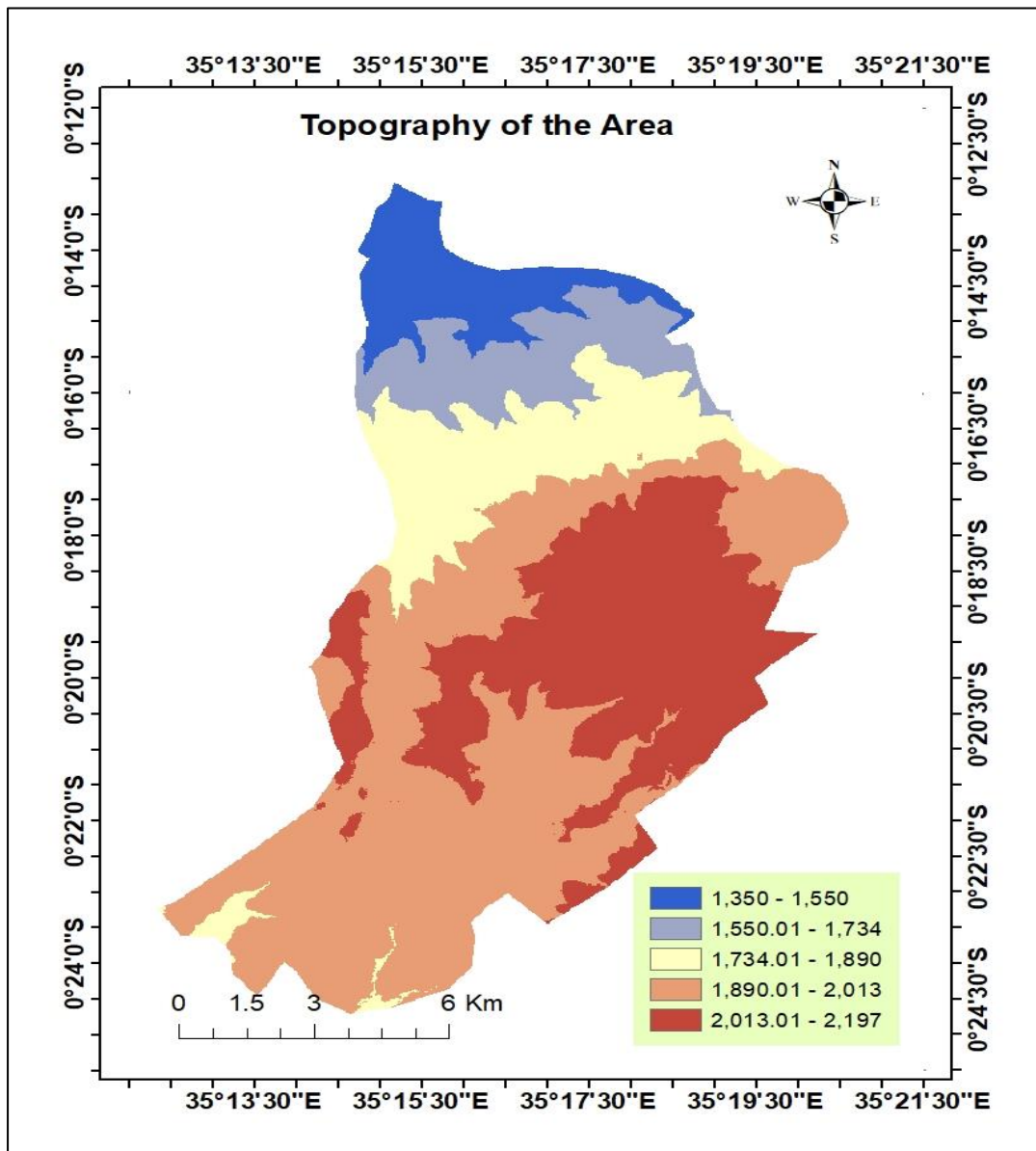


Figure 4.8: Shows the topography of the area under study

Higher elevations can be associated with greater risk for respiratory diseases such as pneumonia among children (Martinez et al., 2020). Respiratory infections are more common in these parts of the world due to the lower oxygen levels that can tax the lungs. Furthermore, colder temperatures experienced at higher elevations stresses the immune system, making individuals more susceptible to infection such as pneumonia (Tse et al., 2019). Cold temperatures at higher altitudes can lead to respiratory issues. Studies suggest that prolonged exposure to cold temperatures can suppress the immune system, which may make children more susceptible to respiratory illnesses (Muller et al., 2020).

In addition to inadequate ventilation, high humidity levels in some areas can also create favorable conditions for the growth of respiratory pathogens, promoting outbreaks of pneumonia. The socio-economic and environmental conditions within these regions must also be considered. High-altitude areas are often rural, with less access to healthcare services. The high rates of pneumonia in these areas are driven by poor living conditions, which lead to increased exposure to pathogens and pollutants (Barouki et al., 2021). In contrast, rates of pneumonia typically are lower at lower altitudes, possibly reflecting better healthcare infrastructure, improved sanitation, and more stable environmental conditions.

4.5.2 Relationship between childhood pneumonia and soil types

The soil types of the study area consisted mainly of a mixture of sand, clay and loam, loam 1 and loam 2 as indicated in Figure (4.9) below. Sandy-Clay-Loam (SCL): Sandy-Loam (SQN 582, HYDGRP C) has relatively high sand content (55%) and moderate clay content (30%). It has moderate infiltration rates, thanks to its texture and bulk density of 1.3 g/cm³, so that it retains some water while still draining properly (see Table 4.9). The second soil type, loam 1 (SEQN 76, HYDGRP D), is characterized by a high silt (35%) and clay (22%) content with moderate sand (44%). The soil is assigned to hydrological group D, which shows low infiltration capacity and high runoff potential. Bulk density (1.4 g/cm³) a bit higher than Loam 2 indicating compactness and decreased aeration.

Table 4.9: Soil properties

SEQN	Texture	HYDGRP	No. of LAYERS	Clay (%)	Silt (%)	Sand (%)	SOL_BD1, (g/cm ³)	
582	Sandy-Clay-Loam	C	2	0	3	1	55	1.3
76	Loam 1	D	2	2	2	3	44	1.4
848	Loam 2	C	2	3	2	3	46	0.8

The third soil (loam 2; SEQN 848, HYDGRP C) is a balanced-textured loam (sand: 46%, silt: 31%, clay: 23%) with lower bulk density (0.8 g/cm³) suggesting good porosity and water-holding capacity. It is moderately infiltrative (HYDGRP C).

