The Influence of Varied Energy Sources and Household Socioeconomic Characteristics on the Prevalence of Acute Respiratory Infections among Children in Nakuru Town, Kenya

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A Thesis submitted to the Graduate School in partial fulfillment of the requirements for the award of a Master of Science Degree in Environmental Science of Egerton University.

Egerton University

November 2015

Declaration and Recommendation

Declaration

This thesis is my original work and has not been submitted or presented for examination in any other institution either in part or as a whole.

Signature………………………………..Date……………………..

Mugambi Munene Mutuma

NM12/3272/12

Recommendation

This thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

This work is dedicated to my dear parents Dr. Albert Rutere and Dr. Hannah Mugambi and my siblings Victor and Makena Mugambi.

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ABSTRACT

Indoor Air Pollution is the result of combustion of biomass fuels, which leads to 3-4 million deaths worldwide and 500,000 deaths in Africa annually. Indoor air pollution is known to cause respiratory illnesses among children under-5. In Nakuru 39.4% of urban dwellers live below the national poverty line of KSH 2,913 per person per month, thus their accessibility to energy sources is limited to charcoal, paraffin, and other biomass. The objective of this study was to assess the influence of energy sources and household socioeconomic characteristics on the prevalence of ARI among children in Nakuru Town, Kenya. The study was conducted on 187 randomly selected households comprising of low-income and middle-income strata in Nakuru Town. Data was collected using structured questionnaires and observation of the physical characteristics of the houses. Descriptive statistics and multiple linear regression analysis tests were used to analyze the data. From the study findings, charcoal was preferred for cooking among low-income households, while gas and charcoal were preferred among middle-income households. Electricity was the most preferable source of lighting energy for both low and middle-income households. The prevalence rates of ARI for middle-income households were 80 in 100 children and 89 in 100 children in low-income households. Among low-income households, cooking was done outside due to discomfort, fire hazards and lack of space, which assisted in reducing exposure to pollutants that cause ARIs. The socioeconomic factors that were significant and affected thepresence of ARI among children in low-income households were carpeting (p=0.003) and hours spent indoors (p=0.026). In middle-income households the socioeconomic factors were insignificant and did not affect the presence on ARI in children. Overall, 78% of low-income households did not meet government ventilation standards thus landlords and homeowners should build a secure roof hatch window for ventilation. It is also recommended that cooking should be done in properly ventilated areas in order to reduce or curb the adverse human health impacts associated with pollutants from biomass fuels.

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LIST OF ABBREVIATIONS

ALRI	Acute Lower Respiratory Infection
ARI	Acute Respiratory Infection
CO	Carbon Monoxide
CH_4	Methane
DALYs	Disability-adjusted Life Years
EPA	Environmental Protection Agency
EMCA	Environmental Management and Coordination Act
G.o.K.	Republic of Kenya
IAP	Indoor Air Pollution
IAQ	Indoor Air Quality
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
KSH	Kenya Shillings
LPG	Liquefied Petroleum Gas
MoH	Ministry of Health
NAWASSCO	Nakuru Water and Sanitation Service Company
NUDP	National Urban Development Policy
NEMA	National Environmental Management Authority
NO_x	Nitrogen Oxides
PM	Particulate Matter
PPM	Parts per Million
SDG	Sustainable Development Goals
SO_2	Sulfur Dioxide
UN	United Nations
UN-Habitat	United Nations Center for Human Settlements
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children’s Fund
WHO	World Health Organization

CHAPTER ONE
1.0 INTRODUCTION

1.1 Background Information

In sub Saharan Africa, about 70 to 90 per cent of the population depends on biomass fuels as energy sources. Further, it is estimated that more than half a million deaths annually in Africa are associated with indoor air pollution arising from combustion of biomass fuels (UNCTAD, 2012). Acute respiratory infections (ARI) are the leading cause of the global burden of disease and account for more than 6% of worldwide diseases and mortality, primarily in developing countries. Between 1997 and 1999, acute lower respiratory infections (ALRI) caused 3.5–4.0 million deaths worldwide more than that caused by any other infectious disease (Ezzati and Kammen, 2001).According to the World Health Organization (WHO), indoor air pollution (IAP) from the use of solid fuels in households in the developing world is responsible for more than 1.6 million premature deaths each year (Mestl et al., 2007).In Kenya, the National outpatient morbidity rates for respiratory infections among children under 5 were 67% or 4.4 million cases reported. In Nakuru Town, the outpatient morbidity rates for respiratory infections among children under 5 were 41% or 60,000 cases reported (G.o.K., 2011; G.o.K., 2012).

ARI is acute respiratory infection, is a respiratory tract infection that inhibits normal breathing function. It usually begins as a viral infection in the nose, trachea (windpipe), or lungs. Acute respiratory infections can be categorized as upper respiratory infection and lower respiratory infection. Upper respiratory infection occurs in the upper tract of the respiratory system otherwise known as the common cold. The lower respiratory infection affects the lung(s) area primarily causing pneumonia or further lung abscess and acute bronchitis. The early symptoms of acute respiratory infection usually appear in the nose and upper lungs. Other symptoms include: Congestion, either in the nasal sinuses or lungs, runny nose, cough, sore throat, Body aches and fatigue. For lower respiratory infections such as pneumonia the common symptoms likely to be seen are: shortness of breath (struggling to breath), coughing, fever, chills, headaches, loss of appetite, hypothermia, and wheezing (DiMaria and Solano, 2012; WHO, 2012).

Acute respiratory infection prevents the body from getting ample oxygen and can potentially lead to death. Acute respiratory infections are contagious meaning that they can spread from person to person (DiMaria and Solano, 2012; WHO, 2012). Children, older adults, and people with immune system disorders are at a high risk of contracting this disease. For persons and children from low-income homes, immune problems will tend to be persistent due to the lack of proper nutritional contents and good healthcare accessibility. The World Health Organization (WHO) indicates that acute respiratory infections kill an estimated 2.6 million children under-5 yearly worldwide (DiMaria and Solan, 2012).

Indoor air pollution refers to the chemical, biological and physical contamination of indoor air, which may result in adverse health effects. In developing countries, the main source of indoor air pollution is biomass smoke, which contains suspended particulate matter, nitrogen dioxide, sulphur dioxide, carbon monoxide, formaldehyde and polycyclic aromatic hydrocarbons. In industrialized countries, NO_2, CO, and formaldehyde are also the main sources of indoor pollution. They originate from compounds such as radon, asbestos, mercury, and human-made mineral fibers. Volatile organic compounds, allergens, tobacco smoke, bacteria and viruses are the other main culprits that contribute to indoor air pollution (United Nations, 1997). According to Moturi (2010), lower respiratory tract infections in children have been linked to indoor air pollution. Other studies have reported an association between exposure to biomass fuel smoke and upper respiratory tract infections.

In developing countries particulate matter has been singled as the prime pollutant responsible for ARI. Other gaseous and particulate products such as nitrogen dioxide and formaldehyde have also been singled out as pulmonary irritants (Ezzati and Kammen, 2001). Given that children are usually at home with the mothers or domestic workers, they are likely to spend majority of their time around cooking areas, increasing their likelihood of exposure to particulate matter and other gaseous and particulate products. The particulate matter concentration (PM_{10}) from where biomass is used could rangefrom 1000ug/m^3 to as high 50,000ug/m^3 (Duflo et al., 2008). The acceptable limit set by the United States Environmental Protection Agency for particulate matter (PM_{10}) concentration is 150ug/m^3 but 50ug/m^3 is the acceptable level (WHO, 2014). Alarmingly the exposure to PM_{10} concentrations faced by the urban poor is 7 to 330 times higher than the accepted US EPA levels. The National Environmental Management Authority (NEMA) of Kenya is in the process of developing a policy on air quality under the Environmental Management and Coordination Act (EMCA).

The common types of lighting and cooking fuels used in Kenyan urban centers are gas, charcoal, firewood and kerosene. Charcoal is the main source of cooking fuel among 43% of the urban poor and 57% of the urban non-poor. As for lighting paraffin is mostly used by both urban poor (76%), while the urban non-poor (48%) may use it as an alternative if there is electricity shortage (G.o.K., 2008). The use of firewood for cooking in a single room, which is not well aerated as observed, is a known documented health risk. Volatilization of particulate matter, chemicals and infectious agents arising from open fires, ravages the respiratory systems of all the household members (Moturi, 2010). In Kenya, the immediate cooking vicinity alone, has reported concentrations of particulate matter (PM_{10}) exceeding 50,000ug/m^3 (Duflo et al, 2008), which is alarmingly above the US recommended levels of 150ug/m^3 but 50ug/m^3.

Socioeconomic factors are known to influence the prevalence of ARI. A study by Rahman (1997) found that the prevalence of ARI among children aged below 5 years in Bangladesh was 58.7% and among the risk factors; malnutrition, illiteracy, poverty, overcrowding, and parental smoking, were found in significant higher proportions in ARI victims compared to those without ARI. These observations underlined the need for research aimed at socioeconomic influences on respiratory infections in developing countries.Indoor air pollution exposure is a function of the complex interplay between household fuel patterns (Smith, 1987), appliances (Ezzati et al., 2000), housing design (Bruce et al., 2002) and human behavior (Barnes, 2005). In addition, risk factors such as nutrition, crowding, family history of infection, poor vaccination history and exposure to environmental tobacco smoke (Kirkwood et al., 1995; Victora et al., 1994) may influence child susceptibility to ARI. Even more challenging is the fact that indoor air pollution unravels against the backdrop of poverty that influence each of these factors.

This study investigated the relationship between incidences of ARI among the under 5 children and the type of energy used as well as household socioeconomic characteristics in Nakuru Town.

1.2 The Statement of the problem

In 2012, Rift Valley Province recorded the highest number of under-5 ARI cases in Kenya with 1,134,123 cases, which was 25% of the cases reported nationally. Nakuru being the largest urban center in the Rift Valley province recorded 59,168 under-5 morbidity cases of respiratory illnesses the highest number of under-5 ARI cases in the region. Over the past three decades, Nakuru town has also witnessed a tremendous increase in its population, which has led to an increase in demand for basic services and infrastructure such as housing. Despite the high growth in population, the growth rate of the formal housing sector has been minimal leading to an increase of residents living in informal housing where living conditions are harsh and are inappropriate for household indoor energy use. Studies have been done in rural areas, but not much documentation has been done in urban areas regarding the relationship between household energy use, household socioeconomic characteristics and ARI. Unlike rural areas, urban areas have a variation in socioeconomic characteristics, energy sources, and a diversity of housing structures.With such a high number of ARI cases, it is therefore imperative, to identify whether energy sources, socioeconomic characteristics and the indoor structure of houses influence the prevalence of acute respiratory infections in children under-5 in Nakuru Town.

1.3 Broad Objective

To assess the influence of energy sources and household socioeconomic characteristics on the prevalence of Acute Respiratory Infections among children in Nakuru Town.

1.3.1Specific Objectives

1. To assess the household socioeconomic characteristics of sampled households.
2. To describe the types of energy sources used based on income groups.
3. To assess the prevalence of ARI among children in sampled households.
4. To assess the relationship between energy sources, household socioeconomic characteristics and the prevalence of ARI among children in Nakuru Town.

1.4 Research Questions

The following were research questions that guided study:

1. What are the household socioeconomic characteristicsof sampled households?
2. What are the types of energy sources used in sampled households?
3. What are the prevalencerates of ARI among children in sampled households?
4. Is there a relationship between energy sources, socioeconomic characteristics and the prevalence of ARI among children in Nakuru Town?

1.5 Justification of the study

It was estimated in 2012 that 4.4 million morbidity cases of ARI were reported for children under-5 in Kenya. Nakuru, the most populous town in the Rift Valley province recorded 59,168 under 5 morbidity cases of respiratory illnesses, while Rift Valley recorded the highest number of under 5 morbidity cases of respiratory illnesses in Kenya with 1,134,123 cases which was 25% of the cases reported nationally (G.o.K., 2011; G.o.K., 2012). Energy expenditure showed that charcoal and paraffin were the most preferred energy sources. With a high number of people living below the poverty line, this would signify that the high under-5 morbidity cases wereas a cause of socioeconomic factors that lead to restricted living conditions and restricted energy use to wood fuel and paraffin. Part of addressing and alleviating the problem of energy use, indoor air pollution and ARI was to ensure that Kenya is moving along the guidelines of the Sustainable Development Goals (SDGs) and Vision 2030 initiatives.

This research was designed to create an insight on the unprecedented environmental health hazards of energy use pollution in households, which have adverse health effects on the respiratory health of children. Data generated from this study would therefore contribute to the realization of Sustainable Development Goals (SDGs) 3, 7, 15 and the social pillar of vision 2030 on healthcare and improved health care services. Exposing the influence of energy sources and household socioeconomic characteristics on ARI in children under 5 will help stakeholders in formulating strategies to ensure healthy lives and promote well-being for all at all ages (SDG 3). Addressing the problem of high biomass usage would serve as a platform for policy development on affordable and clean energy (SDG 7) and ensuring environmental sustainability through sustainable management of forests (SDG 15). Data generated on ARI prevalence rates in children and its relationship to energy sources and household socioeconomic characteristics would serve as a guideline for policy development and the social pillar of vision 2030 for improved health services by reducing the number of ARI cases, raising awareness on environmental friendly fuel sources, and improvement of housing by addressing the issue of urban housing inequality.

