PERCEPTIONS OF EFFECTS OF SHORT LIVED CLIMATE POLLUTANTS ON THE HEALTH OF URBAN POOR COMMUNITIES 2008-2018: A CASE STUDY OF NEW KRU TOWN COMMUNITY, LIBERIA.

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C50/8240/2017

A Research Project Submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Environmental Planning and Management of the University of Nairobi.

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DECLARATION

I, the undersigned, declare that this research is my original work and has not been presented to any other institution for academic credit. Information from other sources has been duly acknowledged.

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C50/8240/2017

This research has been submitted with our approval as the University Supervisors

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Dr. Alice Odingo Date

DEDICATION

To my late uncles:

Hon. Johansen Tarpor Voker, Former National Focal Point to the Cartagena Protocol on Biosafety

&

Mr. Sehgran Kerdia Gomah, Former Media and Communications Officer of the EPA

ACKNOWLEDGEMENT

I wish to acknowledge the kind assistance of Dr. Boniface Wambua, Chairman of the Department of Geography and Environmental Studies who always relentlessly encouraged me to pursue my academic work without break. I am also thankful to the staff of the Department of Geography and Environmental Studies for their assistance. My sincere gratitude goes out to my supervisors, Prof. Elias H. O Ayiemba and Dr. Alice Odingo, whose immerse assistance cannot be overemphasized. I would also want to appreciate the student body of the Department of Geography and Environmental Studies for their friendly collaborations.

This research was prepared with the assistance and support of the Environmental Protection Agency of Liberia as part of its funding received through the Liberia Forest Sector Project of the Norwegian Fund through the World Bank for which we are sincerely grateful. Acknowledgement is also made of the kind assistance of the leadership of Madam Anyaa Vohiri, former Executive Director of the Environmental Protection, Dr. Nathaniel T. Blama, Executive Director and Mr. Elijah Whapoe, Manager for Planning and Policy, whose enormous contributions to the success of this project can in no way be quantified. The supports of my boss, Mrs. Frances Brown-Seydou and all the staff of the Department of Inter-sectoral Coordination helped me reached this level. And also to my good friends at the Climate and Clean Air Coalition, who exposed me to have an interest in the SLCP issues. The team at the CCAC including Elsa Lefevre, Kouadio Ngoran Desire, Tara Bukow and the head of Secretariat, Madam Helena Molin-Valdes, whose great works at the CCAC has helped shaped global actions on SLCPs.

I am also grateful to my parents for their indelible supports and also extend my gratitude to my wife and my children for affording me the chance to undertake this task.

ABSTRACT

Every year dirty air causes premature deaths of more than 5.5 million people around the world making it one of the leading fatal health risks. Short Lived Climate Pollutants (SLCPs) has been widely linked to air quality degradation especially within congested urban slum communities. The study determined the perceptions of the effects of SLCPs on the health of Urban Poor Communities in New Kru Town, Monrovia under the specific objectives including; to determine the types of SLCPs related illnesses experienced within urban poor communities, to determine the SLCPs related disease-causing deaths reported within urban poor communities and to establish potential prevention interventions necessary for curtailing SLCPs. The study employed a mixed method strategy involving 132 households randomly sampled from 200 households in New Kru Town. Key informant interviewees from relevant fields were contacted for pertinent information relating to the same. Statistical and thematic analysis guided the analysis of both quantitative and qualitative data. The research findings depicted that SLCPs indeed affect the health of the urban poor communities. The study found out that respiratory infections were the most common forms of illnesses experienced among the poor urban households due to Black carbon emanating from prolonged use of charcoal, diesel and Jako lantern. Chest pain & shortness of breath were the major symptoms mentioned by the respondents at (51.8%) followed by wheezing at (31.8%) & coughing (16.5%). These respiratory infection symptoms could be attributed to exposure to both indoor and outdoor SLCPs. Stroke was noted to be the leading cause of death. Majority of the deceased (76.4%) were above 50 years old while those between ages 36 – 50 years were only (23.6%). This therefore means that the elderly were more vulnerable to health impacts due to SLCPs. The null hypothesis that; SLCPs does not affect the health outcomes of the urban poor communities was tested and rejected using Pearson's Chi-Square (X^2) test at 0.05 significance level (Calculated value 10.53; Tabulated value 7.82). The study concluded that respiratory infections were the most common forms of illnesses while stroke was the leading cause of death among the urban poor communities. Measures to reduce exposure to SLCPs among urban poor households should involve developing and enforcing air quality monitoring program and implementation of sustainable energy for all programmes.