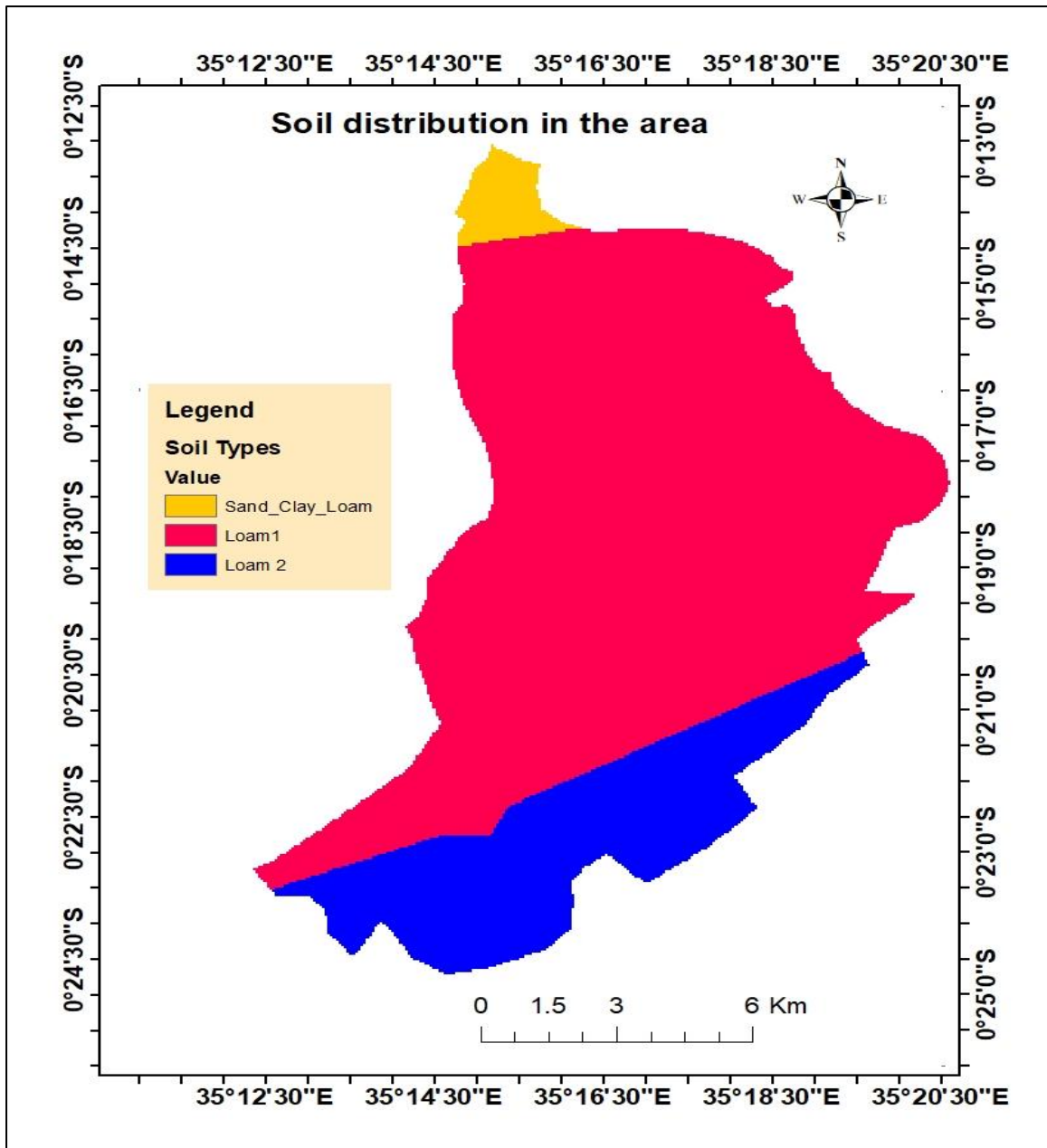


Figure 4.9: Soil types in the study

The soil types found in the study area were generally a combination of sand, clay and loam, loam 1 and loam 2, as shown in Figure (4.9) below. Spatial analysis of pneumonia within the study area shows a higher density of cases in areas dominated by Loam 1 (HYDGRP D) and Loam 2 (HYDGRP C) soils. These results suggest a potential association between environmental risk factors for pneumonia and soil hydrologic properties. Loam 1 (HYDGRP D) has a low infiltration rate, and high runoff often results in waterlogging and high humidity in houses or surroundings. High moisture content, by providing optimal growth conditions for moulds and microbial pathogens, often results in elevated exposure to respiratory infections for children (Peel et al., 2018).

Compaction of soils can also affect sanitation infrastructure, -threatening water supplies. Loam 2 (HYDGRP C) moderate infiltration/moderately well-drained; slight water-holding capacity can increase local humidity but not as much as HYDGRP D soils. Certain soil types can create microclimates that favor the growth of microorganisms, both indoors and outdoors, which can contribute to the development of respiratory illnesses (Miller et al., 2020). Areas with sandy clay loam (HYDGRP C) soil, when present, correlated to lower pneumonia case rates. The sandy texture of these soils facilitates drainage and helps in the redistribution of residual water and atmospheric moisture, which can inhibit growth of the microbes.

Environmental factors such as soil moisture, drainage, and humidity can indirectly influence the prevalence of respiratory diseases by creating an environment conducive to pathogen growth (Barouki et al., 2021; Ferguson et al., 2017). Hydrologically restrictive soils (HYDGRP D), for instance, are linked to waterlogging, poor sanitation, and high moisture levels indoors, all of which have been found to increase the risk of childhood pneumonia (WHO, 2019). On the other hand, soils with higher sand content and improved drainage were associated with lower rates of pneumonia, possibly by limiting inhalation of infectious agents.

In Ainamoi Sub-County, the spatial distribution revealed that childhood pneumonia cases were clustered in areas with Loam 1 (HYDGRP D) and Loam 2 (HYDGRP C) soils types, suggesting a potential link between soil hydrology and occurrence of pneumonia among children under five years. Loam 1, with its low infiltration rate and high runoff potential, is often marked by waterlogging, high humidity, and poor drainage-all of which are conducive to the growth of respiratory pathogens (Peel et al., 2018). These environmental conditions intensify the child's exposure to risk factors for respiratory infections. In comparison, Loam 2, with moderate infiltration, conserves moisture and local humidity, creating favorable conditions for microbial growth (Miller et al., 2020).

In contrast, Sandy Clay (HYDGRP C) showed a lesser occurrence, possibly due to its higher sand content, allowing for better drainage and less moisture retention, which is not conducive to pathogen survival (Barouki et al., 2021). These findings are consistent with current literature linking poor soil drainage and high environmental moisture levels with vulnerability to respiratory diseases, especially in children (WHO, 2019). The findings underscore the importance of an integrated approach to environmental and public health interventions, particularly in areas with hydrologically restrictive soils. Future studies should contemplate longer-term monitoring of soil conditions.

4.5.3 Qualitative analysis of spatial variation of pneumonia

Qualitative interviews confirmed the spatial variation on prevalence described above. One of the key informants said:

"Pneumonia is seasonal and fluctuates in space and time, with children under five being especially vulnerable, particularly in urban areas, during the rainy seasons"

[Participant 8: Male Nurse].

Another participant said:

"I think that pneumonia is very patchy, space and time, and I think that people should try to avoid, I mean, places where there are lots of people, and just general air pollution in the environment."

[Participant 5, Female, Clinician]

Spatial heterogeneity in pneumonia is shaped by a complex interplay of socio-economic, demographic, environmental and health system factors, and understanding these variations is key to developing effective public health strategies and interventions to reduce the burden of pneumonia across regions. Pneumonia is the single cause of death among children under five, and its mortality is strongly linked to poverty-related factors such as undernutrition, unsafe water and sanitation, indoor air pollution from cooking fires, and limited access to health care.

Many childhood pneumonia deaths are linked to air pollution. Other risk factors for respiratory infection acquisition in the study area include poverty, low family income, low parental educational level, low birth weight, malnutrition, and lack of breastfeeding. In support of recent findings Ramezani et al. (2015) reported in developing countries like Ethiopia, under-five children face a multitude of risk factors for pneumonia. Among causes, exclusive breastfeeding, lack of/incomplete immunization, environmental conditions, outdoor/indoor air pollution, micronutrients, and vitamin deficiencies are reported most frequently.

Kipchebor is the largest area (511.8Km²) but has the second highest number of cases, while Kipchimchim has the smallest area and the fewest cases. Bosco et al. (2020) demonstrated spatial variation in the United States, with long-term care facilities in the Southern and Midwestern regions reporting the highest rates of pneumonia, and Kim et al. (2019) demonstrated significant geographic variation in hospitalization rates for bacterial pneumonia in Korea, with socioeconomic factors contributing significantly.

Risk factors for pneumonia differ between urban and rural populations, reflecting differences in environmental, socioeconomic, and access to healthcare variables. This finding corroborates the conclusions in Zhuge et al. (2018) that more residential risk factors were identified in urban dwellings. Furthermore, UNICEF (2016) noted that indoor air pollution is generally worse in peri-urban communities where biomass fuels are more commonly used in cooking and heating due to limited access to other energy sources in Dessie City, Ethiopia.