1.6 Scope

The study focused on children under 5 years old from low-income and middle-income households in Nakuru Town and their caregivers who were interviewed. The caregivers provided information on energy sources (charcoal, paraffin, LPG, wood, etc.) used, and socioeconomic characteristics (education level, income level, and number of household members). Observation of the selected indoor structural characteristics (house type, ventilation chimney, carpeting, floor type roof type, and number of rooms) was carried out. A lot of diseases can be caused by smoke and energy sources, but this research only considered respiratory illnesses that are associated with indoor pollution.

1.7 Limitations

1. The study did not rely on the child's personal physician's opinion on the health status or the medical records of the child. Instead the mother or caretaker was relied upon to provide information on the child's health status or medical records.
2. Though outdoor air pollution may also be a cause for ARIs, it was not considered in the study
3. The results of this study cannot be generalized to all households in sampled areas due to differences in household socioeconomic characteristics.
4. There was no assurance that the caregivers information was accurate to the questions asked. The caregivers were asked to list illnesses that their children suffered from in the previous 2 months before the study began. Vernacular translation was used when necessary to communicate with respondents.

1.8 Assumptions

1. The mothers or caregivers were aware of their children's health status and provided accurate information concerning their children's ARI incidences.

1.9 Definition and Operationalization of Terms

1. **Acute Respiratory Infections (ARI)**: refers to respiratory illnesses respiratory infection, is a respiratory tract infection that inhibits normal breathing function (DiMaria and Solano, 2012, WHO, 2012.). In this study it refered to respiratory illnesses reported by the caregivers.

2. **Caregivers**: refers to those who were responsible for taking care of the children in the households. (Mtango et al., 1992). In this study this term referred to parents, relatives or non-relatives that were responsible of taking care of the children.
3. **Energy Sources**: refers to the fuel sources. In this study the term was used to refer to the fuel sources that are used in the households for cooking and lighting.
4. **Household Size**: refers to number of people living in a house. In this study this term referred to the number of members that lived in each of the sampled household.
5. **Household Socioeconomic Characteristics**: refers to the household socioeconomic characteristics (education level, income level, and number of household members) and dwelling characteristics (house type, ventilation chimney, carpeting, floor type roof type, and number of rooms). In this study this term in-cooperated both household socioeconomic characteristics and selected indoor physical characteristics.
6. **Low-Income Households:** refers to households that were located in the low-income areas. Low-Income households were found in Kaptembwo and Kiratina. (NAWASSCO, 2013)
7. **Middle-Income Households:** refers to households that were located in middle-income areas. Middle-Income neighborhoods were found in Langa-Langa and Shaabab. (Nyasani, 2009).
8. **Ventilation Status**: refers to the suitability of ventilation in a house. In this study the terms used to describe the ventilation status in a household are very poor, poor, fair, good and very good.
    a. Very poor refers to a house having a door, no window, and no chimney.
    b. Poor refers to a house having a door, a window, and no chimney.
    c. Fair refers to a house having a door, one or more windows, and no chimney.
    d. Good refers to a house having two or more doors, two or more windows, and no chimney.
    e. Very good refers to a house having two or more doors, two or more windows and a chimney.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Energy is an important commodity to all urban dwellers in Kenya because it is the source of lighting and cooking. Most urban dwellers live below the national poverty line of KSH 2,913 per month per person (G.o.K., 2006), thus energy accessibility is limited to wood fuel and paraffin. Electricity grids are available, but due to high costs some urban dwellers are left to cope without. The urban dwellers living in informal settlements or congested areas are likely to be exposed to pollutants or particulate matter from wood fuel use and paraffin which accumulate indoors and poses a threat to the dwellers respiratory health. In most cases PM_{10} may range between 1000ug/m^3-50, 000ug/m^3 in developing countries (Duflo et al., 2008). Long-term exposure to biomass related pollutants and particulate matter might lead to infections such as ARI. With neonatal causes being the biggest killer of children under 5, ARI isone of the biggest killers of children under 5 in Kenya and Lower income countries (WHO, 2011).ARI is particularly dangerous because continuous intense exposure to high concentrations of particulate matter heavily affects the lungs and develops further complicated respiratory infections. Overall, the disease burden of Kenya shows respiratory infections as high ranking among other diseases. Around the world respiratory infections are also leading in lower income countries. Though, in middle and high-income countries, ischemic heart disease and cerebrovascular disease lead in the number of deaths.

2.2 Global Burden of Disease among children under-5

The global burden of disease is a World Health Organization effort that ranks the prevalence of diseases based on income of countries.The first Global Burden of Disease (GBD) study introduced the disability-adjusted life year (DALY) as a single measure to quantify the burden of diseases, injuries and risk factors. The DALY is based on years of life lost from premature death and years of life lived in less than full health (WHO, 2008). Looking from a global perspective, developing countries from Africa, Asia and South America primarily contributed to high global disease numbers. In 2008, Pneumonia ranked second with 13% of under-5 deaths globally. Neonatal causes contributed about 40% of under-5 deaths, while diarrheal diseases caused 14% of deaths, malaria 9% of deaths and HIV-AIDS 2% of deaths in under-5 deaths (WHO, 2011).

High concentrations of the many hazardous substances in smoke and exposure to indoor air pollution, particularly accounts for a substantial proportion of the global burden of disease in developing countries among young children (Perez-Padilla et al., 2010). Acute respiratory infections (ARI) and chronic respiratory diseases lead in the causes of global disease, and together account for more than 10% of the global burden of disease and mortality, mostly in developing countries. In 1997 and 1998, the leading cause of mortality from all infectious diseases was acute lower respiratory infections (ALRI) with an estimated 3.7 and 3.5 million deaths worldwide for the two years respectively among infants and children (Ezzati, 2000).

2.3 Disease Burden among African children under-5

Neonatal causes remained the highest killer of children under-5 in Africa with 29% of deaths. Respiratory Infections such as pneumonia caused 14% of under-5 deaths and remained a major factor of death because of their re-occurrence in the child’s health, as they are growing older. Malaria still a menacing disease in Africa was and is responsible for about 18% of under-5 deaths. Diarrhea and HIV meanwhile contributed 17% and 5% of under-5 deaths respectively for African children (WHO, 2011). Biomass combustion in poorly ventilated rooms has women and young children bearing most of this exposure. Young children are exposed because they are with their mothers as they cook.

Biomass fuel usage accounts for 2.7% of the global disease burden and about 32% of this burden falls on Africa, translating to 38.5 million disability adjusted life years (DALYs) (WHO, 2002). A remedy for respiratory infections primarily remains as the need to reduce ones exposure to air pollution which needs to be made aware to people in order to be a step ahead in reducing mortality and outpatient rates in children (Toupin, 2011).

2.4 Disease Burden among Kenyan children under-5

In Kenya, ARI(s) are among the leading cause of mortality, contributing to over 70% of deaths in children under five. In terms of lost healthy life years (measured as disability adjusted life years, DALYs), it is Estimated that ARI is responsible for just under 4% of the DALYs lost which equates to comparable consequences such as those of tobacco use and are only exceeded by those of malnutrition (16%), unsafe water and sanitation (9%) (Moturi, 2010). Neonatal causes continue to be the major contributors of under-5 deaths with 34% of deaths. Malaria as a major cause of death has lowered since the fight against it has been improved causing only 3% of under-5 deaths. But diseases such as pneumonia (14% of deaths) and diarrheal diseases (19% of deaths) continue to dominate as the major causes of death among children under 5. Better prenatal care has allowed for a reduced number of deaths from HIV/AIDS birth to 9% (MCH, 2011; WHO, 2011).

Since 1990, infant and under-5 mortality rates have declined, thanks to programs such childhood immunization and malaria prevention. But, Kenya still ranks 39th in the world in terms of countries with the highest deaths globally. Not only does this show a shaky healthcare sector but also shows that Kenya is not on track to meet MDG 4 to reduce the under-5 mortality by two thirds between 1990 and 2015. Infant Mortality is higher in rural areas. However residents of urban slum settlements exhibit worse health indicators, especially for the under-5 population (Toupin, 2011).

2.5 Outpatient Morbidity for Children under-5 in Kenya

In Kenya, ARI accounted for 67% (4,453,375 out of 6,656,253 cases) of outpatient morbidity in children under the age of 5 in 2010. This makes ARI the leading cause of morbidity in children under 5 surpassing malaria. Table 1 shows the list of outpatient morbidity statistics in children under- 5 years for Kenya in 2010.

Table 1: Under-5 Morbidity 2012 (Kenya)

Disease type	Out-Patient Morbidity
Respiratory disorders including Pneumonia	4,453,375 (67%)
Clinical malaria and confirmed malaria	3,870,121 (58%)
Diarrheal diseases	879,892 (13%)
Skin disorders and open wounds	724,304 (10%)
Intestinal worms	381,068 (6%)

Source: G.o.K., 2011.

2.6 Outpatient Morbidity for children under-5 in Nakuru Town

The under-5 Morbidity rates reported in 2012 for Nakuru Town showed the same trend as that which was reported at the national level. Respiratory related infections still ranked higher, showing that there might be a possibility of the same trend occurring in other counties in the country. Table 2 illustrates the under 5 morbidity in Nakuru Town.

Table 2: Under-5 Morbidity 2012 (Nakuru Town).

Disease type	Out-patient morbidity
Respiratory disorder including pneumonia	59,168 (41%)
Clinical malaria and confirmed malaria	29,012 (20%)
Diarrheal diseases	11,095 (7.7%)
Disease of the skin	5,565 (3.8%)
Ear infections	1,730 (1.2%)

Source: G.o.K., 2012

2.7 Global Household Energy use

In developing countries, especially rural areas, solid fuels are extensively used for cooking and house heating, Worldwide, an estimated 3 billion people use solid fuels as 2.4 billion use biomass (wood, charcoal, animal dung, crop wastes), and the remainder utilize coal for the majority of their household energy needs. The percentage of people using solid fuels varies widely among countries and regions, ranging from respectively 77%, 74%, and 74% in sub-Saharan Africa, South-East Asia, and the Western Pacific Region, to 36% in the Eastern Mediterranean Region, and 16% in Latin America and the Caribbean and in Central and Eastern Europe. In the majority of industrialized countries, solid fuel use falls below the <5% mark (Perez-Padilla, 2010). Sub-Saharan African countries have the least access to electricity in the world. a rural population of 438 million people and an urban population of 109 million have been left to cope without electricity as the total electricity coverage rate of the continent is only 26%. In these areas the primary sources of energy are solid fuels such as biomass and wood fuel (Schwartz & Glemarec, 2009).

2.8 Sources of Cooking and Lighting Fuels in Urban Areas in Kenya

2.8.1 Source of cooking fuels in Urban Areas

Energy use in urban areas in Kenya varies between the poor and the non-poor. The sources of cooking fuel are almost similar, with paraffin and charcoal topping the preference list. Access efficient energy sources such as LPG and electricity is limited to the urban non-poor. Table 3 constitutes the preferred energy sources for both the urban poor and urban non-poor.

Table 3: Preferred Cooking Fuels in Urban areas in Kenya

Urban poor		**Urban non-poor**	
Fuel type	**Percentage**	**Fuel type**	**Percentage**
Charcoal	49	Paraffin	57
Paraffin	43	Charcoal	41
Collected firewood	18	LPG	21
Purchased firewood	12	Electricity	5
LPG	1	Collected firewood	3.3
Electricity	0.7	Purchased firewood	3

Source: G.o.K., 2005

2.8.2 Source of Lighting in Urban Areas

In urban Kenya, paraffin remains a popular means of lighting in poor households due to its affordability and the lack of electricity. Table 4 illustrates the sources of lighting that are preferred among urban dwellers.

Table 4: Preferred Lighting Fuels in Urban areas in Kenya

Urban poor		Urban non-poor	
Fuel type	**%**	**Fuel type**	**%**
Paraffin Light	76	Electricity	62
Electricity	22	Paraffin	48
Dry Cells	6	Candles	16
Candles	6.3	Dry Cells	4

Source: G.o.K., 2005

2.9 Energy Expenditures and Household Size in Urban Areas in Kenya

Biomass energy sources account for more than one half of the total national energy consumption and as much as 95% of household energy in some developing countries, especially in poorer regions of Sub-Saharan Africa and Asia (Ezzati, 2000). The urban poor in Kenya spent on an average 42% of their monthly income on paraffin for lighting and spent another 51% on charcoal for cooking purposes. Electricity usage for the urban poor remained at 7.7% because it was not a priority for them due to its unavailability or it being expensive. The urban non-poor households will spend 39.4% of their monthly income on charcoal, 37% will be spent on paraffin and Gas will cost about 9.6% of the monthly income. Electricity will consume 14.5% of the urban non-poor household income (G.o.K., 2006).

In urban areas such as Nairobi, Mombasa, Kisumu, and Nakuru, the number of household members varies between the urban poor and the urban non-poor. The urban poor will tend to have more people in their house as opposed to the urban non-poor. Fourty six percent of urban poor will have 4-6 members living in a household while another 24% will have 7+ members. On the contrary 54% of urban non-poor will have between 1-3 members while 36% of other urban non-poor may have 4-6 members (G.o.K., 2006). Crowding in the households was inevitable for the urban poor unlike the urban non-poor due to their socio-economic standing.