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LIST OF ABBREVIATION AND ACRONYMS

AAP	Ambient Air Pollution
ALRI	Acute Lower Respiratory Infection
BC	Black Carbon
CCAC	Climate and Clean Air Coalition
COMEAP	Committee on Medical Exposure to Air Particles
COPD	Chronic Obstructive Pulmonary Disease
EEA	European Environmental Agency
EPA	Environmental Protection Agency
HAP	Household Air Pollution
HBP	High Blood Pressure
IHD	Ischemic Heart Disease
LEC	Liberia Electricity Corporation
LISGIS	Liberia Institute for Statistics and Geo Information Services
LPG	Liquefied Petroleum Gas
LPRC	Liberia Petroleum Refinery Company
PM	Particulate Matters
SLCP	Short Lived Climate Pollutants
SNAP	Strengthening National Action for Planning
UNEP	United Nations Environment Programme
USD	United States Dollars

CHAPTER ONE
INTRODUCTION

1.0 Background of the Study

Short Lived Climate Pollutants (SLCPs) have been recognized worldwide as having detrimental impacts on human health, climate systems, ecosystems and vegetation, in particular global crop production (von Schneidemesser & Monks, 2013). Impacts on human health are of special interest considering the multiplicative economic effects it has on the Gross Domestic Product (GDP) resulting from reduced productivity and medical expenses (Pierrehumbert, 2014). In this context therefore, SLCPs refers powerful climate forces that have relatively short atmospheric lifetimes, a day – decade, yet their potential to warm the atmosphere and to cause health impacts are much more greater than other GHGs. Examples of SLCPs include; Black Carbon (BC), a substantial part of particulate matter ($PM_{2.5}$), methane (CH_4), tropospheric ozone (O_3) and a number of fluorinated carbons / Hydrofluorocarbons (HFCs).

In the recent past, SLCPs have taken a toll on the health of the urban poor communities in developing countries whose vulnerability has been linked to their day to day activities involving exposure to black carbon (BC/PM) and tropospheric ozone (O_3) (Kim *et al.,* 2015). A big portion of research, mainly epidemiological (population-based) researches, have associated exposure to $PM_{2.5}$ to a different conflicting health problems, including early fatality, clinical admissions for the damaging of heart and airborne illnesses, and urgent clinical attendance for asthma (Ibid). Fine particles (PM) and tropospheric ozone (O_3) have been linked to serious health impacts, for instance the sooty component of $PM_{2.5}$; Black Carbon are responsible for causing asthma attacks, bronchitis, chronic heart and airborne illnesses (respiratory infections, heart disease and pulmonary diseases), sinus infections and a reduction of general life expectancy (Sabatini, 2018). These substances are known to enter the body through the respiratory system and the human skin (Huang *et al.,* 2014). Besides, the black carbon particle cores in diesel particulate matter are incrusted with a series of other chemical participles, having over 40 dangerous organic compounds that are known to cause cancer (Secretariat, 2017). According to a report by WHO, (2016a) estimates that 7 million premature deaths in the urban poor communities in the world were linked to air pollution in 2012. It has been reported that 1 in 10 deaths is caused by air pollution (World Bank, 2016). For 2013 alone, there were over three thousand deaths from SLCPs related diseases in Liberia alone (WHO, 2016b).