Wu et al. (2020) showed that urban areas such as New York City (NYC) and urban areas in China have higher rates of community-acquired pneumonia (CAP) than rural areas. For example, NYC had the highest mean annual age-adjusted community-setting pneumonia-associated hospitalization (CSPAHA) rate at 475.3 per 100,000 population, significantly higher than rural areas.

Furthermore, socioeconomic and demographic variables, including deprivation index and primary care physician density, have been associated with differences in hospitalization rates for pneumonia. In Korea, higher deprivation scores correlated with higher hospitalization rates, whereas a higher number of primary care physicians correlated with lower rates. In Minnesota, Kim et al. (2019) found that increased pneumonia hospitalization risk was correlated with lower median household income and higher race/ethnic diversity indices.

4.6 Pneumonia household response strategies

Results in Table 4.9 show the multiple response strategies of pneumonia. The most common response strategies were use of warm clothing (31%), environmental hygiene (16%), and balance diet and proper housing ventilation (each 11%). This indicates that's warm environment helps to manage respiratory infections. Some aspects relating to warm conditions in response to pneumonia household strategies focused on body temperature management, by maintaining appropriate body warmth helps support the immune system's fight against the infection. Physiological benefits are another aspect in which warmth can help improve blood circulation, support better respiratory function and assist in mucus mobilization and clearance from the lungs thus enhancing smooth inhalation. Warm condition strategies maintaining a comfortable room temperature.

Table 4.10: Household pneumonia response strategies

Variables	Frequency	Number of respondents (%)
Warm clothing	101	31
Balanced diet	35	11
Medical checkup	29	9
Well-ventilated house	34	11
Environmental hygiene	50	16
Humid cleaning	25	8
Use of herbal medicine	20	6
Avoid overcrowding and pollutants	29	9
Total	323	100

Qualitative findings support the quantitative results which revealed that warm conditions may help reduce the incidence and severity of pneumonia by mitigating the effects of cold-induced respiratory stress and supporting better clinical outcomes in patients with respiratory diseases. Warm conditions play a crucial role in pneumonia response strategies by mitigating the adverse effects of cold temperatures, which are associated with increased pneumonia risk. For example, one of the key informants reported:

“The response strategies used by most households in the area is controlling the causes or risk factors directly such as cleaning their homes and using warm clothing. From my experience, most families with a history of pneumonia, practice regular cleaning to reduce dust and allergens” **[Participant 1, Male Physician]**

Other key informants pointed to some other response strategies in rural based locations such as Poiywek and Kipchimchim which include using warm clothing, household hygiene and shifting from muddy housing structures. One of the key informants reported:

“In this area, most families with a background of pneumonia practice household hygiene and often use clean sources of energy such as biogas. These families have also shifted from muddy housing structures to help avoid the prevalence. During cold weather, we also encourage most pneumonia related patients who visit our facility to keep warm clothing” **[Participant 3 Male Clinician]**

In support of these findings, Makrufardi et al. (2024), reported that cold temperatures significantly elevated the risk of pneumonia, especially among vulnerable populations, including children and the elderly. Moreover, according to a study by Zheng et al. (2021), extreme temperatures, especially extreme cold, are associated with a higher risk of pediatric pneumonia events, especially in children living in temperate climate zones.

According to Lehman et al. (2010) low nutritional status is associated with increased risk and severity of acute lower respiratory tract infections in young children in Papua New Guinea. Adequate control and prompt treatment of infectious diseases improved nutritional status. At the same time, improvement in nutritional status reduced morbidity and mortality due to infectious disease, particularly acute lower respiratory tract infections and diarrhoea.

Therefore, from previous findings the house ventilation plays a significant role in the control and prevention of pneumonia. Proper ventilation helps reduce the concentration of airborne pathogens that can cause pneumonia and Increases air circulation, which regulate and removes infectious particles from the indoor environment, helps to prevent the accumulation and transmission of respiratory pathogens and prevents excessive moisture that can promote bacterial and fungal growth thus improves overall indoor air quality. In the current study, few participants are using proper ventilation as one of the mitigation strategies (11%).

According to Liu et al. (2024), frequent household ventilation, cleaning, and exposure to sunshine can reduce the effects of household damp-related exposures on childhood pneumonia, while air humidifier and air conditioner use may increase the risk. Frequent checkup and avoiding crowded places/Pollutants/Smokers are 11 percent represented on response strategy on pneumonia on children under 5 of age in the study area. Findings showed that regular medical screenings help detect early signs of respiratory issues and allow timely diagnosis and intervention before pneumonia exceeded. Findings also show that children and immunocompromised individuals are susceptible to high risk of pneumonia. Frequent checkups help manage pneumonia and help evaluate individual risk factors like age, underlying health conditions, and immune status, enabling preventive measures. In support of previous findings M, et al. (2024) reported that community-based interventions significantly improve health-seeking behavior, knowledge, and practices in children under five with pneumonia, reducing mortality and morbidity.

These studies indicate that isolation from crowded places can reduce the risk of pneumonia in children under five by reducing exposure to respiratory infections. Crowding is

a major risk factor for pneumonia; and avoidance of exposure to pollutants and smoking; can greatly reduce the risk of pneumonia in children under five by reducing exposure to indoor air pollution and secondhand smoke. According to Karki et al. (2015), household smoke and parental smoking are modifiable risk factors for pneumonia in children under 5 years of age in Nepal. According to WHO (2014), indoor air pollution from cooking and heating with biomass fuel, living in overcrowded homes, and parenting smoking are major risk factors of pneumonia.

In support of this earlier finding, Ram et al (2014) reported a decreased risk of childhood pneumonia associated with lower crowding and improved ventilation in living quarters in urban Dhaka, Bangladesh. Crowding, a tin roof in the living space, low socioeconomic status, and male sex of the child were risk factors for pneumonia. The living space in case households were 28% less likely than in control households to be cross-ventilated. Particulate matter concentrations were not significantly associated with pneumonia. With increasing urbanization and supply of improved cooking fuels to urban areas, the high burden of respiratory illnesses in urban populations such as Kamalapur may be reduced by decreasing crowding and improving ventilation in living spaces.

The findings show that avoiding Pollutants is a strategy that plays a significant role in combating pneumonia in under 5 years old through the following ways it reduces exposure to air pollution this helps to maintain the role of lung tissues and mucous membranes, making them more resilient against respiratory infections, industrial emissions, avoid outdoor activities during high pollution days and wear protective masks in areas with significant environmental contamination. Indoor air quality improvements minimizing indoor smoke from cooking and heating sources (especially wood or coal stoves) reduce respiratory tract inflammation. Using cleaner cooking technologies and ensuring proper ventilation can decrease lung inflammation and infection risk. Reducing exposure to secondhand tobacco smoke prevents immune system suppression and respiratory tract damage.

Other Strategies include proper garbage disposal (9%), humid cleaning (8%), keeping environment clean/hygienic (7%) and herbal medicine provision (6%) play a significant role to under five pneumonia control. In support to recent study Naz *et al.* (2020) reported that pneumonia prevalence in Pakistan declined with decreased use of polluting fuel, but overcrowded homes and biomass cooking increased the risk, suggesting the need for mitigation measures in under-five children in Pakistan also Khan et al. (2018) Children in Pakistan who use polluting fuels for cooking are 1.5 times more likely to have acute respiratory infection symptoms than those using cleaner fuels, around 2.7 billion people in

the world cook with polluting fuels, such as wood, crop residue, animal dung, charcoal, coal, and kerosene. Household air pollution from cooking polluting fuels is recognized as a major risk factor for the disease burden. In their research in Nepal among children under five years, Paudel et al. (2024) identifies the following factors significantly contributing to the risk of childhood pneumonia: non-exclusive breastfeeding; indoor air pollution; incomplete basic immunizations; low birth weight; and severe acute malnutrition. Exclusive breastfeeding is an important component, and gender appears to be involved in the association between exclusive breastfeeding and pneumonia incidence. Moreover, Jackson et al. (2013) reported that seven risk factors, such as low birth weight, exclusive breastfeeding, crowding, indoor air pollution, incomplete immunization, undernutrition, and HIV infection, significantly increase the risk of severe pneumonia in children under five years of age. These seven risk factors showed a strong, consistent association with severe ARI across studies, with the following meta-analysis estimates for odds ratios (interpretable as 95% confidence intervals): low birth weight, 3.18 (1.02-9.90); lack of exclusive breastfeeding, 2.34 (1.42-3.88).