2.10 Education and Income in Urban Areas in Kenya

In Kenya, Literacy rate is greater than 63% (UNESCO, 2006) showing that a good proportion of the population had attended some form or as a whole of secondary education. The gender gap inthe education sector in Kenya has been based of beliefs that females benefit less from education and for economic reasons they will bring less of the education investment to back the family. Girls are likely to be needed more at home to fulfill their domestic role (UNFPA, 1996). In urban areas like Nairobi, those with low levels of education experience worse poverty rates. In rural areas more children have attended later stages of school than those from Nairobi slums where there are few or no public schools (Oxfam, 2009). Lack of education among many female caretakers causes lack of the ability to recognize and understand ARI related symptoms. Mishra (2003) and Juma (2007) argue that there is a lack in caretaker skill and understanding when it came to recognizing respiratory related symptoms and their severity, which may have led to under reporting of cases. There is a need to introduce programs that carried out civic education on respiratory illness awareness as a way of combating these illnesses.

In the year 2006 a World Bank study showed that average per capita income among poor households was Ksh. 2,776 with the median monthly amount being Ksh. 2,444 (Oxfam, 2009). The median unemployment in urban areas in Kenya (19.9%) was higher than rural unemployment rates (9.8%) due to rapid urbanization. The Unemployment rate of youth in urban areas in Kenya aged 15-24 was 24% in 2005/06 (KIPPRA, 2011). Income disparities such as lack of income and low-income, limits households to using polluting fuel sources such as charcoal for cooking and paraffin for lighting, which factor into increasing ARI exposure. Nyasani (2009), noted that in low-income areas of Nakuru town such as Kwa Rhoda, 81% of households were limited to charcoal use for cooking compared to Langa-Langa where charcoal (54%) and L.P.G. gas (44%) for cooking.

2.11 Biomass Pollutants

Particulate Matter or PM_{10} refers to small particles with a diameter of 10 microns or less and are able to penetrate deep into the lungs and seem to have the greatest health-damaging potential (WHO, 2014) 50ug/m^3 is the accepted norm for PM_{10} but the mean 24-hour PM_{10} concentration in solid-fuel-using households in India was sometimes found to exceed 2000ug/m^3. Also in Bangladesh an average of 600g/m3 $PM_{10}$was measured in surveyed households. Similarly, a study of about 400 households in the provinces of Shaanxi, Hubei, and Zhejiang, China, were monitored for PM_4, and it was found that most households exceed China's Indoor Air Quality Standards (Duflo et al., 2008). Research in Kenya has shown a concentration of 50,000ug/m3 in the immediate vicinity of the cooking area. Such high concentrations indicate that constant exposure will lead to complicated respiratory infections (Duflo et al., 2008;Ezzati, 2000).

In rural South-western Nigeria, research has shown that Pollutants such as Hydrogen Sulfide (H_2S), Carbon Monoxide (CO), Nitrogen Oxides (NO_X), Sulfur Dioxide (SO_2), and Methane (CH_4) are known to emit from biomass fuel use. The concentrations of these gases in the households were found to be significantly above the accepted limits. In Nigeria the nationally accepted ambient air standards of these gases are H_2S (0.06 ppm), CO (10-20 ppm), NO_x(0.06 ppm), SO_2 (0.01 ppm) and CH_4 (0.06 ppm) (Oguntoke et al., 2010). Carbon Monoxide is known to bind to hemoglobin in blood and interferes with the transporting of oxygen, which causes headache, nausea and dizziness. CO is also associated with low birth weight and feto-toxicant, which lead to perinatal deaths or poor fetal growth. Nitrogen Oxides and Sulfur Dioxide are known to cause irritation by affecting the mucosa of the eyes, nose, throat and respiratory tract. SO_2 and NO can also cause bronchial reactions such as broncho-restriction (SO_2) and bronchial infections (NO_X) with long-term exposure biomass smoke. Other hydrocarbon, aldehyde, and ketone-based pollutants cause further effects and irritation in eyes and upper and lower respiratory systems (Perez-Padilla et al., 2010).

2.12 Biomass Pollution and Respiratory Infections

Numerous studies in developing countries have linked biomass fuel to increased cases of respiratory infections. In India, Mishra et al (1999) studied the relationship between the use of biomass cooking fuels and its effect on the increasing prevalence of active tuberculosis among household members. Cooking Fuel type was seen to have a large effect when the analysis was done separately for men (Odd Ratio=2.46: 95% Confidence Interval= 1.79-3.39) and women (OR=2.74: 95% CI= 1.86-4.05) and rural (OR= 2.65: 95% CI=1.74-4.03) and urban areas (OR 2.29; 95% CI=1.74-4.03).In this study, persons that were living in households that mainly used biomass as source of cooking fuel had substantially higher prevalence of active tuberculosis than persons living in households that were using cleaner fuels. Fuel type used showed a higher prevalence of active tuberculosis in Women and rural dwellers (Mishra et al., 1999). In China, Mestl et al (2007) through combined exposure-response function and current mortality and morbidity rates suggested the burden of disease of China from indoor air pollution would decrease. For the burden of disease to decrease, outdoor air pollution needed to be reduced because it also served as a factor to respiratory diseases (Mestl et al., 2007).

In Central Kenya, Ezzati and Kammen (2001) found that ARIs were increasing concave functions of average daily exposure to PM_{10} above 1000-2000 ug/m^3. They suggested that public health programs should focus on reduction of exposure to below 2000 ug/m^3, which will provide substantial health benefits (Ezzati and Kammen, 2001). Indoor air pollution has proven to be a major environmental health hazard for South African children. Studies done in South Africa have shown a strong and relatively consistent association between indoor air pollution and acute lower respiratory infections (ALRI) in children, regardless of the relatively small-scale nature of the epidemiological evidence. Children living in households that rely on polluting fuels such as wood fuels are more than 2 to 4 times likely to suffer from an ALRI as compared to children living in homes that rely on electricity consequentially this results in up to 1,400 annual deaths in children under five (Barnes et al., 2009).

2.13 Housing Policy in Urban Kenya

The Sessional Paper No. 3 on *National Housing Policy of July 2004* was approved by Parliament as the institutional framework for governing housing development. It proposed the facilitation of an annual delivery of 150,000 housing units in the urban areas and quality improvement of 300,000 units in the rural areas by the Government. The overall goal of the National Housing Policy of Kenya was to catalyze the provision of adequate shelter and a healthy living environment at an affordable cost to different socio-economic groups in Kenya in order to nurture sustainable human settlements (G.o.K., 2004).The *Planning and Building Regulations 2009*byThe National Planning and Building Authority was established to express the expected standards of proper housing regarding indoor and outdoor structuring and materials.The largest single input in construction is building materials, which account for about 70% of the housing cost. As the population increases, demand for building materials increases and Kenya is well equipped with ample natural resources that can be used as basic materials. Unfortunately, the housing sector is constantly faced with the existence of inappropriate standards and By-laws have greatly reduced the range of approved materials and building technologies (Matindi, 2008).

2.14 Air Quality Regulations

In developed countries strict measures have been put in place to curb indoor pollution in order to ensure acceptable living conditions. Countries like the United States have established the Environment Protection Agency as the overseer and regulator of environmental activities. Environmental Protection Agency (EPA) of the United States has a standard for an acceptable annual 24-hour average of $PM_{10,}$ which is 150ug/m^3. It states that this level should not be exceeded more than once per year. This standard by the United States ensures that the indoor air quality (IAQ) in buildings is maintained to a certain standard that would cause no harm to the occupants (Ezzati, 2000). Almost all African countries have no indoor or outdoor air quality management capabilities despite themhaving rapid urban population growth. Lack of expertise to formulate air pollution management policies seems to be the main setback accompanied by low budget priority and financial constraints. The lack of appropriate legislative and administrative frameworks and the division of air quality regulation between a number of government ministries and the local administrations further complicates proper policy making (Mulaku and Kariuki, 2001).

For a long time, there has never been any legislative or administrative framework within which air quality management could be formulated and implemented in Kenya. Over the course of time, Kenya's potential to manage air quality has improved somewhat with the passage of the Environmental Conservation and Management Act of 1999 (G.o.K., 1999), whose administrative framework is still being put into place. The government of Kenya, through The Ministry of Environment, Water and Natural Resource established the *National Environmental Policy 2013*. This document contains policy statements on different environmental areas and the way forward. Air quality is addressed. In Section 6.1 sub-section 6.1.1, "Air Pollution is recognized as the leading cause of respiratory disease and the effects of outdoor pollution are compounded with those of indoor pollution. Most households use charcoal or firewood for domestic cooking and indoor pollution affects both urban and rural populations" (G.o.K., 2013). On the policy statements, the government assures that it will, "promote alternative cooking stoves and technologies that are none polluting and construction of well ventilated houses" (G.o.K., 2013).

2.15 Conceptual Framework

The independent variables of this study were socioeconomics (energy source, education level, income level, household size) and housing structure (floor type, roof type, ventilation, number of rooms, and carpeting). The intervening variables were housing policy, social culture and caretaker awareness. The dependent variable of this study was ARI prevalence. ARI can be influenced positively or negatively by the independent variables. The energy source that will be used in the household will be regulated by income and household size. Polluting energy sources such as biomass are likely to influence the presence of ARI due to the particulate matter and poisonous gases emitted. Education level will determine if there is awareness on proper energy use and the appropriate energy sourceto be used in order to avoid unwanted indoor pollution. If the household is not aware on the proper use of biomass and the dangers of indoor pollution then ARI will likely be present in the household. The household Income level factors into energy type affordability. Low-income households will likely afford biomass energy sources given their strenuous budget thus indoor pollution and ARI are likely to be present.Middle-income households will likely have access to cleaner forms of energy such as electricity and L.P.G. thus indoor pollution and ARI will less likely to be present.

Household size will be associated with ARI if too many members occupy the house if it is not sizeable to accommodate the members. The house will be congested allowing airborne pollutants and airborne contamination to be rampant increasing the prevalence of ARI. Floor type such as earthen floors, which contain dust, allergens, and particulate matter are likely to influence the presence of ARI among children. Roof type should not trap or allow for pollutants and particulate matter to reflect back into the indoor environment. ARI will be prevalent if the pollutants and particulate matter trapped or reflected from the roofcontaminate the indoor environment. The number of rooms in the house is important due to the fact that it eases congestion and allows for movement of air. A congested house is highly likely to influence ARI prevalence because particulate matter and pollutants can easily settle. Ventilation is a major factor in reducing indoor pollution. Since in most households cooking is preferably done indoors, ventilation allows for pollutants and particulates to be expelled and not pollute the indoor environment of thehouse. Households that are properly ventilated are less likely to experience prevalence of ARI among children. The presence of carpeting will help prevent from the cold floor and also moisture, dust mites and allergens, which can be a factor of ARI. Carpeting can also be a source of allergens such as dust mites if not properly vacuumed or cleaned

The National Housing Policy of July 2004 has been the ideal framework and direction on urban housing development. If the policies are adhered to by the government and housing developers, then it will ensure a trend of proper housing structures in urban areas that would aid in the reduction of ARI incidences from indoor pollution. Failure to adhere to the policies may cause the continuance of mushrooming slums and shanty houses with an already growing urban population, which will continue to see an increase in ARI incidences. Social Culture also has an impact on socioeconomics of the household, which could lead to ARI among children.Social cultures such as the assumption that biomass fuels and more efficient and cheaper than cleaner fuels such as L.P.G could put children at risk of contracting ARI. Awareness is an important aspect because it determines whether the caretakers are capable of consciously identifying ARI symptoms, understanding the importance of proper ventilation and the types of energy sources to use to avoid exposing their children to pollutants that can cause respiratory infections among. Age also can be a determining factor of awareness because a caretaker who has a higher age is likely to be more conscious of the effects of biomass pollution on ARI among children.

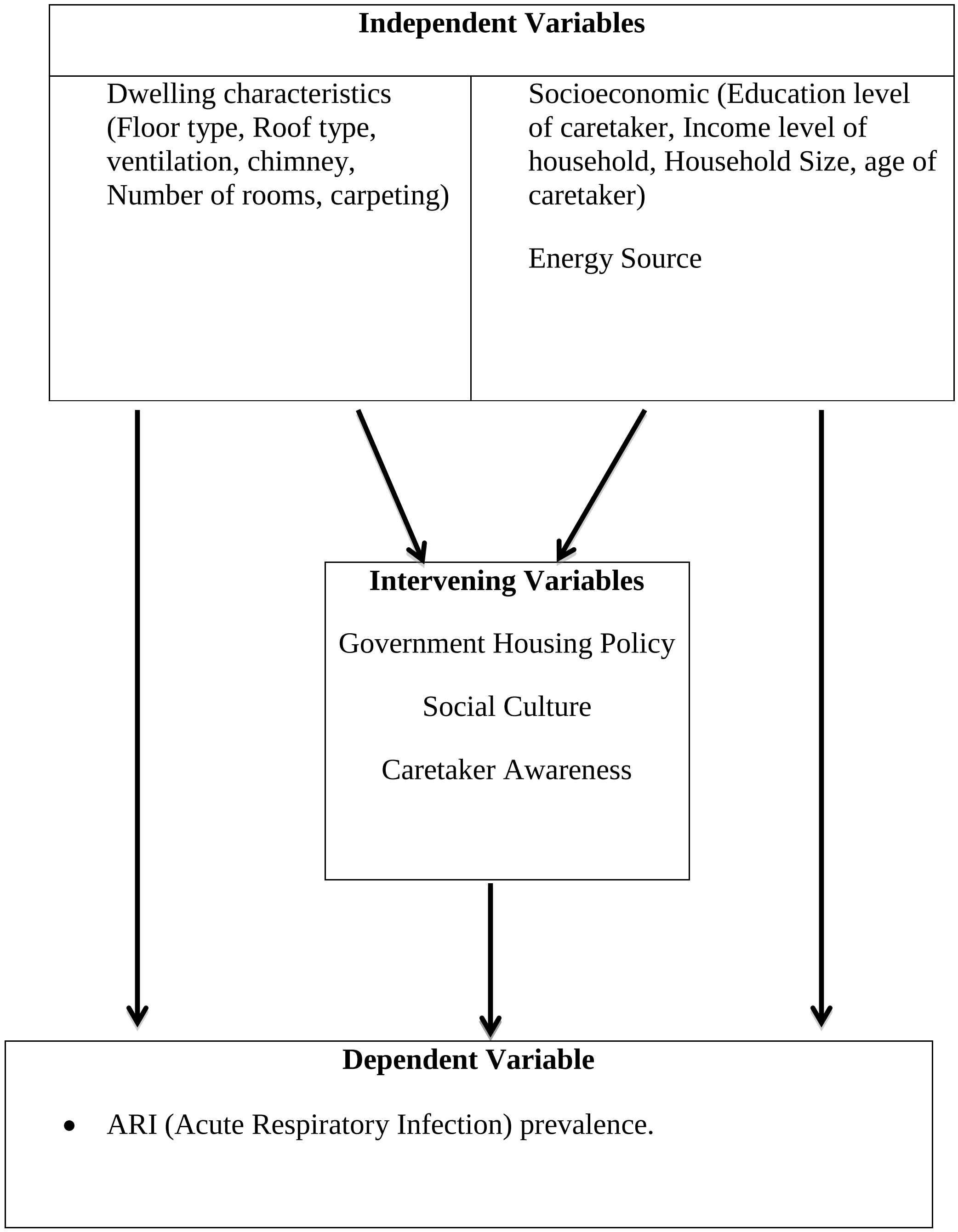

Figure 1: Conceptual Framework.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area and Methodology