While the health impacts of SLCP is widely acknowledged through the works of the Climate and Clean Air Coalition (CCAC), the process of implementing rigorous national, regional and continental air quality programs in developing countries has not been adequately addressed (Von Schneidemesser *et al.,* 2015). Consequently, the urban poor communities have continuously remained exposed to their emission. Addressing SLCPs tends to have a multiple benefits. Its holistic reduction will have beneficial effect on health, and climate, water and food security as well as ecosystems, which are also indirectly related to health impacts (Pope *et al.,* 2015). Similarly, the issues of health impacts of air pollution have been directly and indirectly addressed in the Sustainable Development Goals (SDGs). These global goals aimed at transforming the World community by 2030 set out 17 primary goals with 169 targets that cover broader range of socio-economic development issues that include the poverty alleviation, improving human health, water, sanitation, climate change and environmental sustainability. Efforts to achieve these goals are crucial especially in many urban communities that spend a third of their income on treating health effects such as malaria, typhoid and respiratory illnesses resulting from polluted environment. Meanwhile, providing affordable and clean energy as well as investing in clean energy infrastructure will assist in the fight against urban ambient air pollution as most urban poor communities depend on biomass and diesel for lighting and heating thus increasing air pollution consequently affecting their health. In a nutshell, when SDGs targets are achieved it will help restore the warming planet from climate change impacts through regulation of emission from various sources and promotion of the use of clean energy thus contributing to good health.

Liberia is among some of the countries in the World with a very low life expectancy rates (Mondal & Shitan, 2014). According to the WHO, (2016b) the Life Expectancy at birth male/female is 60/63 hence putting the country at position 151 out of the 200 countries surveyed. Also according to the (Ibid) Death Burden Analysis, pollution from air quality is among some of the major causes of death in the country for which short lived climate pollutants plays a pivotal role. Short Lived Climate Pollutants (SLCP) is responsible for the millions of fatalities worldwide today (Schmale *et al.,* 2014; WHO, 2016b). Developing countries have got their fair share. Monrovia, the capital city of Liberia was originally constructed for an estimated 500,000 inhabitants who were mainly ex-slaves from America and a remnant of local tribes including the Kru, Bassa and Grebo people (O'Connor, 2013). The increase in population of the city has

quadrupled the number of vehicles for private and public uses. Today, the city pays hosts to over 1 million people who work in diversity of areas and commute between the busy central district of Broad Street and the many city suburbs.

With the increase in commercial and private vehicles and the lack of stable electricity for urban use which has led to people using biomass for heating and cooking has brought with it the new phenomenon of Short Lived Climate Pollutants (SLCPs) identified by the Climate and Clean Air Coalition as the new killer weapon (Chandrappa & Kulshrestha, 2015). In other words, SLCPs are fine Particulate Matters (PM) that emanate from incombustible diesel fuel, from methane gas as a result of waste disposal, from biomass fuels and also from some Hydrofluorocarbons (HFCs) that are not captured under the Montreal Protocol (Kemp *et al.*, 2013). According to Kim *et al.*, (2015) these PM2.5 and PM10 have adverse impacts on our climate, on food security and on human health. SLCPs are responsible for the degradation and destruction of most ambient air quality in most urban areas in Liberia, due to emission from diesel moving equipment, biomass for cooking and heating, and other sources, contributing to the death of thousands of urban dwellers (Salomon *et al.,* 2013). The World Health Organization, (2016b) has estimated that around three thousand Liberians die annually from diseases related to air pollution. A larger part of this number is in the major city Monrovia, which can boast of most of the major slums in the country.