In a study by Paudel et al. (2024) in children under five years in Nepal, the following are found to be significantly associated with the risk of childhood pneumonia: non-exclusive breastfeeding; indoor air pollution; incomplete basic immunizations; low birth weight; and severe acute malnutrition. Exclusive breastfeeding is an important component, and gender appears to be involved in the association between exclusive breastfeeding and pneumonia incidence. Moreover, Jackson et al. (2013) reported that seven risk factors, including low birth weight, lack of exclusive breastfeeding, crowding, indoor air pollution, incomplete immunization, undernutrition, and HIV infection, significantly increase the risk of severe pneumonia in children under five years of age. These seven risk factors were significantly associated with severe ARI in a consistent fashion across studies, with the following meta-analysis estimates of odds ratios (with 95% confidence intervals): low birth weight 3.18 (1.02-9.90), lack of exclusive breastfeeding 2.34 (1.42-3.88).

4.6.1 Cross-tabulation between energy source and response strategies

Results in Table 4.10 underscore the role of various energy sources in household prevention or management of pneumonia. The findings revealed that wood fuel is the most common energy source (85.8%) and the most response strategy was the use of warm clothing (31%). There was no significant association between energy source and household pneumonia response strategies ($p=0.968$). Among wood fuel users, 28.9% use warm clothing as a dominant response strategy. Despite the differences in energy sources (which likely

correlate with different levels of indoor air pollution), the pattern of response strategies is relatively similar across groups.

Table 4.11: Chi-Square tests of energy source and the response strategy

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.888 ^a	32	.968
Likelihood Ratio	23.004	32	.878
Linear-by-Linear Association	3.748	1	.053
N of Valid Cases	323		

Wood fuel users show slightly more diversity in response strategies, which could reflect either greater awareness of multiple approaches or greater need for multiple interventions. Results may inform targeted public health interventions that consider both patterns of energy use and existing response mechanisms.

Table 4.12: Cross-tabulation of type of energy and the response strategy

Response Strategies	Wood	Hydro/Solar	Biogas/Gas	Fossil	Others	Total
Warm clothing	80	8	6	6	1	101
Balanced diet	31	1	2	1	0	35
Frequent checkup	27	1	1	0	0	29
Proper ventilation	31	1	1	1	0	34
Environmental hygiene	41	5	3	1	0	50
Humid cleaning	22	1	1	1	0	25
Herbal medicine	17	1	1	1	0	20
Avoid overcrowding/pollutants	28	1	0	0	0	29
Total	277	19	15	11	1	323

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the findings, conclusions, and provides recommendations.

5.2 Summary of findings

The quantitative analysis of the study revealed that pneumonia is a major public health problem for children younger than five years of age in the study area, which manifested with various symptoms such as shortness of breath, chest congestion, and persistent coughing. Pneumonia prevalence was not significantly linked to energy sources but was positively correlated with housing type ($P < 0.05$). For example, timber/wooden houses experienced a higher prevalence of pneumonia, while modern houses showed lower rates. Other factors, including exposure to indoor air pollution, also contributed, with many families from lower-income backgrounds more likely to use biomass fuel stoves to reduce exposure to pollutants.

The study found that pneumonia prevalence wasn't distributed evenly across the area. Cases were concentrated in densely populated urban and rural hotspots. The variance in pneumonia observed across space was attributable to a complex combination of socio-economic, demographic, environmental and healthcare system factors. Understanding these factors is essential for designing applicable public health policies and interventions to reduce the burden of pneumonia across various settings. Four key variables were found to be the most important predictors of childhood pneumonia: family history, humid cleaning practices, residential location, and household crowding. Other contributing factors included overcrowding, environmental factors (malnutrition, poverty), poor ventilation, and indoor air pollution. Genetic factors, particularly involving immune system characteristics or family susceptibility, were also found to contribute to pneumonia risk.

Furthermore, living environment (urban, peri-urban, or rural) was significantly associated with pneumonia prevalence. For example, lower prevalence is generally expected in rural areas, and rural risk factors include poor housing conditions and possible exposure to agricultural environments. Rates of pneumonia were also statistically linked to frequency of exposure to crowded places, environments that promote social mixing and higher risk of respiratory infections. Interestingly, indoor air pollution tended to be dominant in peri-urban settlement patterns, which tend to have high use of biomass fuel for cooking and heating due to limited access to other energy forms.

Finally, the most common response strategy used by households to manage pneumonia was warm clothing, suggesting that a warm environment may have a role in managing respiratory infections. Other common strategies were ensuring sufficient ventilation within housing, improving housing hygiene as well as avoiding overcrowding and exposure to pollutants.

5.3 Conclusions

The study concludes that pneumonia remains a major public health concern for children under five in the study area. Persistent symptoms such as coughing, chest tightness, and shortness of breath underscore the ongoing struggle. While no significant statistical relationship was found between household energy sources and pneumonia prevalence, housing type showed a marked effect. Traditional timber housing types exhibited higher pneumonia rates compared to modern homes, highlighting the importance of housing quality as an indirect determinant of child health.

The study also highlights four key determinants of pneumonia risk: hereditary factors, humid cleaning practices, residential location, and household crowding. Family history implies a genetic component, highlighting the importance of genomic awareness in public health strategies. Environmental and behavioral factors including overcrowding, poor ventilation, exposure to indoor air pollution, and low income were related to pneumonia risk, particularly in peri-urban settings with high biomass fuel use. While spatial variation was not statistically significant, clustering of cases in densely populated urban and rural areas pointed to the relevance of living conditions, healthcare access, and environmental exposures in shaping disease patterns. Interventions to control pneumonia should be adapted to the geographic and demographic differences in risk factors.

5.4 Recommendations

This section presents recommendations that are aimed at addressing the identified challenges highlighted in the study. It's divided into policy actions and further research.

5.4.1 Recommendations for policy actions

Based on this study's findings, policy action recommendations are provided as follows:

- (i) Emphasis should be placed on household cleaning and ventilation. Efforts should be made to avoid overcrowding and maintain a sanitary environment to reduce the likelihood of pneumococcus.

- (ii) Community leaders can play a role in spreading the word about the causes of pneumonia. This involves promoting awareness about the significance of sanitation and other determinants of pneumonia.
- (iii) Governments should establish integrated community case management centers and response initiatives, particularly in high-pneumonia areas. These centres would support early diagnosis and intervention.
- (iv) Pneumonia prevention should be a top public health priority for children under 5 years of age. This includes strengthening pneumonia surveillance systems in high-prevalence areas and increasing funding for child health programmes.

5.4.2 Recommendations for further research

- (i) Quantifying the seasonal component of pneumonia in a longitudinal study to assess the relative contribution of different seasons.
- (ii) Further studies should focus on evaluating the adoption and effectiveness of various childhood pneumonia control strategies in Kericho County.
- (i) A comprehensive study to investigate socio-economic characteristics of households, including income, education, and housing conditions, and their relationship with pneumonia prevalence is required.