3.1.1Location

Nakuru Town is located 160 kilometers northwest of Nairobi, 0.2833° South and 36.0667° Eastalong the Kenya-Uganda highway, at an altitude of 1800 meters. The British colonial authorities founded Nakuru in the beginning of the 20th century as a station along the Ugandan Railway. Later on Nakuru became an agricultural regionoccupied by farming white settlers. On the western and south-eastern areas of Nakuru town large ranches and farms can still be found, some of which are still owned by settlers while others were turned into limited companies specializing in dairy farming, meat and horticultural production. The town's industry is mostly related to the agricultural sector. Milling, tanning, oil refining and agro-products cover the bulk of the secondary sector, together with textile and soap manufacturing (Nyasani, 2009).

3.1.2 Population

Over the past three decades, Nakuru town has witnessed a massive increase in its population with migration from rural areas to the already overcrowded informal settlements. According to the 2009 Kenyan Census the population of Nakuru town stood at 309,424 with 91,110households and 42,295 households, which constituted the study population (G.o.K., 2010).It isestimated that those under 18 years of ageaccounted for 54% of the population, while children under five years accounted for 16%.Nakuru's municipal boundaries were expanded from encompassing 32 square kilometers in 1952 to 78 square kilometers in 1978. They were further expanded to include Lake Nakuru National park and the peri-urban agricultural settlements to the southwest of the town for a total area of 290 square kilometers in 1992. Of the total area, 56 square kilometers are urbanized, 32 square kilometers are predominantly agricultural, and the remaining 202 square kilometers is the national park(G.o.K., 2010) and (Nyasani, 2009).

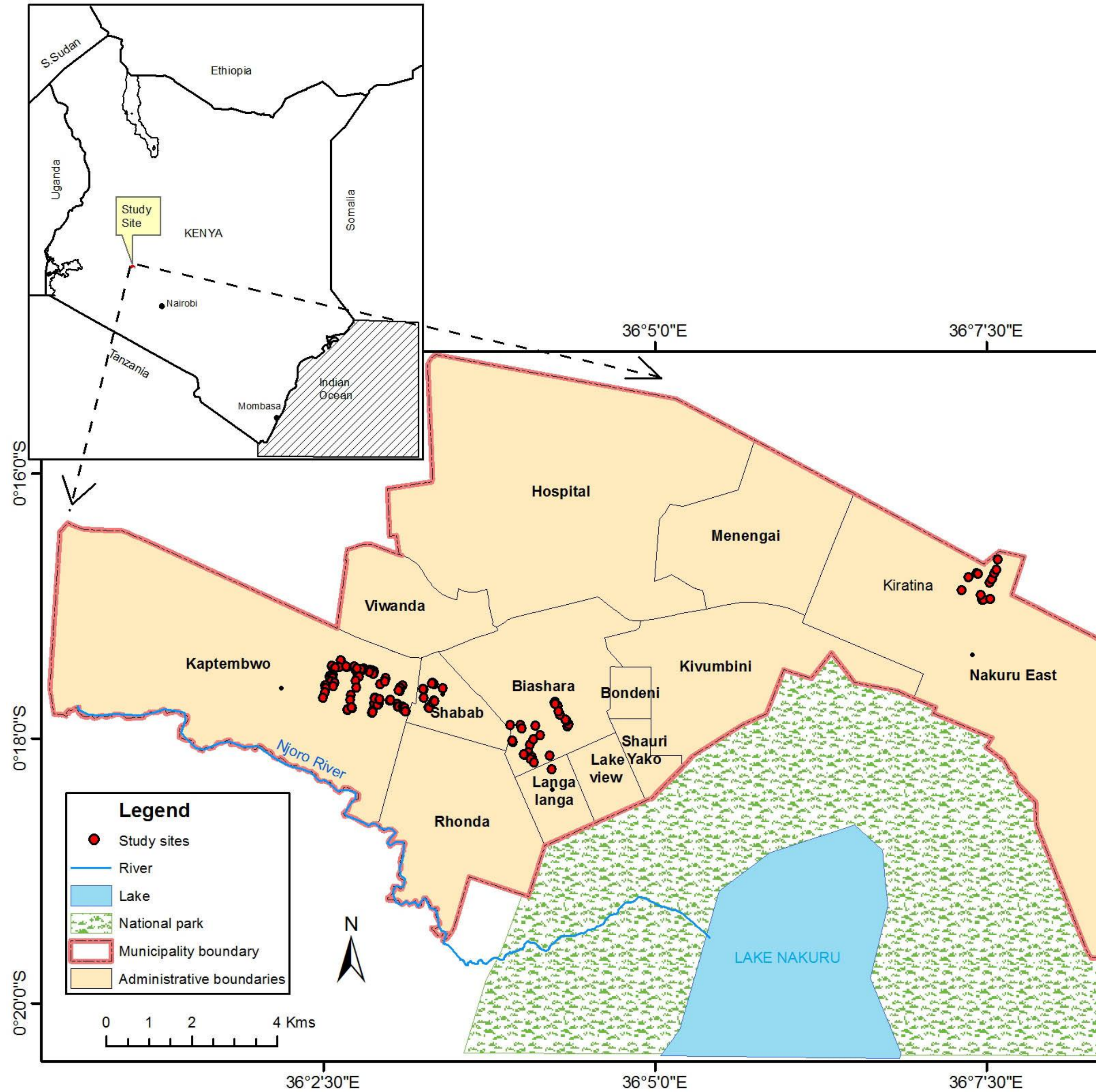

Figure 2: Map of Study Sites in Nakuru Town, Kenya.

Source: County Government of Nakuru, 2014.

3.2 Research Design and Target Population

The research design chosen for this study was a cross-sectional survey. Cross-sectional surveys involve the collection of data at a single point in time from a specified population (Mugenda & Mugenda, 2003). This type of research design is used to document the prevalence of particular characteristics in a population. The design was considered appropriate for this study because it offered an opportunity to establish relations and variations between subgroups in the population of study. It also allowed for comparative analysis of urban households, whichwould cut across different socioeconomic categories of urban households. The selection of low and middle-income households was done through a review of the water and sanitation service pro-poor strategy plan carried out by NAWASSCO that listed Kaptembwo and Kiratina as low-income areas and Shaabab and Langa-Langa as middle-income areas (NAWASSCO, 2013). High-income areas in Nakuru Town were not studied due to accessibility issues during the pilot testing

3.3 Sample Size

A multi-staged sample design with a non-random first stage followed by a random second stage was used. Stage one consisted of non-random selection of low-income and middle-income areas for studying. Stage two consisted of random selection of householdsfor studying. Purposive sampling wasused across transect lines and selection of study candidates was done using the snowballing method.

To obtain the sample size, the following formula was used (Nassiuma, 2000):

$$n = n'N / N\text{-}1+n' \quad \text{[Equation 1]}$$

Where:

n = sample size

N= accessible population

n'= sample size for simple random sampling with replacement

But, $n'=Z_{\alpha/2}/d^2 \, xP(1-P)$

$Z_{\alpha/2}$ = degree of confidence taken as 1.96 at 95%

d = level of statistical significance taken as 0.05

P = proportion of the target population estimated to have the characteristic being measured ARI (taken as 0.4 at 40%). The low-income areas (Kaptembwo, and Kiratina) and middle-income areas (Shaabab and Langa-Langa) had a total of 42,295 households. The calculated sample size was as follows:

$$n' = 1.96/(0.05)^2 \times (0.4)(1 - 0.4)$$

$$n' = 188$$

$$n = 188 \times 42{,}295/42{,}295-1+188$$

n= **187 households (total sample size)**

The calculated total sample size of households was 187, which needed to be proportionately allocated to the two stratums (low-income areas and middle-income areas). Since low-income areas consisted of 65% of the total households and middle-income areas consist of 35% of the households, the allocation will be as follows:

Low-income Areas= 0.65 x 187= **122 households** (Sample Size)

Middle-income Areas= 0.35 x 187= **65 households** (Sample Size)

Table 5: Study Areas

Stratum 1: Low-income Areas			
Location	**Households**	**Proportion (%)**	**Sample Size**
Kaptembwo	23, 200	85	104
Kiratina	4,239	15	18
Total	27,439	100	122
Stratum 2: Middle-income Areas			
Shaabab (Githima)	5,182	35	23
Langa-Langa	9,674	65	42
Total	14,856	100	65

Source: G.o.K., 2009; Nyasani 2009

3.4 Data Collection

Data was collected by the means of Questionnaire (appendix 1) and Observational schedule (appendix 2). The Questionnaire was used to collect data on the socioeconomic aspects of the household such as education level, household size, income level,energy source and the child's health status.For the child's health status, the respondents were requested to list the diseases that their children suffered from 2 months prior to the study TheObservation schedule was used to collect data onthe physical characteristics of the house such as housing type, flooring type, roofing type and ventilation. Data on ventilationaspects of the sampled households was analyzed using the likert scale on appendix 4with choices ranging from very poor to very good.

The Likert scale was an observation guide for determining whether the house had ventilation provisions such as door(s), window(s), and chimney(s). Based on the observed presence of these ventilation factors, the appropriate ventilation status was ticked on the observation schedule based on which of the five choices on the likert scale the ventilation status fell on. Agreeing or disagreeing denoted whether or not the house was properly ventilated based on the presence of ventilation indicators such as door(s), window(s), and chimney.Data collected on the presence and the types of ARI in children were used to calculate ARI prevalence in the study areas. The Prevalence rates of this study were calculated as per 100 in accordance to the following formula (CDC, 2010):

$$\text{Prevalence}= \frac{\text{Persons with a given health indicator during a specified time period}}{\text{Population during the same time period}} x100$$

[Equation 2]

The per-capita household income in the samples households in this study was calculated using the following formula (Singapore Polytechnic, 2015):

$$\text{Per-capita income}=\frac{\text{total household income}}{\text{total household size}} \text{[Equation 3]}$$

One hundred and twenty-two questionnaires were administered to stratum one (low-income areas) and 65 questionnaires were administered to stratum two (middle-income areas) totaling to 187 questionnairesas shown on Table 4.A GPS wasused for mapping out households that were assessed.

3.5 Data Analysis

The data from this study was analyzed using various statistical methods as outlined in table 5. Data analysis was done using SPSS version 21. A multiple regression analysis was carried out at 95% confidence level. The Multiple Linear Regression equation is as follows:

$$y_i= b_o+b_1x_{1j}+b_2x_{2j}+b_3x_{3j}+b_nx_{nj} \ldots E_{ij}$$

Where: $y_i$is the dependent/response variable

b_o is the constant

$x_{1j}, x_{2j},x_{3j\ldots}$ are the independent/predictor variablewhich were education level, income level, cooking and lighting energy sources, hours indoors, hours outdoors, household size, number of rooms, floor type, roof type, and ventilation.

Table 6: Data Analysis Table

Study Question	Variables	Data Analysis
What are the household socioeconomiccharacteristics of sampled households?	Income level, education level, household size, number of rooms, floor type, roof type, carpeting and ventilation	Descriptive analysis i.e. Frequencies and means.Comparison of indoor structural characteristics in houses among low and middle-income. Comparison of socioeconomic characteristics. Calculation of Per-capita income.
What are the types of energy sources used in sampled households?	Energy sources (for cooking and lighting),	Descriptive analysis i.e. Frequency and mean.Comparison of the most common cooking and lighting sources among low and middle-income.
What are the prevalence rates of ARI among children in sampled households?	ARI	Calculation of ARI prevalence rates for low and middle-income groups.
Is there a relationship between energy sources, household socioeconomic characteristics and the prevalence of ARI among children in Nakuru Town?	Energy sources, Household indoor characteristics, household socioeconomic characteristics, ARI	Multiple Linear Regression analysis explained whether there was a relationship between the explanatory variable (ARI) and response variables (energy sources and household indoor socioeconomic characteristics). The significantimpact of energy sources and household indoor socioeconomics on respiratory infections in children u-5was determined.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1Socioeconomic Characteristics of Sampled Households in Nakuru Town

The majority of respondents from both low and middle-income households who participated in this study were females who comprised 93% (n=174) of respondents while male respondents comprised 6.95% (n=13) of the respondents.In low-income areas, mothers constituted of 98.4% (n=120) of the female respondents. Mothers in middle-income households were available on weekend as they were reported to be at work on weekdaysthus they constituted of 80% (n=52) of the respondents. Fathers in both low and middle-income households comprised 1.6% (n=2) and 6.2% (n=4) of respondents respectively. Male household members were reported to be at work during the weekdays and thus absent from the house at the time of the study.