1.1 Statement of the Research Problem

Air quality degradation has surfaced to be predominantly one of the key leading health risks in the world (Finn & O'Fallon, 2017). Vulnerability to dirty air is considered as the fourth leading fatal health risk worldwide according to research. More than 5.5 million people around the world die prematurely every year from illnesses caused by inhaling dirty air (WHO, 2016b). SLCP has been widely linked to air quality degradation especially within congested urban slum communities (Herfindahl & Kneese, 2015). Most inhabitants of these slum communities rely on biomass for cooking and heating which expose them to indoor air pollutants. Additionally, their mode of transport has further exposed them to vehicular emissions with high contents of $PM_{2.5.}$ Besides, poor management of solid waste in these areas has contributed to emissions of methane that acts a precursor to tropospheric ozone which collectively result in ill health and respiratory and cardiovascular diseases such as heart disease, respiratory illnesses, acute stroke, lung cancer, and obstructive and chronic pulmonary sicknesses such as bronchitis and emphysema. Studies

have suggested that the most vulnerable groups to such SLCPs are the women, children and the elderly (Yari *et al.*, 2016; WHO, 2016a; WHO, 2016b; Monks *et al.*, 2015; Blaikie & Muldavin, 2015; Yamineva & Romppanen, 2017). Despite the widely acknowledged health impacts of SLCPs there has only been a remarkable concern on the negative impacts of SLCPs on climate systems, agriculture and ecosystem with most available scholarly literature focusing on the global crop production in relation to water and food security within the Americas, Asia and the Caribbean. This has been achieved through the efforts of Climate and Clean Air Coalition (CCAC) since its formation in 2012. To date, there has been little scientific research intervention to ascertain the linkage between air quality degradation and the number of associated slum community diseases especially in Africa where majority of cities have slum settings with huge populations. This therefore serves as a key motivation to conduct the study and also setting the pace for future holistic assessment of health impacts of SLCPs in Liberia. Meanwhile, there have been several methods of assessments in scholarly literature of the health impacts as a result of climate related illnesses. Some of these methods have involved a qualitative quick impact analyses which have not given a true description of the happenings on the ground. Reliance on these for decision making in the past have led to failed policies; but the use of cross-sectional data gathering which incorporates those directly involved as well as other players involved reduce the biases in the final analysis of the research findings.

1.2 Research Questions

1. What are the types of SLCPs related illnesses experienced within urban poor communities due to SLCPs?
2. What are the SLCPs related disease-causing deaths reported within urban poor communities?
3. What are some of the potential prevention interventions necessary for curtailing SLCPs?

1.3 Research Objectives

1.3.1 General objective

The general objective of the study was to determine the perceptions of the of Urban Poor Communities in New Kru Town, Monrovia on the health effects associated with Short Lived Climate Pollutants (SLCPs).

1.3.2 Specific objectives

The specific objectives were;

1. To determine the types of SLCPs related illnesses experienced within urban poor communities.
2. To determine the SLCPs related disease-causing deaths reported within urban poor communities.
3. To establish potential prevention interventions necessary for curtailing SLCPs.

1.4 Research Hypotheses

Null Hypothesis (H_0): SLCPs do not affect the health outcomes of the urban poor communities.

Alternative Hypothesis (H_1): SLCPs do affect the health outcomes of the urban poor communities.

1.5 Justification of the Research

The efforts of the CCAC to combat SLCP have been endorsed by nearly every country around the world including Liberia. An office has been established to coordinate SLCP issues at the national level. The country participated in the CCAC Strengthening National Action for Planning Project to increase the level of awareness in country for SLCP mitigation. Air degradation from SLCP sources is a major global challenge especially for developing countries. Liberia continues to import vehicles that have aged. More than half of the vehicles imported in country are used vehicles. With the global efforts to reduce sulphur concentration in fuel to as low as 32 part per million in fuel and gasoline, sulphur concentration in fuel in Liberia is still well over 550 ppm, combined with the age of vehicles leads to high level pollution. Already, more than half of the country depends on charcoal and fuelwood for heating and cooking that have led to indoor air pollution. It is also evident that fire is set to most of the open wastes dumpsites around the country. As population increases in the capital, air contamination is expected to increase thereby worsening already crippled health care system that was unearthed by the 2014 outbreak of EBOLA in the country. The efforts by Liberia and the CCAC to reduce SLCPs in the country did not go far beyond policy makers. The Strengthening National Action Planning (SNAP) process to strengthen its national institutions to tackle SLCPs in the country for two consecutive years, the lead institution, the Environmental Protection Agency of Liberia was only able to conduct a rigorous awareness campaign on the danger pose by SLCP. The SNAP