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APPENDICES

APPENDIX 1: HOUSEHOLD QUESTIONNAIRE

Dear respondent,

My name is Nicholas Tonui, an MSc student at Egerton University, Njoro. This questionnaire is designed to collect data for the study on the topic entitled “**Determinants, Prevalence, Spatial Variation of Pneumonia and Control Strategies Among Children Aged Under Five Years In Kericho County, Kenya**”.

The purpose of this study is to provide an assessment of the spatial variation and prevalence of Pneumonia among children in Ainamoi Sub-County. Your most valuable contribution to the questions enclosed will be highly appreciated as this will provide a baseline data and information for policy makers to design or enhance the control strategies of the pneumonia among children. Your data will be treated with utmost confidentiality and will be used solely for academic purpose.

For any information regarding the study, do not hesitate to contact the university regarding the same.

Thank you

SECTION A. GENERAL INFORMATION

Date	
Questionnaire No	
Sub-County	
Ward	
Location	

GPS coordinates	
Name of respondent (Optional)	
Telephone No.	

SECTION B. RESPONDENT'S CHARACTERISTICS

1	Age of Respondent (Years)	[In year or year of birth] _____
2	Gender of Respondent	1= Male [] 0= Female []
3	Relationship of respondent with the child	Respondent and his/her age: 1) Mother [] 2) Father [] 3) Sibling [] 4) Other []
4	Occupation of Head Household:	1) Medical practitioner [] 2) Academic Trainer [] 3) Farming [] 4) Other professional occupational [] 5) Casual laborers [] 6) Other /please write _____
5	Education level of parent/caregiver	0=No formal Education [] 1= Primary [] 2= High School [] 3= College [] 4= University []
6	Number of defendants members in the HH	_____ (Specify the exact number)
7	Number of children under five years	_____ (Specify the exact number)
8	Sex of child(children):	1) Male [] 2) Female []

SECTION C. PREVALENCE OF PNEUMONIA AMONG CHILDREN UNDER FIVE

		Response Yes.....1 No.....2>>>next item	Explanation
Activity code		C.01	C.02
A	Were there any occurrences of any respiratory illness, especially PNEUMONIA or asthma, in the last 1 year in your HH among child under-five years?	1) Yes, [] 2) No []	(Specify period if possible)
B	If yes in A above, how many times did your child experience pneumonia cases?	Indicate frequency 1. Once [] 2. More than once but not often [] 3. More than once but often [] 4. Very frequent []	Feel free to describe the frequency here
C	How many times in a given season?	1) Winter/rainy season [] 2) Summer/dry season []	Please circle appropriate one
D	If yes in A, state the frequency of routine medical check-up.		
E	IF YES, what diseases do you know? (Can be many answers)	1) coughing [] 2) bronchitis [] 3) laryngitis [] 4) pneumonia []	

		5) TB of lung [] 6) Asthma [] 7) Common cold [] 8) others (please write) []	
F	From which sources do you get information on respiratory diseases among the children?	1) from health workers [] 2) TV and radio [] 3) newspapers and other print media [] 4) Own Experience [] 5) Social media [] 6) Public forums/barazas [] 7) other sources (please write)	
G	Identify the potential causes of pneumonia disease in your HH or neighborhood	1) Air pollution [] 2) Contact Way [] 3) From Infected Persons [] 4) Dirty / Dusty environment [] 5) Poor housing design or material [] 6) By Other Ways []	
H	In your opinion does air pollution have an effect on respiratory diseases?	1) yes [] 2) No []	
I	Do you know some sources of indoor air pollutants?	1) Yes [] 2) No []	

SECTION D. DETERMINANTS OF PNEUMONIA AMONG ON CHILDREN

Productive capital		RESPONSE	
		Yes.....1 No.....2 >>>next item	
Activity code		D.01a	D.02
A	If a child got respiratory diseases more than once, do you know cause of illness?	1) Yes [] 2) No []	
B	Please state the causes of PNEUMONIA in your opinion		

C	Did siblings get PNEUMONIA in the last 1 year?	1) yes [] 2) No []	(Specify period if possible)
D	Did child's mother get PNEUMONIA last year?	1) yes [] 2) No []	(Specify period if possible)
E	Daily activity of your child	1) Attending kindergarten [] 2) Informal playgroup/day-care [] 3) Stay with care giver [] 4) Stay with parent/grandparents or other family members []	
F	Type of family house/residence:	1) Mud walled-house iron sheet roofing [] 2) Traditional grass-thatched [] 3) Timber/wooded house [] 4) Fully furnished rented apartment [] 5) Unfurnished apartment house [] 6) Iron sheet-walled house [] 7) Permanent housing (blocks/bricks) [] 8) Other housing (specify) _____	
G	Type of fuel/source of HH energy	1. Wood fuel/Charcoal [] 2. Electricity/solar [] 3. Biogas/Gas cylinders [] 4. Fossil fuel (Kerosine) []	
H	How do you rate the air ventilation of your house?	1) Very well ventilated [] 2) Well-ventilated [] 3) Moderately ventilated [] 4) Poorly ventilated [] 5) No ventilation []	
I	Major HH food profile/composition: What is the chief household regular diet	List _____	
J	Range of income levels of head of HH (Provide your range of income levels on monthly basis)	1. 0 – 5,000 [] 2. 5,001 – 15,000 [] 3. 15,001 – 25000 [] 4. 25001 – 35,000 [] 5. Above 35000 []	
K	Proximity to health facilities	1. <1 Km 2. Between 1 – 2 Km 3. More than 2 Km	

SECTION E. MEASURING SPATIAL VARIATION OF CHILD PNEUMONIA

		RESPONSE	Notes
Activity code	QUESTION	E.01	E.02
A	Residential/locality	How do you classify your place of resident? 1. Urban setting [] 2. Peri-urban setting [] 3. Rural/remote countryside []	
B	Proximity to industrial/manufacturing plant or factory/mining etc.	1. Within 1Km [] 2. More than 1km but < 10km [] 3. More than 10km [] 4. No industry in the vicinity []	
C	Settlement/residential type/characteristic.	1. Informal settlements in urban [] 2. Formal settlement in urban [] 3. Informal housing in rural [] 4. Permanent housing in the rural []	
D	Time of the year when there is more prevalence of pneumonia	1) Winter/rainy season [] 2) Summer/dry season []	
E	Frequency of attending large/crowded places	1. Verry frequent [] 2. Frequent [] 3. Rarely [] 4. Very rarely	
F	Method of waste/garbage disposal	1. Collection by municipality [] 2. Individual HH disposal area [] 3. No collection/disposal point []	

SECTION F: MEASURING EFFECTIVENESS OF HOUSEHOLD RESPONSE STRATEGIES

HOUSEHOLD RESPONSE STRATEGIES		RESPONSE	Explanation
Activity code	Question	F.01	F.02
A	What is the frequency of air ventilation of your home in winter/rainy season?	1) daily [] 2) weekly [] 3) monthly [] 4) occasionally [] 5) never []	

B	What is the frequency of air ventilation of your home in summer/ dry season?	1) daily [] 2) weekly [] 3) monthly [] 4) occasionally [] 5) never []	
C	Do you measure indoor temperature by thermometer?	1) Yes [] 2)No []	
D	IF measure temperature by thermometer please tell the minimum and maximum in you estimation	Min 1) winter/rainy _____ 2) Summer/dry _____	Max 1) winter 2) Summer
E	Do you dry clothes in your home?	1) yes [] 2) no []	
F	What is the frequency of humid cleaning in your home?	1. Daily [] 2. Few times a week[] 3. Few times a month [] 4. Once a month[] 5. Less than once a month [] 6. Never []	
G	Are there any cases of wind through your home in cold season?	1) Yes [] 2)No []	
H	What do you do to prevent a child from getting Pneumonia in the cold season?	(please write) _____	
I	Do you have any ventilation system to remove smoke and steam?	1) Yes [] 2) No []	
J	Do you use a fan to remove smoke and steam during cooking?	1) always [] 2) sometimes [] 3) never use [] 4) don't have any equipment []	

APPENDIX 2: HEALTH FACILITIES INTERVIEW SCHEDULE

Code (if relevant)	Date (dd/mm/yy)	Interview number

1. Introduction

This interview aims to assess the spatial variation and determinants of child pneumonia among children under five years in Ainamoi Sub-County, Kericho County. It will focus on thematic areas that are critical to child pneumonia. That is: prevalence of pneumonia among children, determinants, spatial variations and to identify the community response strategies.