The age of the respondents varied, among low and middle-income households. In low-income households, those aged 18 or below consisted of 5.7% (n=7), respondents aged 19-25 consisted of 51.6% (n=63), respondents aged 26-30 consisted of 27% (n=33) and those aged 31-35 and 36+ consisted of 7.4% (n=9) and 8.2% (n=10) of household respondents respectively. In middle-income households, respondents aged 18 or below consisted of 10.8% (n=7). Those aged 19-25 consisted of 29.2% (n=19) of respondents. Those aged 26-30, 31-35, and 36+ consisted of 24.6% (n=16), 16.9% (n=11), and 18.5%(n=12) of household respondents respectively.

The numbers of household members in low and middle-income household were similar.In low-income households, the most frequent household size consisted of 4 members per household.In middle-income households, the most frequent number of members in a household consisted of 4 members per household.These results are consistent with findings from the Government of Kenya (2006) where 46% of urban poor were recorded to have 4 members living in a household. On the contrary 54% of urban non-poor were recorded havingabout 3 members per household. The urban poor were recorded having more people per household as opposed to the urban non-poor (G.o.K., 2006).

In both low and middle-income households only 1% (n=1) of respondents had no formal education. Upper primary level education was attained by 23.8% (n=29) of respondents in low-income and 18.5% (n=12) of respondents in middle-income households.Secondary education was attained by 66.4% (n=81) of respondents in low-income households. In middle-income households 53.8% (n=35) of respondents attained secondary education. Tertiary education was achieved by 20% (n=13) of middle-income household respondents, and by 9% (n=11) of low-income household respondents.These results were consistent with the findings reported by UNESCO (2006) where literacy rates reported in Kenya were reported to be high, with more than 63% of the Kenyan population having attended some form of or a whole of secondary education (UNESCO, 2006).

Income was noted to be a sensitive topic among respondents from low and middle-income households. Figure 3 displays the monthly income per household.

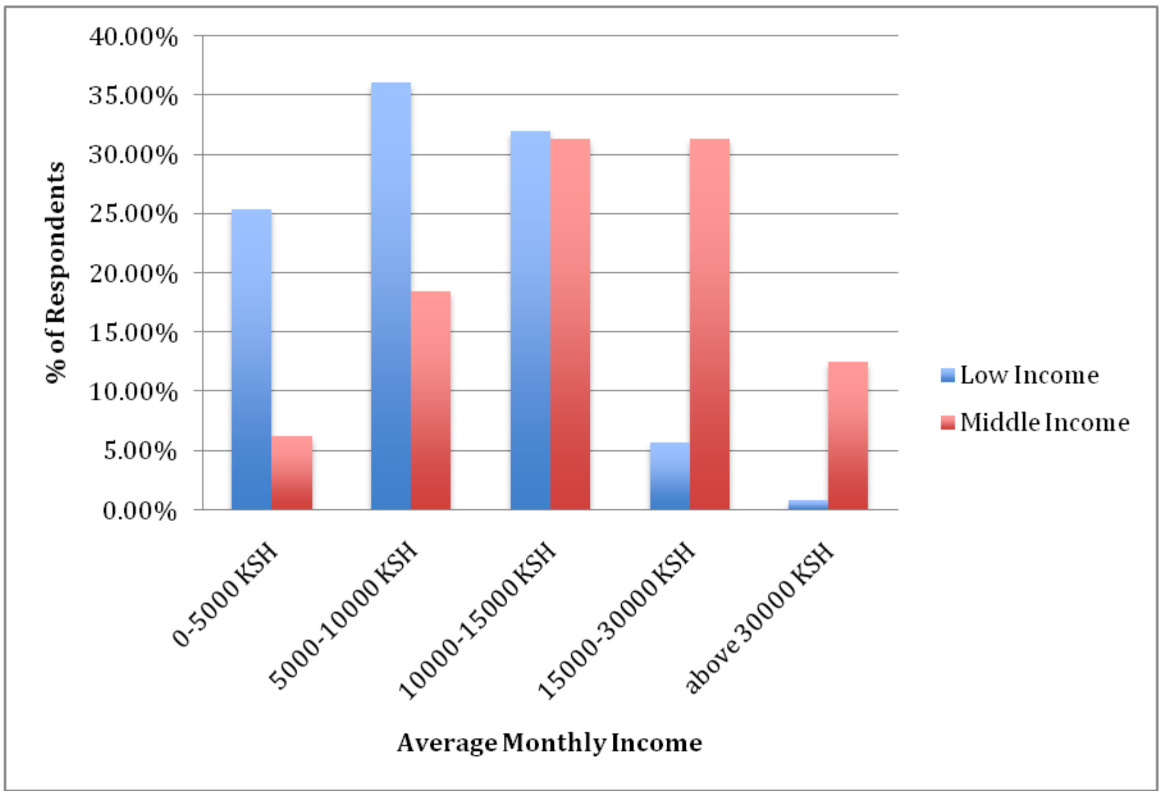

Figure 3: Monthly Income in Sampled Households.

In Low-income households the most frequent income category was a monthly income of KSH 5000-10000 reported by 36.1% (n=44) of respondents. In middle-income households, monthly incomes of KSH 10,000-15,000 and KSH 16,000-30,000 were frequent income categories reported by 30.8% (n=20) of respondents respectively. The per-capita income of low and middle-income was calculated using equation 3. The low-income per-capita was KSH 2,143 per house per month and the middle-income per-capita was KSH 5,571 per house per month. The reported monthly income for low-income household was below the national poverty line of KSH 2,913 per person per month while the middle-income household per capita income was above the national poverty line (G.o.K., 2006). Such low monthly income among urban dwellers could be attributed to the fact that urban unemployment rate is at 19.9% primarily due to an increase in urban population and competition for employment. Most urban dwellers are diverting themselves toward informal employment where productivity is low and earnings are unpredictable (KIPPRA, 2011).In Nakuru town, Nyasani (2009) noted that income disparities limited low-income earners to the use of biomass fuels such as charcoal and paraffin. Due to the high population growth formal housing was minimal and thus low-income residents opted for informal housing. The lack of access to formal housing and cleaner fuel sources increase exposure to pollutants that lead to ARI symptoms. In this study it was noted households with low-income, used fuel sources such as charcoal and kerosene and also lived in smaller houses with poor ventilation.

4.2 Indoor socioeconomic characteristics of sampled houses in Nakuru Town

The Indoor socioeconomics characteristics of households also consisted of the structural aspects and added modifications of the studied households. Household structure included material used for building the wall, floor type, roof type, availability of ventilation, number of roomsand carpeting. The National Planning and Building Authority's *Planning and Building Regulations 2009* were used to make comparisons and also to see if established building standards were being adhered to. Thehousing room space standards set by United Nations Habitat and Shelter UK were used to compare and contrast the study results, as there were no local policies or regulations indicating housing standards in Kenya.

The type of material that was used in building the walls of the houses varied across low-income and middle-income neighborhoods. In low-incomeneighborhoods, 52.5% (n=64) of houses were built using stone as material for the wall while 39.3% (n=48) were built using mud and sand. Middle-incomehouses had a high preference for stonewalls, which was used on 87.7% (n=57) of the households studied. Similarly in Mukuru Slums Nairobi, Gulis et al (2004) reported that poor quality building materials were commonly used in constructing the houses and the walls were either mud, wood or iron sheets. To further elaborate on building materials, under section B, sub-regulation BB76.2 of the National Planning and Building Authority,*Planning and Building Regulations 2009* it is stated that “poor quality materials mean any building materials which are, in the absence of special care, liable to rapid deterioration or are otherwise unsuitable for use in the construction of permanent buildings” (G.o.K, 2009). Building materials that arepoor quality deteriorate quickly and allow moisture into the building, which can cause occupants to develop respiratory illnesses andcreating an environment where mold can thrive (NIOSH, 2013). The building materials that were chosen by both the low and middle-income households were compliant with the G.o.K (2009) *Planning and Building Regulations 2009*of Kenya, except for 39.3% of houses in the low-income areas that were built of mud and sand.

Concrete flooring was a highly commonfloor type among low and middle-income households with 99.2% (n=121) of low-incomehouses and 93.8% (n=61) of middle-incomehouses having concrete flooring.Similarly, 0.8% (n=1) and 1.5% (n=1) of low and middle-income households respectively had earthen floors. Tile flooring was not present in the low-incomehouses in this study but was present in 4.6% (n=3) of middle-incomehouses. Section M, sub-regulationMM27.3 of the *Planning and Building Regulations, 2009* on floor requirement states that, “The floor shall be, constructed of non-combustible and durable materials which do not assist the creation of dust and shall have sufficient structural strength” (G.o.K., 2009).Flooring that accumulates dust will likely increase household occupants chances of developing respiratory related illnesses. According to Habitatfor Humanity Australia, children who lived in houses that had concrete flooring as opposed to mud flooring, had lowered odds of acquiring respiratory infections (Habitat for Humanity Australia, 2014).

The Roofing material that was of high preference in both low and middle-income households was ironsheet. In low-income households, 99.2% (n=121) households used irons sheets for roofing while 78.5% (n=51) of middle-income households used iron sheets for roofing. Middle-income households also reported a variety of roofing types with 13.8% (n=9) of houses having slab for roofing, 4.6% (n=3) asbestos, and 3.1% (n=2) tiles. The houses in the study had sturdy and strong roofing structures and were in accordance with section K, sub regulation KK1 of the *Planning and Building Regulations, 2009* regardinggeneral requirements for roofs.It states,"the roof of any building shall be constructed toresist any forces which it may be subjected to, be durable and waterproof and have a ceiling assembly" (G.o.K., 2009).Roofing that allows for moisture and cold to penetrate from outside the house will cause occupants in the household to contract respiratory related illnesses (NIOSH,2013).Even though Iron sheet roofing was popular, it can also allow moisture to penetrate the house if there is no proper ceiling assembly.

Ventilation is one of the key structures of the house as it is important in the prevention of excess indoor pollution. The ventilation status is according to Appendix 4, which illustrates the types of ventilation status. Figure 4 illustrates the ventilation status of sampled housesfor both low and middle-income households.

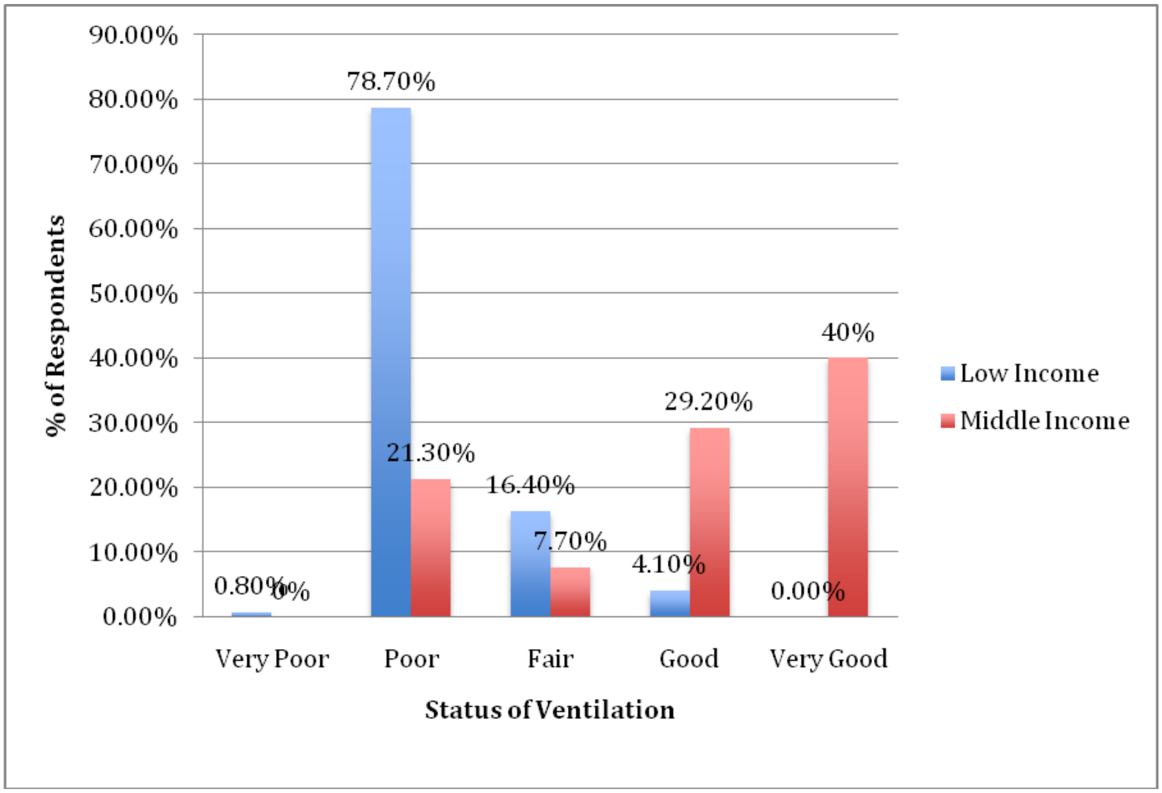

Figure 4: Ventilation Status of Sampled Households.