project was aimed at devising policies which engendered the Air Quality regulation. The SNAP Project also assisted in the development of a National Communication Strategy document and as well as a resources mobilization strategy to advance the fight against SLCP in Liberia. Real work of determining the health risk pose by SLCP in urban poor cluster communities has not been undertaken and this research aims at unearthing the serious vulnerability of those communities to the impacts of SLCP: therefore the key expected values of this research are to create a platform for a more robust national assessment of SLCPs and increase awareness among Liberians on the health impact of SLCPs to take a national action to reduce its impacts; and devise and recommend policy option to curb SLCPs by integrating SLCP-health issues into national development planning and programs. This study is further justified from a theoretical perspective by the fact that there has been generic assessment of the impacts of SLCPs on global climate systems and agricultural systems. However, there has not been direct investigation of the potential health effects of SLCPs such as tropospheric ozone and black carbon.

1.6 Scope and Limits of the Study

While it is true that SLCPs affect other systems in our universe, this study was only limited to air quality degradation and how it impacts on urban poor communities' health with a particular focus on New Kru Town in Monrovia. It further examined the state of organic solid waste management, energy sources and their contributions to SLCPs emissions and eventual diseases and deaths. However, the study did not involve performing medical examination on the respondents.

1.7 Operational Definition of Terms and Concept

a) **SLCP**s- are black carbon, methane and tropospheric ozone which are powerful climate forcers with a lifespan of a day to a decade but have harmful effect on human health, climate and agriculture sectors, (Norwegian Environment Agency). According to the California EPA's Air Resources Board, SLCPs are black carbon (soot), methane (CH4), and fluorinated gases (F-gases, including Hydrofluorocarbons, or HFCs). Accordingly, they are climate forcers that are powerful and harmful air degrading that have an adversely dangerous effects on climate change in the near term, as compared to other longer-lived GHGs like carbon dioxide (CO2).

b) **Hydrofluorocarbons:** also known as HFC, are fluorinated gases (F-gases), made up of ozone-depleting substances (ODS) that are being phased out under the Montreal Protocol.

It is one of SLCPs, which speeds up the impact of ground level ozone (California Environmental Protection Agency's Air Resources Board).

c) **Particulate Matters-** are total suspended fine particles in the air that seriously impact human health. They include inorganic and organic particles such as dust, pollen, soot, smoke and liquid droplets that degrade air.

d) **Urban Poor Communities**- are communities that lack basic improved social status such as little consideration for formal employment activities, little or no real standardized housing condition necessity. It also includes little or no social protection and limited health services and education facilities.

e) **Health**- is the state of complete social well-being both physically and mentally, and not merely the absence of illnesses or inflictions. It is a person total well-being, with and without the presence of diseases (WHO, 2016a).

f) **Black Carbon:** black carbon (BC) is a main part of soot which is normally not gas but exists in the atmosphere as particles or so called particulate matter (PM). It is a climate forcer harming human health.

1.8 Outline of Chapters

The chapters in this research work follow a standard format with five main sections regarded as chapters. Chapter one describes the background of the study. Furthermore, the chapter includes information about the Statement of the research problem, research questions, research objectives, justification of the study, research hypothesis, scope and limitations as well as operational definition of key terms and concepts. Chapter two presents the review of related literature to the study. The chapter reviews main literature sources on the health impacts of SLCPs specifically the urban poor communities. Special emphasis is placed on the practical evidence of deaths among urban poor due to pollution, human health impacts of SLCPs and the basic strategies/policies that has been put in place to curtail the rapid urban pollution. The chapter also explains the conceptual framework for the research study. Chapter three presents the detailed description of study area including major economic activities, nature of human settlement and waste management strategies. In addition, it provided the research design and methodological techniques that were applied in the study. It explains the data sources and data collection methods and instruments as well the data collection procedure. It further gives a detailed sampling procedures and data analysis methods. Chapter four of the research presents