1.1 What is your current position?

1.2 What is your current place of work or institution?

1.3 You are representative of which of the following?

- | | |
|--------------------------|---|
| <input type="checkbox"/> | 1. The Ministry of Public Health and Sanitation |
| <input type="checkbox"/> | 2. A health professional association |
| <input type="checkbox"/> | 3. A regulatory body, such as a health professional council |
| <input type="checkbox"/> | 4. A private health service, such as a private clinic |
| <input type="checkbox"/> | 5. A public health service, such as a public hospital |
| <input type="checkbox"/> | 6. A client or patient of a health service |
| <input type="checkbox"/> | 7. A provider of in-service or continuous professional development training |

8. Other (Specify):

2. Prevalence

2.1 In your opinion, what is the prevalence rate of pneumonia among children who patronage your facility for treatment (Multiple response allowed)

- 1) Many times, a week
- 2) Once a week
- 3) Infrequent within a week
- 4) Once in a while in a month
- 5) Rarely
- 6) None within a month
- 7) Other (Specify):

2.2 In relation to your previous response, what is the single most important factor that causes child pneumonia?

2.3 In your opinion, does outdoor air pollution predisposes the children to pneumonia more than household factors?

1. Yes
2. No
3. I don't know

2.3.1 Why? Explain your answer.

2.4 In your opinion, what are the prevalence factors of pneumonia among children under-five in your facility?

3. Determinants

3.1 In your opinion, what do you think are the key environmental related predisposing factors for child pneumonia in your working locality? (Multiple Response allowed)

<input type="checkbox"/>	1. Place of residence	
<input type="checkbox"/>	2. Maternal age	
<input type="checkbox"/>	3. Maternal education	
<input type="checkbox"/>	4. Maternal occupation	
<input type="checkbox"/>	5. Household crowding index	
<input type="checkbox"/>	6. Home aeration (subjective)	
<input type="checkbox"/>	7. Household cigarette smoke exposure	
<input type="checkbox"/>	8. Outdoor air pollution (Factory near residence)	
<input type="checkbox"/>	9. I don't know	
<input type="checkbox"/>	10. Other (Specify):	<input type="text"/>

3.2 In your opinion, what are the child-related factors associated with the risk of pneumonia among under-five children? (Multiple response allowed)

<input type="checkbox"/>	1. Age	
<input type="checkbox"/>	2. Sex	
<input type="checkbox"/>	3. Weight for age	
<input type="checkbox"/>	4. Birthweight (grams)	
<input type="checkbox"/>	5. Birth order	
<input type="checkbox"/>	6. Prematurity	
<input type="checkbox"/>	7. Place of delivery	
<input type="checkbox"/>	8. Mode of birth	
<input type="checkbox"/>	9. Breastfeeding practice	
<input type="checkbox"/>	10. Vaccination status	
<input type="checkbox"/>	11. Concomitant illness	
<input type="checkbox"/>	12. Other (Specify):	<input type="text"/>

3.2.1 Which of the above factors do you think is the most determinant of the pneumonia among children under-five in Ainamoi Sub- County? Explain your answer.

3.3 In your opinion, what are the risk factors independently associated with pneumonia under-five children? (Multiple response allowed)

<input type="checkbox"/>	1. Presence of concomitant illness	
<input type="checkbox"/>	2. Poor home aeration	
<input type="checkbox"/>	3. Exposure to outdoor air pollution	
<input type="checkbox"/>	4. Place of delivery	
<input type="checkbox"/>	5. Prematurity	
<input type="checkbox"/>	6. Low birth weight < 2500 gm	
<input type="checkbox"/>	7. Birth order ≥ 4	
<input type="checkbox"/>	8. Age ≤ 12 months	
<input type="checkbox"/>	9. Other	<input type="text"/>
	(Specify):	

4. Spatial variation

4.1 In your opinion, do you think pneumonia varies in space and time?

<input type="checkbox"/>	4. Yes
<input type="checkbox"/>	5. No
<input type="checkbox"/>	6. I don't know

4.1.1 Why? Explain your answer.

4.2 In your opinion, what are the main reasons for the spatial variation of pneumonia prevalence among children in rural and urban settings in Ainamoi Sub-County?

5.1 Community Response strategies

5.1 What are some of the community prevention measures for pneumonia among children under-five (policy recommendation) in Ainamoi Sub-County?

APPENDIX 3: CASE BOOK

	Prevalence of pneumonia	Determinants of pneumonia	Spatial variation of pneumonia	Control strategies of pneumonia
P1: Role: physician Sex: Male Facility: St. Leonard	<p>I believe the main factors contributing to pneumonia among children under five in my facility are pollutants and exposure to cold. Pneumonia can be prevented through proper ventilation using windows, fans, and HVAC systems. In my view, the prevalence rate is significant, occurring several times a week. While indoor air pollution is a key risk factor, I think outdoor air pollution poses a greater threat to children.</p>	<p>In my view, key risk factors for pneumonia include place of residence, such as rural or peri-urban areas, and age, with young children and the elderly being more vulnerable. In our facility, the most common symptoms are congestion and rapid breathing. Major indoor air pollution sources include combustion from cooking, heating, and tobacco, VOCs from building materials, and biological contaminants like mold, pet dander, and dust mites.</p>	<p>In terms of special variation yes pneumonia far is in space and time my advice would be to avoid areas which are crowded and polluted areas the main reason for special variation of pneumonia among children enrolled in upon areas is the household characteristics and Divas daily activities</p>	<p>The response strategies used by most households in the area is controlling the causes or risk factors directly such as cleaning their homes and using warm clothing. From my experience, most families with a history of pneumonia practice regular cleaning to reduce dust and allergens</p>
P2: role: nurse	<p>In my view, early exposure to outdoor air pollution can lead</p>	<p>I believe air pollution and prolonged exposure to airborne</p>	<p>With rising urban air pollution, studies should aim</p>	<p>Urban morphology significantly impacts energy consumption in buildings, decreasing cooling</p>

<p>sex: male facility: kipchinchim dispensary</p>	<p>to respiratory issues but can be managed by avoiding crowded areas. Pollutants like sulfur dioxide, and humidity are linked to pneumonia and higher hospitalization rates.</p>	<p>contaminants contribute to respiratory issues like asthma and COPD. Specifically, air pollution significantly affects conditions like acute community-acquired pneumonia (CAP).</p>	<p>to study its link to pneumonia severity and hospitalization outcomes. Rapid urbanization and increased density have worsened air pollution and energy use.</p>	<p>load and increasing ventilation potential during hot conditions, wind flow plays an important role in passive or active ventilation systems, helping to reduce the cooling load of buildings</p>
<p>P3: role: clinical officer sex: male facility: kipchinchim dispensary</p>	<p>Many patients, especially children under five years are patronage our clinic due to chest and breathing challenges during cold and hot seasons/conditions</p>	<p>Extreme temperatures significantly increase the risk of pediatric pneumonia, often caused by <i>Streptococcus pneumoniae</i>, <i>Haemophilus influenzae</i> (Hib), or respiratory syncytial virus. Evidence shows temperature variations strongly influence pneumonia cases and hospitalizations in children.</p>	<p>Changes in seasons like climate change, either warm or cold impacts human infectious disease via pathogen, host and transmission. This can be combat by going beyond empirical observation of association between climate and health effect and adopting certain proactive measures.</p>	<p>In this area, families with a history of pneumonia practice good hygiene, use clean energy like biogas, and have moved away from muddy houses to reduce risks. During rainy seasons, many families are advised to dress warmly. The government should support these families by setting up local weather warning systems and improving pneumonia prediction.</p>
<p>P4: Clinician</p>	<p>Pneumonia affects children more severely due to their</p>	<p>Children's developing organs and narrower airways make them</p>	<p>Pneumonia varies across space and time. I advise</p>	<p>There are many response strategies that communities can employ to mitigate the</p>