In low-income areas the ventilation status of 78.7% (n=96) of householdswas pooras they only had a single door and window for ventilation.In middle-income households 40% (n=26) of households had very good ventilation as they had a chimney, two or more doors and two or more windows. Among middle-income households,40% (n=26) of households met the ventilation standards spelled out by The National Planning and Building Authority's, *Planning and Building Regulations*, 2009 as they had properly erected chimneys and fireplaces. None of the low-income households met the required standards. Not having a properly erected chimney or fireplace indoors is a major concern during biomass or charcoal usage as the most significant health concern is the smoke. Smoke contains carcinogens and small particles, which damage the lungs and respiratory organs (WHO, 2009).Section N of the *Planning and Building Regulations, 2009*sub regulation NN27.1 on chimney requirements states that, "Every fireplace used for the burning of solid fuel shall have a fireplace made of non-combustible material of adequate thickness. Moreover, Regarding the appropriate height of the chimney, sub regulation NN26.5 further states that that, "The height of any chimney outlet shall be not be less than 1 m above the highest point of contact between such chimney and the roof… shall be not less than 1 m above the highest point of any window or roof light capable of being opened or any ventilation inlet situated in any roof or external wall…shall be not less than 1 m above the eaves level in the case of any chimney which does not pass through the roof of a building" (G.o.K., 2009).Other than smoke, Poor ventilation can lead to the trapping of dust, mites, particulate matter, and other poisonous gases, which are harmful to the household occupants (Perez-Padilla et al., 2010).

In this study, every room of the house was considered in the observation schedule. In low-income areas,households that had one room constituted of67.2% (n=82) of households. This finding is consistent with those of Cheserek and Opata (2011) where due to economic circumstances low-income groups were seen to have a high preference for living in single room houses.Low-incomehouseholds that hadtwo rooms or more rooms constituted of 32.7% (n=40) of households. Inmiddle-income areas, four room houses were frequent with58.5% (n=38) of households reported having four or more rooms.Furthermore, The UN-Habitat advicethat a house is considered to provide sufficient living area for the household members if not more than three people share in aspects of living and sleeping in a habitable room of at least 4 sq. m. (United Nations, 2008).In England, for example, the minimum floor area for one person is 6.5-8.4 sq. m. and 10.2 sq. m. for two people. In disaster conditions, the internationally recognized area is 3.5 sq. m. per person (Shelter, 2014).In low-income areas, 32.7% of households met the United Nation's and Shelter U.K. standards listed above as they had more 2 rooms or more.Low-income household were overcrowded, as majority of the houses were single rooms with 3-4 members living in them. Households that met the UN and Shelter UK standards in middle-incomeareas consisted 83.1% of houses. Single room houses tend to be overcrowded which is recognized as a hazard to health as there is lack of sufficient habitable space. Overcrowding has been associated with the spread of infectious diseases such as respiratory illnesses, accidental deaths, cardiovascular diseases, stress and depression. This risk is compounded when already overcrowded dwellings are located in, or near, polluted areas (Habitat for Humanity Australia, 2014).

Carpets were added modifications meant for beautification and/or used against cold floors. AmongLow-income households,64.8% (n=79) of houses had no form of carpet. Plastic carpets were present in 23% (n=28) of low-incomehouses while woolen carpet was present in 12.3% (n=15) of low-incomehouses. In middle-incomehouseholds' woolen carpet was preferable in 43.1% (n=28) of households while 21.5% (n=14) of households had plastic carpeting. Though 64.6% of middle-income households had some form of carpeting, 35.4% (n=23) preferred not to have any form of carpeting. If carpets are not properly maintained and cleaned, they can provide a microhabitat for dust mites. Furthermore carpets can hold moisture and allergens, which can lead to respiratory illnesses. (NIOSH, 2013)

4.3 Energy sources used in households

Sources of fuel that were used for cooking in urban areas varied in terms of preference among households. In low-income households, charcoal had a high preference with 72.1% (n=88) household having reported using it for cooking. In middle-income household, 47.7% (n=31) used charcoal for cooking though a close 41.5% (n=27) of households preferred using gas. The below figure 3 further shows energy sources that were common for cooking among sampled households.

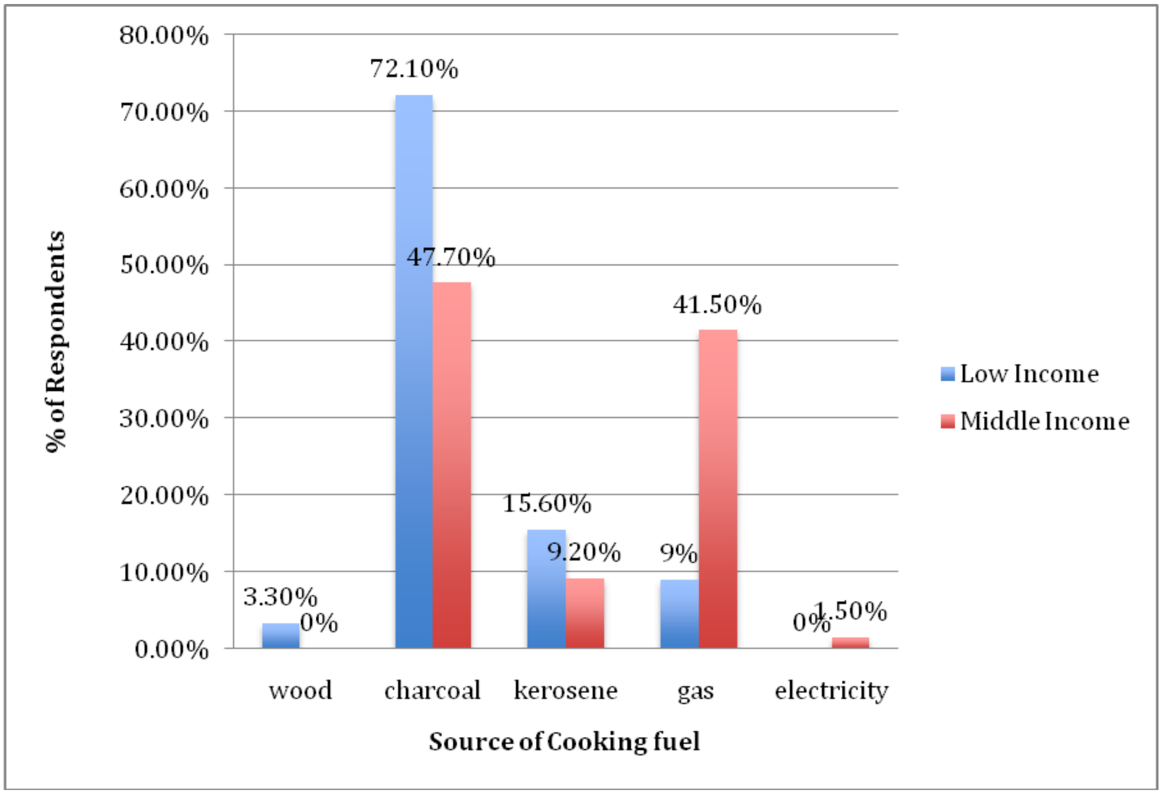

Figure 5: Cooking Fuels used in Sampled Households.

These results were consistent with those reported by the Kenya Demographic and Health Survey 2008-09 on cooking fuels, which show that among urban dwellers, charcoal was preferred by 41.1%, and LPG used by 21.7% of urban households in Kenya. Kerosene also was noted to be highly preferable among urban dwellers with 26.9% of households using it as cooking fuel (G.o.K., 2010).

To explain the high usage of charcoal in most urban areas in Kenya, Karekezi et al (2008) noted that, urban households liked charcoal because it did not produce a lot of smoke and its calorific value was twice as much as that of wood and therefore lasted longer, especially when it was used with improved cook stoves. Charcoal was considered to be relatively affordable, economical and convenient. It was sold on average, US$ 5 per 36 kg bag while convenient fuel sources such as kerosene retailed atUS$ 0.85 per liter. Without considering the upfront costs, both Electricity and LPG could be affordable. Electricity sold forUS$ 0.08 per kWh for electricity and LPG cost US$ 13 to refill a 6kg cylinderIt's relatively low price and an extensive distribution network ensures its availability (Karekezi et al., 2008).

With L.P.G. being a cleaner and efficient energy source for cooking energy Karekezi et al (2008) further noted that LPG was not a very common source of fuel among the urban poor population but trends indicated that its use and dissemination was steadily growing. The high upfront cost of LPG cylinders made it unaffordable among the majority of the urban poor with a cylinder costing almost 10 to 15 times the national per capita income (Karekezi et al., 2008). The health implications of household energy use on respiratory health was highlighted by Kilabuko and Nakai (2007) who noted that, Kerosene can be burnt very cleanly in pressurized burner but is often used in ways, which raise some health concerns through its use by stoves. Respiratory IllnessPrevalence in children from households cooking on biomass fuels and from households using kerosene or charcoal was more or less the same but a little higher among children from households using.

4.4 Energy Sources used for Lighting

Electricity was the most commonlighting source in Nakuru Town with 82.8% (n=101) of low-income households and 95.4% (n=62) of middle-income having access to it. For those households that did not have access to electricity, 16.4% (n=20) of them in low-income areas preferred kerosene, while only 3.1% (n=2) in middle-income areas used kerosene for lighting. Candle was the least used source of lighting fuel with 0.8% (n=1) of low-income and 1.5% (n=1) middle-income households using it as a source of lighting. Figure 6 depicts lighting energy prevalence in Nakuru Town.Nationally among urban households, 65.6% had access to electricity for lighting which (G.o.K., 2010).

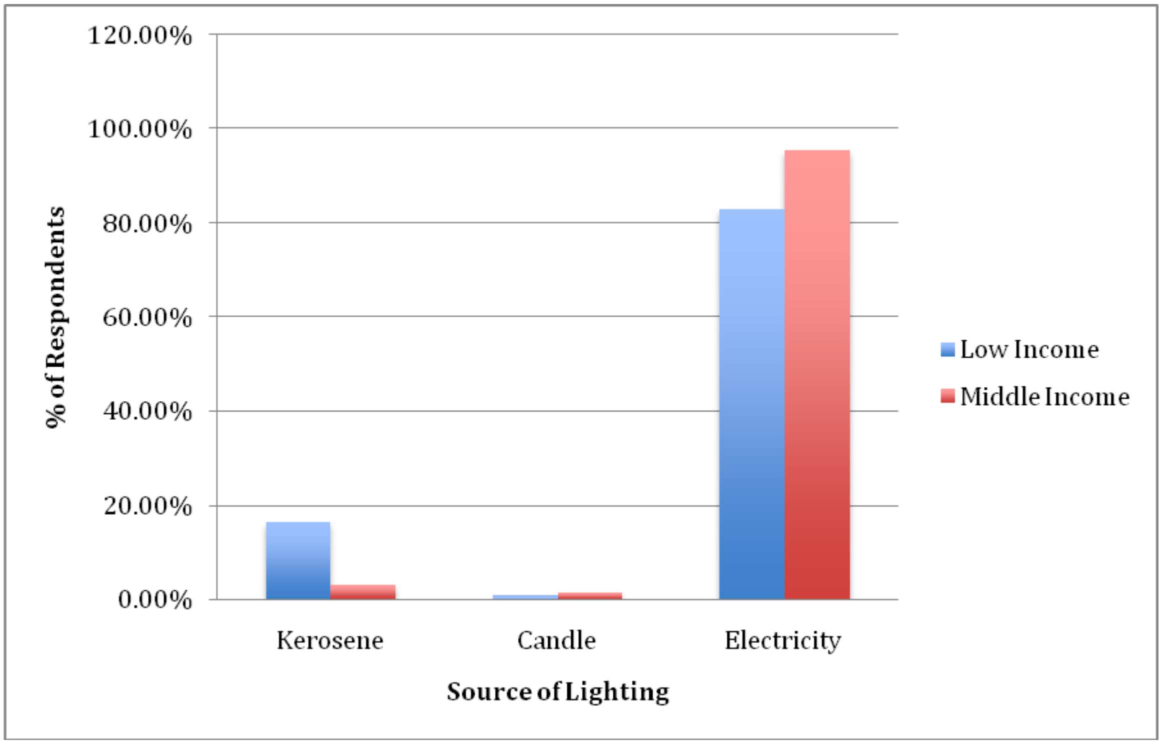

Figure 6: Lighting fuels used in Sampled Households.

The World Health Organization (WHO) stated that the "Reliance on kerosene lighting presents health risks from indoor air pollution such as respiratory illnesses especially to women and young children (WHO, 2012). Findings of this study on urban electricity access was consistent to the findings of a study done by Karekezi et al (2008) in Kibera Nairobi where Electricity was the next most commonly used energy option for lighting as it met the primary lighting needs of about 42 % of Kibera residents (Karekezi et al, 2008) this insinuates that electricity access in urban areas has greatly improved and that less people are relying on kerosene and biomass for lighting.

4.5 Prevalence Rates of Respiratory diseases in Nakuru Town

During the course of this study, (ARI) respiratory infections were highly common among low and middle-income households. The respondents were requested to list the diseases that their children suffered from 2 months prior to the study. Figure 7 depicts the prevalence rates per 100 children among low and middle-income areas in Nakuru Town.