the findings and discussion in relation to the conceptual frameworks and the reviewed literature. Chapter six presents summary of research findings, the conclusions drawn from the research findings and recommendations for the study including areas for further research.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This section reviews the literature on health impacts caused by SLCPs. It pays particular attention to the types of illnesses & diseases experienced within urban poor communities due to SLCPs, the number of reported deaths within urban poor communities due to SLCPs and the Potential prevention interventions necessary for curtailing SLCPs. A detailed description of both theoretical and conceptual issues of the study is also presented. Finally, a summary of the existing knowledge and knowledge gaps emerging from the reviewed literature is made as further justification for this work.

2.1 The types of SLCPs related illnesses experienced within urban poor communities.

The major types of illnesses among the urban poor communities resulting from urban air pollution worldwide have been well documented in literature (WHO, 2016a; Chi *et al.,* 2016). The health of urban populations has been significantly affected by air pollution. Strong fairy tale information suggests that air pollution has consequentially greater effects on populations in urban areas with lower income. In São Paolo, Brazil, a research finds out that there is an alarming hospitalization due to pneumonia and respiratory illness as a result of increasing air quality contamination, which is higher in cities (Nhung *et al.,* 2017). Similarly, Chi *et al.,* (2016) while investigating air pollution impacts on the health of urban people worldwide outlined five different kinds of airborne conditions of health resulting from air pollution. These diseases included stroke, Chronic Obstructive Pulmonary Disease (COPD), Ischaemic Heart Disease (IHD), lung cancer and Acute Lower Respiratory Infection (ALRI). Similarly, Jaggernath (2013) and Jiang (2015), while assessing the health impacts of SLCPs including particulates and tropospheric ozone on the most vulnerable and sensitive populations concluded that particulates and tropospheric ozone are the major causes of heart and lung sicknesses, like asthma among adults, older people and children, who are actively outdoors. Similar studies by, Stohl *et al.,* (2015) found out that exposure to tropospheric ozone (O_3), a highly reactive oxidant can harm human health leading to impacts ranging from minor effects such as irritation of the eyes, nose, throat and respiratory evidence, such as shortness of breath and coughing to more serious impacts such as a decrease in lung function and respiratory symptoms and aggravated

asthma. Stohl argued that air quality degradation is independently and consistently related to the most problematic health impacts, including cardiopulmonary and lung cancer and other diseases, the nature of which may vary with the pollutant constituents. Providing further evidence World Health Organization, (2016a) while examining the types of diseases attributed to Ambient Air Pollution (AAP) and Household Air Pollution (HAP) across all the regions of the world in 2012 found out that lower respiratory infection, Ischemic Heart Disease (IHD), COPD and lung cancer were found themselves among the five highest illnesses in the world due to air pollution.

Sancini *et al.,* (2014) in efforts to delve into health risk investigation for Air Pollutants observed cardiac gene expression and lung alterations in mice exposed to winter fine particulate matter in Milano, and while assessing the health impacts of high concentrations of particulates in the air in Italy concluded that exposure to extremely high contaminated air may experience: wheezing, coughing, breathing difficulties, irritation of the eyes, nose, and throat, chest tightness, and worsening of existing lung and heart problems, such as asthma and increased risk of heart attack. Sancini and his colleagues further argued that long-term exposure to degraded air can cause damage to the immune, neurological, reproductive, and respiratory systems and cancer while in extreme cases, can even cause fatality. Similarly, Khillare *et al.,* (2014) conducted an assessment of impacts of Ambient Air Pollution (AIP) involving on-road measurement of emissions from public service vehicles in California pointed out that exposure to Diesel particulates contribute largely to cancer risk as well as the worsening of asthma and other harmful health effects.