<p>Facility: Poiywek Dispensary</p>	<p>narrow airways, causing inflammation and mucus buildup that increase breathing effort and oxygen demand, risking respiratory failure. Reduced oxygen delivery impairs organ development, while cardiac stress and metabolic disruptions hinder growth and overall function.</p>	<p>more vulnerable to pollutants, which can cause significant obstruction. Other factors include hypoxemia severity, inflammatory response, and pre-existing respiratory conditions.</p>	<p>residents to avoid overcrowded areas with pollutants like dust, smoke, and fumes. In my view, this variation is linked to household characteristics and daily activities of children under five.</p>	<p>prevalence of pneumonia this includes using ventilation in their homes using clean sources of energy such as electricity instead of fossil fuels also they can perform daily humidity cleaning in their homes and avoid dusty environments patients with symptoms of pneumonia should also avoid overcrowded homes and dump clothing such as beddings. They should also practice the habit of airing their clothes and taking them to a sunny environment to keep them dry and free from potential pollutants.</p>
<p><i>P 5: Male</i> <i>Pediatricia</i> <i>n, kericho</i> <i>county</i> <i>hospital</i></p>	<p>Exposure to household air pollution is associated with an increased risk of pneumonia in children in this area especially where the income level is low. However, exposure-response data are limited and please do not quote me as reference because I don't have data to</p>	<p>Air pollution exposure leads to severity of pneumonia cases among the under 5 mostly in rural regions because of periodic high levels of outdoor air pollution due to different households varying cooking fuels (biomass, coal) also traditional cooking methods and households' characteristics and nature of ventilation.</p>	<p>Spatial variation in household air pollution (HAP) and pneumonia risk is Influenced by the geographic factors which include urban and rural Setting.in urban areas population density and housing patterns significantly affect children under 5 years due to of pollutants from</p>	<p>To mitigate the pneumonia epidemic one way is by introducing cleaner-burning biomass-fueled cookstoves to prevent pneumonia in children under 5 years old in rural areas. Pneumonia also can be managed improving the levels of healthcare infrastructure which affect pneumonia diagnosis and treatment because of the availability tools and equipment.</p>

	support these. I know of many families with risk of pneumonia are using biomass-fueled cookstoves to reduce these exposures.		closer living quarters and industrial proximity and in rural areas pneumonia is experience due to traditional cooking methods and fuel types.	
<i>P 6: Male Nurse, kericho county hospital</i>	Some of the prevalence of pneumonia according to me is occupational Factors and nutritional Status. Malnutrition weakens the immune system, making children more vulnerable to infections like pneumonia. This is will increase prevalence of severe pneumonia among malnourished children	For the fact food insecurity or Poor dietary quality and limited access to nutritious food leads to malnutrition thus increasing susceptibility to pneumonia due to vitamin and mineral deficiencies in the somatics tissues. Some the working environment contributes to high risk of pneumonia to children under because of limited workplace safety measures and job-related exposure to pollutants at work place i.e factories.	Exposure to air pollution, especially particulate matter, has been linked to increased incidence of pediatric pneumonia. Short-term exposure to these pollutants can exacerbate respiratory conditions, leading to pneumonia. Pneumonia cases often peak during colder months due to increased indoor crowding and reduced ventilation, which facilitate the spread of respiratory infections.	Nutritional status is a crucial determinant of pneumonia severity in children, with malnutrition significantly increasing the risk of severe and persistent pneumonia. Environmental factors like crowding and bed-sharing also play a role in the spread and severity of pneumonia. Addressing these factors through nutritional interventions and improved living conditions could reduce pneumonia incidence and improve outcomes in children.

<p>P 7: Male: Physician, Siloam hospital</p>	<p>According to me, vulnerability can significantly increase pneumonia risk and severity in children under five due to Socioeconomic factors, biological vulnerabilities and environmental risks. These vulnerabilities compound each other - for example, malnutrition further weakens already developing immune systems.</p>	<p>Some determinant under socioeconomic factors include:</p>	<p>Pneumonia varies in space and time, during the rainy season's pneumonia is mostly reported thus children should be kept in a warm environment condition to gap the incidence of pneumonia on children especially under five because of their vulnerability. More so in urban setting most of the activities are conducted indoors while in rural activities are outdoors thus parent or caregivers exposes young ones to predisposing factors</p>	<p>Some community prevention measures for pneumonia among children under five years include creation of awareness to the parents and caregivers by conducting education or creating a room of understanding on health education to prevent pneumonia and also to inform them on immunization processes this will help to cap the issue of pneumonia among children under five years in the region. To prevention pneumonia strategies must address both biological and social vulnerabilities through vaccination, nutrition support, improved living conditions and healthcare access.</p>
<p>P8: Female Pediatrician, Kericho county</p>	<p>Those who are visiting our clinic have many and most single factors that cause pneumonia is poverty; the</p>	<p>Looking closely, these deaths are concentrated amongst the poorest populations, low and middle-income earners due to reduced</p>	<p>it's true pneumonia varies in terms of regions.in areas close to factories cause high levels of air pollution</p>	<p>To combat this epidemic menace among the children, health care facilities must be well equipped for prevention and care-seeking behavior and also create awareness of warning</p>

<i>hospital</i>	<p>high death rates of pneumonia can be linked to poverty. Poverty leads to pneumonia through factors such as lower family income, poor sanitation, lack of immunization, indoor air pollution, and limited access to healthcare services.</p>	<p>access to quality health care, nutrition and basic environmental hygiene which contributes to exacerbating the disease incidence. Overcrowded housing, which is more common in poverty, increases transmission of respiratory pathogens</p> <p>Poor ventilation in substandard housing increases exposure to indoor air pollution Limited access to clean water and sanitation facilities affects overall hygiene</p> <p>Poverty is a significant determinant of pneumonia, particularly in terms of both risk and outcomes</p>	<p>exposure hence led to a compromise in breathing mechanism of the respiratory tract, therefore increasing the risk of the development of acute respiratory infections</p>	<p>signs and symptoms and improve on access to health information and resources. control exposure to indoor air pollution from cooking with solid fuels and exposure to environmental tobacco smoke.</p>
<i>P 9: Male, Opsgyne, kericho</i>	<p>Socioeconomic factors, including poverty, education Level, Living Conditions and</p>	<p>Parental education level can significantly influence the risk and management of pneumonia in</p>		<p>Educated parents are more likely to adopt preventive measures such as ensuring proper vaccination, maintaining good hygiene, and</p>

<p>county hospital</p>	<p>a lack of access to clean water and sanitation, contribute to the vulnerability of children to this disease.</p>	<p>children. Limited health literacy and disease awareness, poor understanding of prevention measures, reduced ability to recognize early symptoms and less knowledge about proper hygiene practices. Higher education levels are often associated with better socioeconomic status, which can lead to improved living conditions, such as better housing and access to clean water and sanitation. These factors can reduce the risk of pneumonia.</p>		<p>avoiding exposure to environmental pollutants more so higher parental education levels contribute to better knowledge, health-seeking behavior, and socioeconomic conditions, all of which play a crucial role in reducing the incidence and severity of pneumonia in children.</p>
<p>P 10: Male: clinician chasanga dispensary</p>	<p>Yes, vaccination plays a crucial role in preventing pneumonia, Key Vaccines That Prevent Pneumonia are Pneumococcal Vaccines.</p>	<p>`Gaps in vaccination coverage and challenges in accessing healthcare services remain barriers to effective pneumonia control, Limited awareness of vaccination importance</p>	<p>Yes, there are significant differences in vaccination between rural and urban areas. In rural areas vaccination is a challenge because of limited access to</p>	<p>For me, I do recommend the implementation of community-based interventions that address the multifaceted determinants of pediatric pneumonia. These interventions should focus on improving environmental conditions, enhancing access to preventive measures such as</p>