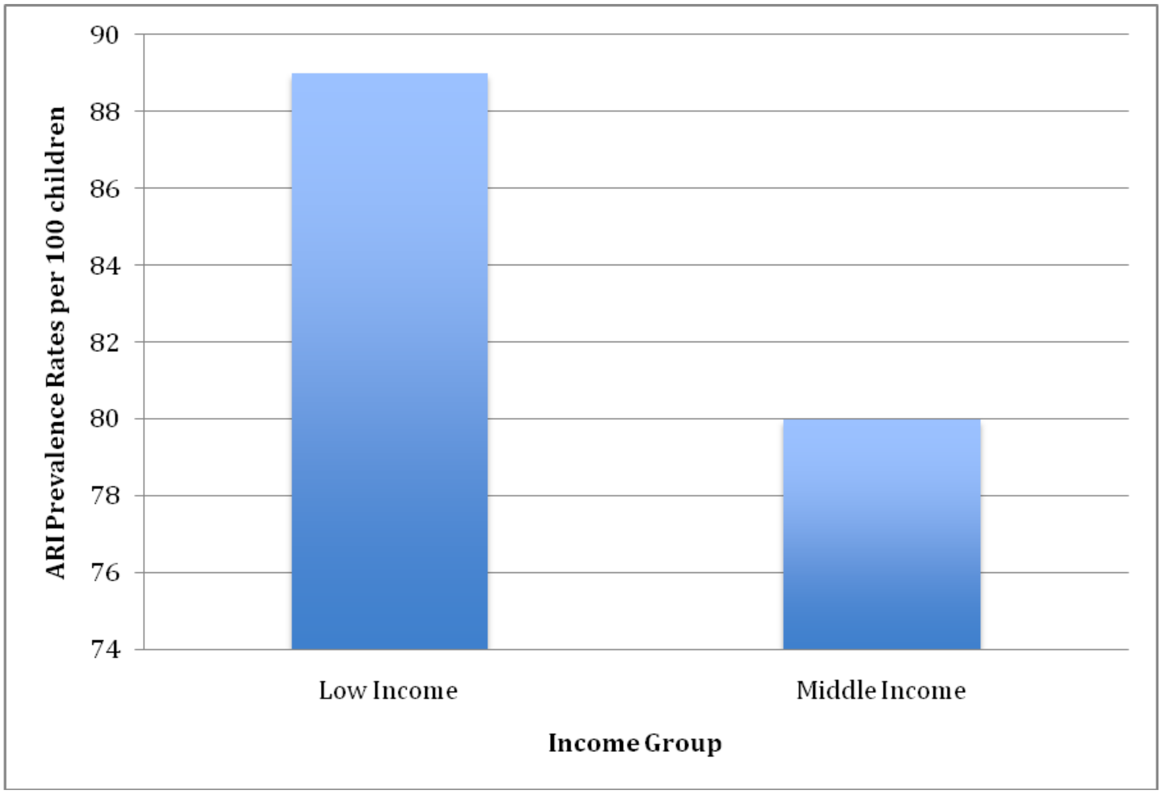

Figure 7: ARI Prevalence Rates of Sampled Households.

The total prevalence rates of ARI for middle-income households were 80 infections per 100 children and 89 infections per 100 children in low-income households. Nationally, the outpatient morbidity rates for children under 5 was 67% (n=4,453,375) while in Nakuru the outpatient morbidity rates were 41% (n=59,168) regarding respiratory disorders and pneumonia (G.o.K., 2011;G.o.K., 2012). These findings were not consistent with those found in the study areas in Nakuru town as they were lower where 86% (n=161) of the households reported some form of respiratory disorder. Mishra (2003) stated that there is also a possibility of underreporting of ARI due to caretaker's lack of awareness that the child had the disease (Mishra, 2003).Juma (2007) argued that due to the introduction of the integrated management of childhood illnesses (IMCI) in developing countries by the WHO and UNICEF had greatly improved and emphasized caretaker skills in recognizing symptoms such as those related to respiratory illnesses and their severity. The fact that IMCI programs are free of charge has improved healthcare seeking behavior by caretakers in Kenya.Almost all mothers would seek health care whenever their under fives show any symptom of disease severity (Juma, 2007).

4.6 Analysis ofhousehold indoor socioeconomics influenceon ARI

The study sought to determine whether there was a relationship between household socioeconomics and the presence of ARI among children in low and middle-income households in Nakuru Town. A multiple regression analysis was carried out at 95% confidence level (α=0.05.).Table 7 shows the results of the relationship between household socioeconomic factors and ARI in low-income.

Table 7: Low-incomeSocioeconomic Factors.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t-values	p-values
	B	Std. Error	Beta		
(Constant)	1.617	.867		1.866	.065
Level of education attained by caretaker	-.075	.050	-.148	-1.484	.141
Number of members living in the house	.079	.055	.151	1.427	.156
Average income of family	.067	.034	.198	1.984	.051
Source of cooking fuels	-.015	.045	-.033	-.335	.738
Main source of light	.064	.040	.155	1.612	.110
Hours child spend indoor per day	**-.126**	**.056**	**-.342**	**-2.260**	**.026**
Material used to build a house	-.024	.020	-.117	-1.177	.242
Number of rooms	-.046	.059	-.096	-.769	.443
Type of floor used in the house	.197	.324	.057	.607	.545
Any form of carpet	**-.053**	**.018**	**-.306**	**-3.025**	**.003**
Type of roofing	-.047	.157	-.028	-.301	.764
Is the house properly ventilated	-.005	.069	-.009	-.079	.937

a. Dependent Variable: presence of respiratory disease

The multiple regression analysis for low-income households revealed hours spent indoors (p=0.026) and carpeting (p=0.003) were significant factors toward the prevalence of ARI in children under-5. Children who spent longer times indoors were more likely to be exposed to ARI causing pollutants. Perez-Padilla (2010) noted that the indoor environment in most low-income households had poor ventilation. Poor ventilation causes the trapping of dust, allergens, particulate matter, and other poisonous gases, which are harmful to the respiratory health of household occupants such as children under-5 (Perez-Padilla et al, 2010).

Children who spent time in houses with some form of carpeting had a lower chanceof contracting some form of ARI. In low-income households 23% (n=28) had plastic carpet while 12.3% (n=15) had woolen carpet. Low-income households that had no presence of carpet constituted of 64.8% (n=79), suggesting that the lack of carpeting contributed to a higher chance of ARI presence. In middle-income households 21.5% (n=14) had plastic carpets while 43.1% (n=28) had woolen carpeting. Houses that had no carpeting constituted of 35.4% (n=23) of household. Carpeting can help against the cold and dampness found in flooring. According to a study carried out by Habitat for Humanity Australia, a clear association between damp houses and a higher prevalence of poor health was identified in low-incomehouses. Damp houses have a higher incidence of dust mites and mold (spores) causing or exacerbating respiratory conditions such as asthma, wheezing, aches and pains, diarrhea, nausea and headaches. This explains the high rates of respiratory illnesses in children from houses without some form of carpeting on the floor (Habitat for Humanity Australia, 2014).However, households that have carpets that harbor dust, mites, moisture and allergens are likely to increase symptoms of infectious diseases such as respiratory illness (NIOSH, 2013).If woolen carpets are not adequately cleaned, they can be a source of allergens and other respiratory irritants.

Table 8: Middle-income Socioeconomic Factors.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t-values	p-values
	B	Std. Error	Beta		
(Constant)	1.947	.810		2.404	.020
Level of education attained by caretaker	-.019	.066	-.043	-.293	.771
Number of members living in the house	-.111	.076	-.206	-1.464	.150
Average income of family	-.011	.060	-.031	-.184	.855
Source of cooking fuels	-.005	.065	-.012	-.075	.940
Main source of light	.104	.168	.098	.618	.539
Hours child spend indoor per day	-.123	.128	-.258	-.963	.340
Material used to build a house	.014	.081	.029	.168	.867
Number of rooms	.024	.098	.070	.239	.812
Type of floor used in the house	.060	.125	.068	.478	.635
Any form of carpet	-.049	.039	-.207	-1.252	.217
Type of roofing	.100	.061	.231	1.645	.106
Is the house properly ventilated	-.076	.095	-.224	-.800	.427

a. Dependent Variable: presence of respiratory disease

The multiple regression analysis for middle-income households revealed that all the factors were not significant as their p-values were greater than 0.05 significant levels.Thus we conclude that in middle-income households none of the predictor variables had a significant effect on ARI prevalence among children under-5 from middle-income households.

Sources of energy used in low and middle-income households were expected to significantly contribute toward ARI prevalence among children under-5 in this study. Low-income houses in this study were primarily single room houses;with poor ventilation some cooking was done outside due to lack of space, discomfort and to avoid fires. Cooking outdoors was done as a measure to assist in the reduction of exposure to ARI causing pollutants. Plate 1 below illustrates cooking being done outside a sampled house in a low-income area.

Plate 1: Cooking done outdoors.

Studies done by Ezzati (2000), Duflo et al. (2008), Barnes et al. (2009) andMishra et al (1999) indicated that indoor air pollution and respiratory illnesses in rural areaswere associated with the usageof biomass fuel as cooking was done in poorly ventilated rooms. Research in Kenya Ezzati (2000) revealed that wood fuel use emitted particulate matter that had a concentration of 50,000ug/m3 in the immediate vicinity of the cooking area. Such high concentrations indicated that constant exposure would lead to complicated respiratory infections (Duflo et al., 2008; Ezzati, 2000). In South Africa, children living in households that relied on polluting fuels such as wood fuels were more than 2 to 4 times likely to suffer from anrespiratory infections as compared to children living in houses that relied on electricity (Barnes et al., 2009). Mishra et al. (1999) also discovered that active tuberculosis was more prevalent in households that used biomass fuels in India. Unlike the former studies, this study showed that there was some level of awareness among households as cooking using charcoal was primarily done outside to avoid polluting the indoor environment of the house.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This research was based on comparative analysis of low-income and middle-income urban dwellers. Findings of this study were based on the household socioeconomic characteristics, energy sources used for cooking and lighting, prevalence ARI among children and the relationship between energy sources, household socioeconomic characteristics and prevalence of ARI.

The household socioeconomic characteristics of this study varied among low and middle-income households. The most frequent age group of respondents among both low and middle-income households was age 19-25. The average monthly income for low-income households was KSH 7,500 and KSH 12,500 among middle-income households.Secondary level education was the most common level of education, which was achieved by 66.4% of low-income household caregivers and 53.8% of middle-income household caregivers. Ventilation standards were met by 40% of middle-income households while one of the low-income households met the standards.Household socioeconomic characteristics did not have an influence on the presence of ARI in children.

The types of energy sources that were highly used in sampled households were, charcoal and L.P.G. Charcoal was a highly used for cooking in low households by 72.1% of households. Among middle-income households' charcoal was used by 47.7% and L.P.G. by 41.5% of households as a sources of cooking energy. Electricity was the most preferable source of lighting as it was accessible to 82.8% of low-income households and 95.4% of middle-income households. Energy sources did not have an influence on the prevalence of ARI

The total prevalence rates of ARI for middle-income households were 80 infections per 100 children and 89 infections per 100 children in low-income households. Common cold (61 infections per 100 children) had the highest prevalent rates. ARI rates in both low and middle-income households were high but the infection rates of low-income households were higher than those in middle-income households.The factors that were significant andaffected thepresence of ARI among children in low-income households were hours spent indoors(p=0.026) and carpeting (p=0.003). In middle-income households socioeconomic factors were not significant toward the prevalence of ARI.

5.2 Recommendations

1. If meeting the costs for proper chimney construction proves difficult, the Ministry of Housing and Planning should ensure that all the houses they built have a secure roof hatch window, where occupants can open if they decide to cook in the house or just to let fresh air into the house. This will result in a much more conducive indoor environment.
2. Public Health facilities and policy makers should advise the public through increased awareness campaigns on the importance of cooking in properly ventilated areas in order to reduce or curb exposure of occupants to respiratory infections associated with pollutants from biomass fuels.
3. Public Health facilities should emphasize the importance of prevalence rates calculation in order to clearly understand what proportion of the under 5 population is found to have ARI or any other reported disease(s) at a given time. Prevalence rates should be reported at the sub-County and at County levels as a whole.
4. The Government should introduce subsidies that increase the availability and affordability of clean energy sources to low-income areas. This would decrease the use of polluting biomass cooking fuels such as charcoal and kerosene.
5. Low-Income houses that do not have some form of carpet should get one but ensure that it is properly cleaned and void of moisture.
6. The Ministry of Housing at the County level should develop an institutional framework that spells housing standard policies and implement the urban building code by-laws that will ensure houses meet the minimum requirements for space and ventilation.

5.3 Suggestion for Further Research

The outdoor environment in most urban areas has challenging factors such as solid waste burning, motor vehicle fumes and a sometime dry and dusty weather, which produce pollutants that children are exposed to as they are playing outside their houses. Further research should be doneby measuring and monitor outdoor air ambient quality where children under 5 play and interact with the outdoor environment. This research would try to establish if outdoor air pollution is an influencing factor on the prevalence of ARI among children under-5 in urban areas.

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APPENDICES

You have been randomly selected to provide information and participate in this study. This study is for a Master of Science degree at Egerton University, Njoro. The purpose of this study is to investigate the influence of energy sources and household socioeconomic characteristics on respiratory infections in children under-5 in your area. This study will be carried out through a questionnaire and an observational schedule of the house. The information that you give in this study will be used for study purposes only and will be treated with confidentiality. If you have any questions during the course of this study, do ask please.