			<p>healthcare facilities and few trained personnel on healthcare especially in rural base settings hence lower awareness about vaccination importance.</p> <p>Urban areas have better healthcare infrastructure and multiple vaccination centers which leads to regular vaccine supply.</p>	<p>vaccination, and promoting better healthcare-seeking behaviors through education and awareness campaigns. It is essential for healthcare providers, policymakers, and community members to collaborate in developing and implementing culturally appropriate and sustainable interventions. This cooperation aims to lessen the impact of pneumonia on children and their families. Also to bridging the gap, mobile vaccination units for rural areas and Public awareness campaigns must be impressed.</p>
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APPENDIX 4: COUNTY GOVERNMENT DEPARTMENT OF HEALTH SERVICES



COUNTY GOVERNMENT OF KERICHO DEPARTMENT OF HEALTH SERVICES

Kericho County Hospital Grounds,
Administration Block, 1st Floor.

Hospital Road
P.O. Box 112 - 20200
KERICHO

Ref: D/NURS/15021/097

Date: 18/12/2023

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORITY: NICHOLAS TONU

This is to confirm that the above named has been authorized by National Commission for science, Technology and Innovation and County Government of Kericho; Department of Health Services to carry out research on “**assessment of spatial variation and prevalence of pneumonia among children under five years in Ainamoi Sub-County, Kericho County, Kenya,**” for a period ending 31st March 2024.

Kindly accord him the necessary assistance.

Dr. Betty Langat
County Director of Health
KERICHO COUNTY



APPENDIX 5: RESEARCH AUTHORIZATION FROM MINISTRY OF EDUCATION



**◦ MINISTRY OF EDUCATION
State Department for Basic Education**

Email: cdekerichocounty@gmail.com
When Replying Please Quote:

County Education Office
P.O BOX 149
KERICHO

Ref: No. KER/C/ED/RC/VOL.111/2/92

1st November, 2023

TO WHOM IT MAY CONCERN.

RE: RESEARCH AUTHORIZATION: MR. NICHOLAS TONU

I refer to the Director NACOSTI Letter Ref: No.867627 dated 29th April, 2023 granting the student above authority to conduct research in Kericho County. His area of study is titled ***“ASSESSMENT OF DETERMINANT PREVALENCE AND SPATIAL VARIATION OF PNEUMONIA AMONG CHILDREN UNDER FIVE YEARS IN AINAMOI SUB-COUNTY, IN KERICHO COUNTY, KENYA”*** for the period ending 29th April, 2024.

This is to request your office to accord him the necessary support during the research period.

Thank you.



**JULIUS A. NGONESHI
COUNTY DIRECTOR OF EDUCATION
KERICHO COUNTY.**



APPENDIX 6: RESEARCH AUTHORIZATION FROM THE MINISTRY OF INTERIOR



**THE PRESIDENCY
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT**

Telegrams:
Telephone: Kericho 20132
When replying please quote
kerichocc@yahoo.com

COUNTY COMMISSIONER
KERICHO COUNTY
P.O. BOX 19
KERICHO

REF: MISC.19 VOL.VIII (147)

1ST November, 2023

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION -MR. NICHOLAS TONU

I am pleased to inform you that you are authorized to undertake research vide letter Ref. No. NASCOTI/P/23/25064 dated 29th April,2023 on *“Assessment determinants ,prevalence, and spatial variation of pneumonia among, children under 5 years in Ainamoi Sub County, Kericho County, Kenya”* for a period ending 29th April, 2024..

JOYCE MUTHONI
FOR: COUNTY COMMISSIONER
KERICHO COUNTY

APPENDIX 7: INTRODUCTION LETTER FROM GRADUATE SCHOOL

EGERTON

Tel. Pilot: 254-51-2217620
254-51-2217877
254-51-2217631
Dir. line/Fax: 254-51-2217847
Cell Phone



UNIVERSITY

P.O. Box 536 - 20115
Egerton, Njoro, Kenya
Email: tpgs@egerton.ac.ke
www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

NM14/14508/18
Ref:.....

23rd March, 2023
Date:.....

The Director General
National Commission for Science Technology and Innovation,
P. O. Box 30623-00100
NAIROBI.

Dear Sir,

**RE: REQUEST FOR RESEARCH PERMIT – MR. NICHOLAS TONUI
REG. NO. NM14/14508/18**

This is to introduce and confirm to you that the above named student is in the Department of Geography, Faculty of Environment Resource Development, Egerton University.

He is a bona-fide registered M.Sc. student in this University. His research topic is “Assessment of Determinants, Prevalence and Spatial Variation of Pneumonia among Children Under Five Years in Ainamoi Sub-County, Kericho County, Kenya”

He is at the stage of collecting field data. Please issue him with a research permit to enable him undertake the studies.

Your kind assistance to him will be highly appreciated.

Yours faithfully,



Prof. George M. Ogendi, Ph.D
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

GMO/wg

“Transforming Lives Through Quality Education”

APPENDIX 8: NACOSTI LICENSE


REPUBLIC OF KENYA


NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

RESEARCH LICENSE

Ref No: 867627 Date of Issue **29/April/2023**



This is to Certify that Mr.. **NICHOLAS TONU** of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kericho on the topic: **AN ASSESSMENT OF DETERMINANT PREVALENCE AND SPATIAL VARIATION OF PNEUMONIA AMONG CHILDREN UNDER FIVE YEARS IN AINAMOI SUB COUNTY, KERICHO COUNTY, KENYA** for the period ending : **29/April/2024**.

License No **NACOST/VP/23/25064**

867627
Applicant Identification Number


Director General
NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY &
INNOVATION

Verification QR Code



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See overleaf for conditions

APPENDIX 9: ABSTRACT OF PUBLISHED PAPER

2958-7999, Vol. 5 (2) 2025

Determinants, Prevalence and Spatial Variation of Pneumonia Among Children Under Five Years in Ainamoi Sub-County, Kericho County, Kenya

Determinants, Prevalence and Spatial Variation of Pneumonia Among Children Under Five Years in Ainamoi Sub-County, Kericho County, Kenya

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<https://doi.org/10.62049/jkncu.v5i2.322>

Abstract

The incidence of acute respiratory infections (ARIs) in Kenya has seen a steady increase, from 8% in 2008 to 9% in 2014 and 14% in 2020, despite concerted governmental efforts to reduce pneumonia-related mortality in children under five. The prevalence of pneumonia in Kenya stands at 16%, higher than the regional average of 14% across Africa. This study sought to evaluate pneumonia prevalence, its determinants, spatial distribution, and household response strategies. An empirical and theoretical review formed the foundation of the research, drawing on germ theory and protective motivation theory. The study utilized a mixed-methods approach combining questionnaires and key informant interviews. The sample size of the study was 391 respondents who were selected using snowball sampling. Data analysis was done using frequencies, percentages, and Chi-square tests. The findings indicated that the pneumonia prevalence rate among children under five in the study area remained high (36%), across key indicators such as cough, breathing issues, and chest complications. The determinants of pneumonia prevalence included hereditary factors, humid cleaning practices, residential location, and frequency of exposure to overcrowded environments (p -value < 0.005). Child pneumonia prevalence in Ainamoi Sub-County. Findings present the three symptoms related to pneumonia: cough, breathing, and chest symptoms.