APPENDIX 1: Questionnaire For The Caregivers and Assessment of the Child.

1. Date and time:

Location:

2.	Caretaker’s role at house
3.	Age of the Bracket of Caretaker 1) <18 ( ) 2) 19-25 ( ) 3) 26-30 ( ) 4) 31-35 ( ) 5) 36+ ( )
5.	Sex of Caretaker: 1) Male [ ] 2) Female [ ]

6.		Level of education attained by caretaker? Tick One 1) No formal Education ( ) 2) Lower primary ( ) 3) Upper primary ( ) 4) Secondary ( ) 5) Tertiary ( )
7.	Household size	How many members live in the house? 1) 2 members ( ) 2) 3-4 members ( ) 3) 5-6 members ( ) 4) 7+ members ( )
8.		What type of economic tie do you have to the house? Tick One 1) Rented ( ) 2) Owned ( ) 3) Caretaking ( ) 4) Other (please specify) ( )
9.		What is the average monthly income of family? Tick One 1) Below 5,000 ( ) 2) 5,000-10,000 ( ) 3) 10,000-15000 ( ) 4) 20,000-30,000 ( ) 5) Above 50,000 ( )

10.	What are the most preferred sources of cooking fuels in your house? (Rank from 1-5. 1 being the most preferred and 5 being the least preferred.) **A)** Wood fuel ( ) **B)** Charcoal () **C)** Kerosene ( ) **D)** Gas ( ) **E)** Electricity () **F)** Other (please specify in the space below)
11.	What is the main source of lighting used in your house? Tick only one 1) Kerosene ( ) 2) Candle light ( ) 3) Electricity ( ) 4) Solar ( ) 5) Other (please specify)
12.	Child's Age(below 5 years old) 1) 0-1 ( ) 2) 2-3 ( ) 3) 4-5 ( )
13.	Child's Sex 1) Male ( ) 2) Female ( )

14.	How many hours does the child spend Indoors in a day? 1) 6-8 hours ( ) 2) 9-12 hours ( ) 3) 13-16 hours ( ) 4) 17-20 hours ( ) 5) 24 hours ( ) How many hours does the child spend outdoors in a day? 1) 1-2 hours ( ) 2) 3-4 hours ( ) 3) 5-6 hours ( ) 4) 6-7 hours ( ) 5) 8+ hours ( )
15.	Can you list theinfections your child has suffered from in the past 2 months?

APPENDIX 2:Observation Schedule

1	Housing type	What materials were used to build the house? **1)** Polythene ( ) **2)** Mud ( ) **3)** Mud and Sand/Cement ( ) **4)** Wooden ( ) **5)** Iron sheets ( ) **6)** Stone ( ) **7)** Other ( )
2.	Dwelling size	How many rooms does the house have? 1) 1 ( ) 2) 2 ( ) 3) 3 ( ) 4) 4+ ( )
3.	Flooring	What type of flooring is used in the house? 1) Earthen ( ) 2) Concrete ( ) 3) Wood ( ) 4) Tiles ( ) 5) Other ( ) Is there any form of carpet on the floor? 1) Plastic carpet ( ) 2) Woolen ( )

		3) Sisal ( ) 4) Papyrus ( ) 5) None ( )
4.	Roofing	What type of roofing is used on the house? 1) Polythene ( ) 2) Iron Sheets ( ) 3) Tiles ( ) 4) Slab ( ) 5) Asbestos ( ) 6) Other ( )
5.	Classification of House	What is the classification of the house? 1) Permanent (foundation present) ( ) 2) Semi-permanent (no foundation) ( ) 3) Temporary (no foundation) ( ) 4) Other Please specify ( )

6.	Ventilation	Is the house properly ventilated? 1) Very Poor ( ) 2) Poor ( ) 3) Fair ( ) 4) Good ( ) 5) Very Good ( )

APPENDIX 3: Descriptives for Low and Middle-incomeHouses

Low-income Descriptive (Frequency Tables)

Level of education attained by caretaker

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no formal education	1	.8	.8	.8
	upper primary	29	23.8	23.8	24.6
	secondary	81	66.4	66.4	91.0
	tertiary	11	9.0	9.0	100.0
	Total	122	100.0	100.0	

Number of members living in the house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 members	2	1.6	1.6	1.6
	3-4members	86	70.5	70.5	72.1
	5-6 members	28	23.0	23.0	95.1
	7+ members	6	4.9	4.9	100.0
	Total	122	100.0	100.0	

Average income of family

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 5000	31	25.4	25.4	25.4
	5000-10000	44	36.1	36.1	61.5
	10000-15000	39	32.0	32.0	93.4
	16000-30000	7	5.7	5.7	99.2
	above 50000	1	.8	.8	100.0
	Total	122	100.0	100.0	

Source of cooking fuels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	wood	4	3.3	3.3	3.3
	charcoal	88	72.1	72.1	75.4
	kerosene	19	15.6	15.6	91.0
	gas	11	9.0	9.0	100.0
	Total	122	100.0	100.0	

Main source of light

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	kerosene	20	16.4	16.4	16.4
	candle	1	.8	.8	17.2
	electricity	101	82.8	82.8	100.0
	Total	122	100.0	100.0	

Material used to build a house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	mud	5	4.1	4.1	4.1
	mad and sand	48	39.3	39.3	43.4
	iron sheet	5	4.1	4.1	47.5
	stone	64	52.5	52.5	100.0
	Total	122	100.0	100.0	

Number of rooms

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 room	82	67.2	67.2	67.2
	2 rooms	33	27.0	27.0	94.3
	3 rooms	5	4.1	4.1	98.4
	4+ rooms	2	1.6	1.6	100.0
	Total	122	100.0	100.0	

Type of floor used in the house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	earthen	1	.8	.8	.8
	concrete	121	99.2	99.2	100.0
	Total	122	100.0	100.0	

Any form of carpet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	plastic carpet	28	23.0	23.0	23.0
	woolen	15	12.3	12.3	35.2
	none	79	64.8	64.8	100.0
	Total	122	100.0	100.0	

Type of roofing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	iron sheet	121	99.2	99.2	99.2
	slab	1	.8	.8	100.0
	Total	122	100.0	100.0	

Classification of houses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	permanent	68	55.7	55.7	55.7
	semi-permanent	51	41.8	41.8	97.5
	temporary	3	2.5	2.5	100.0
	Total	122	100.0	100.0	

Is the house properly ventilated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	.8	.8	.8
	disagree	96	78.7	78.7	79.5
	neither agree nor disagree	20	16.4	16.4	95.9
	agree	5	4.1	4.1	100.0
	Total	122	100.0	100.0	

Hours child spend indoor per day

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6-8 hours	4	3.3	3.3	3.3
	9-12 hours	36	29.5	29.5	32.8
	13-16 hours	50	41.0	41.0	73.8
	17-20 hours	31	25.4	25.4	99.2
	21-24 hours	1	.8	.8	100.0
	Total	122	100.0	100.0	

Hours child spend outdoor

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2 hours	29	23.8	23.8	23.8
	3-4hours	5	4.1	4.1	27.9
	5-6 hours	5	4.1	4.1	32.0
	6-7 hours	7	5.7	5.7	37.7
	8+ hours	76	62.3	62.3	100.0
	Total	122	100.0	100.0	

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.316	13	.178	2.069	.022[b]
	Residual	9.299	108	.086		
	Total	11.615	121			

a. Dependent Variable: presence of respiratory disease.
b. Predictors: (Constant), is the house properly ventilated, level of education attained by caretaker, type of roofing, type of floor used in the house, main source of light, hours child spend outdoor, source of cooking fuels, any form of carpet, material used to build a house, average income of family, number of members living in the house, number of rooms, hours child spend indoor per day.

Middle-income Descriptive (Frequency Tables)

Level of education attained by caretaker

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no formal education	1	1.5	1.5	1.5
	lower primary	4	6.2	6.2	7.7
	upper primary	12	18.5	18.5	26.2
	secondary	35	53.8	53.8	80.0
	tertiary	13	20.0	20.0	100.0
	Total	65	100.0	100.0	

Number of members living in the house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 members	2	3.1	3.1	3.1
	3-4members	31	47.7	47.7	50.8
	5-6 members	25	38.5	38.5	89.2
	7+ members	7	10.8	10.8	100.0
	Total	65	100.0	100.0	

Average income of family

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 5000	4	6.2	6.3	6.3
	5000-10000	12	18.5	18.8	25.0
	10000-15000	20	30.8	31.3	56.3
	16000-30000	20	30.8	31.3	87.5
	above 50000	8	12.3	12.5	100.0
	Total	64	98.5	100.0	
Missing	System	1	1.5		
Total		65	100.0		

Source of cooking fuels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	charcoal	31	47.7	47.7	47.7
	kerosene	6	9.2	9.2	56.9
	gas	27	41.5	41.5	98.5
	electricity	1	1.5	1.5	100.0
	Total	65	100.0	100.0	

Main source of light

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	kerosene	2	3.1	3.1	3.1
	candle	1	1.5	1.5	4.6
	electricity	62	95.4	95.4	100.0
	Total	65	100.0	100.0	

Material used to build a house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	mud	1	1.5	1.5	1.5
	mad and sand	3	4.6	4.6	6.2
	iron sheet	4	6.2	6.2	12.3
	stone	57	87.7	87.7	100.0
	Total	65	100.0	100.0	

Number of rooms

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 room	11	16.9	16.9	16.9
	2 rooms	9	13.8	13.8	30.8
	3 rooms	7	10.8	10.8	41.5
	4+ rooms	38	58.5	58.5	100.0
	Total	65	100.0	100.0	

Type of floor used in the house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	earthen	1	1.5	1.5	1.5
	concrete	61	93.8	93.8	95.4
	tiles	3	4.6	4.6	100.0
	Total	65	100.0	100.0	

Any form of carpet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	plastic carpet	14	21.5	21.5	21.5
	woolen	28	43.1	43.1	64.6
	none	23	35.4	35.4	100.0
	Total	65	100.0	100.0	

Type of roofing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	iron sheet	51	78.5	78.5	78.5
	tiles	2	3.1	3.1	81.5
	slab	9	13.8	13.8	95.4
	asbestos	3	4.6	4.6	100.0
	Total	65	100.0	100.0	

Classification of houses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	permanent	59	90.8	90.8	90.8
	semi-permanent	5	7.7	7.7	98.5
	temporary	1	1.5	1.5	100.0
	Total	65	100.0	100.0	

Is the house properly ventilated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree	15	23.1	23.1	23.1
	neither agree nor disagree	5	7.7	7.7	30.8
	agree	19	29.2	29.2	60.0
	strongly agree	26	40.0	40.0	100.0
	Total	65	100.0	100.0	

Hours child spend indoor per day

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	9-12 hours	19	29.2	29.2	29.2
	13-16 hours	26	40.0	40.0	69.2
	17-20 hours	18	27.7	27.7	96.9
	21-24 hours	2	3.1	3.1	100.0
	Total	65	100.0	100.0	

Hours child spend outdoor

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2 hours	16	24.6	24.6	24.6
	3-4hours	4	6.2	6.2	30.8
	6-7 hours	10	15.4	15.4	46.2
	8+ hours	35	53.8	53.8	100.0
	Total	65	100.0	100.0	

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.712	13	.132	.807	.650[b]
	Residual	8.002	49	.163		
	Total	9.714	62			

a. Dependent Variable: presence of respiratory disease

b. Predictors: (Constant), is the house properly ventilated, level of education attained by caretaker, number of members living in the house, hours child spend outdoor, type of roofing, type of floor used in the house, main source of light, source of cooking fuels, material used to build a house, any form of carpet, average income of family , hours child spend indoor per day, number of rooms.

Same comments as above

APPENDIX 4: Ventilation Status

The definition for the Likert Scale below was done after the pretesting of the questionnaire where ventilation characteristics were surveyed as follows:

1. No chimney. No hood. One door. No window- Very Poor.
2. No chimney. No hood. One door. One window- Poor.
3. No chimney. No hood. One door. Two or more windows- Fair.
4. No chimney. No hood. Two or more doors. Two or more windows- Good.
5. Chimney or hood. Two or more doors. Two or more windows- Very Good.

APPENDIX 5: Research Authorization Permit

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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9[th] Floor, Utalii House
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P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

NACOSTI/P/14/9530/3144

Date:
1st October, 2014

Munene Mutuma Mugambi
Egerton University
P.O. Box 536
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of the influence of energy sources and household socioeconomic characteristics on the prevalence of acute respiratory infections among children in Nakuru Town, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Nakuru County** for a period ending **30th December, 2014.**

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

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

DR. M. K. RUGUTT, PhD, HSC.
Ag. SECRETARY/CEO

Copy to:

The County Commissioner
The County Director of Education
The County Coordinator of Health
Nakuru County.

THIS IS TO CERTIFY THAT:
MR. MUNENE MUTUMA MUGAMBI
of EGERTON UNIVERSITY, 0-20100 NAKURU,has been permitted to conduct research in *Nakuru County*

Permit No : NACOSTI/P/14/9530/3144
Date Of Issue : 1st October,2014
Fee Recieved :Ksh 1,000

on the topic: *ASSESMENT OF THE INFLUENCE OF ENERGY SOURCES AND HOUSEHOLD SOCIOECONOMIC CHARACTERISTICS ON THE PREVALENCE OF ACUTE RESPIRATORY INFECTIONS AMONG CHILDREN IN NAKURU TOWN, KENYA.*

for the period ending:
30th December,2014

....
Applicant's Signature

....
Secretary
National Commission for Science, Technology & Innovation