Epidemiological studies conducted by Frumkin, (2016) on the health impacts of a range of SLCPs such as Tropospheric Ozone (O_3), Black Carbon (BC) and Methane (CH_4) noted that these SLCPs have had immensed contribution to both acute and chronic heart and respiratory diseases. Tropospheric Ozone was particularly noted to be deadly for the elderly, children and people with lung or heart illnesses; it can worsen emphysema, asthma, bronchitis, and may for ever scar lung tissue. Heart disease, strokes, congestive heart failure, heart attacks and possible reproductive and developmental abnormalities were mainly associated with the exposure to long - and short -term ozone. The study went on to stress that formation of air polluting particulate matter, mainly BC and co-emitted pollutants are strongly associated with both short- and long-term health impacts. $PM_{2.5}$ has been specifically associated with a number of health impacts as well, including early deaths in children, in adults with heart and lung diseases, from heart

attacks, acute lower respiratory infections such as pneumonia, strokes, chronic respiratory disease such as bronchitis, cardio-respiratory, aggravated asthma and other symptoms. However, contrary to other studies the duo found out that BC co-emits with Polycyclic Aromatic Hydrocarbons (PAHs) are destructive and thus have contributed to many forms of cancers within the study population. Methane on the other hand was not directly linked to any disease but it serves as an agent or as a precursor to the construction of tropospheric ozone (O_3), which in turn affects human health. Accentuating similar sentiments is a new epidemiological research done by Balakrishnan, (2014) involving the assessment of the effects indoor air pollution on health due to short and long term exposure among children in the Eastern Cape; South Africa which quantitatively demonstrated that 70% of children were suffering from severe lower respiratory tract disease due to daily exposure to high levels of smoke from cooking and heating. Air quality studies have also demonstrated a strong trend in indoor air pollution among the urban poor households because of the increased reliance on biomass for cooking and lighting. The study by Pinto, (2016) on indoor air quality in India among 72 paraffin burning urban households showed that 42% of the household members had suffered chronic lower respiratory tract diseases.

Finally studies by Beelen *et al.,* (2015) involving the assessment of effects of long-term exposure to particulate air quality degradation on health in the UK pointed out that inhalation of particulate pollution even at minimal quantities can have adverse health impacts. The study revealed that long-term exposure to $PM_{2.5}$ exacerbates heart and lung conditions, mainly impacting the quality of life, and increase hospital admissions and deaths. The study further noted that the elderly, those with pre-existing respiratory and cardiovascular disease and children are known to be more exposed to the health impacts from air pollution.

2.2 The SLCPs related disease-causing deaths reported within urban poor communities

The issue of SLCPs vis-à-vis deaths in urban poor communities has been widely documented in scholarly literature (Wiedinmyer *et al.,* 2014). According to WHO, (2016b), 80% of urban areas have unhealthy amount of air pollution that are critical now in other places to the extent that over 5.5 million people died yearly in urban settings from these pollutions. When conducting an assessment of deaths resulting from urban air pollution across the globe in 2012 WHO, (2016b), quantitatively demonstrated that approximately 1.8 million people succumbed to air pollution related illnesses and diseases (Table 2.1). In another similar study involving 184 developing countries across Asia, WHO revealed that many deaths have been reported in

Beijing, Hong Kong, and the Shanghai areas in China. Similarly, Burnett *et al.,* (2014) reported that unchecked open air burning of domestic waste has been documented in many developing countries, creating fears for air quality and health impacts though not yet accurately been quantified. The study showed that early mortalities of adult were as a result of chronic exposure to ambient $PM_{2.5}$ coming from poorly controlled burning of wastes from domestic sources. In other studies by Burnett *et al.,* (2014) and Cesaroni *et al.,* 2013 on $PM_{2.5}$ health effects which involved aggregating mortalities to the country level, found the countries with the largest total mortalities due to waste combustion to be China, India, Pakistan, Italy and Russia. Burnett and his colleagues quantitatively demonstrated that these four countries amount to 78% of the global mortality while the countries with the highest mortalities per capita are Montenegro, Bulgaria, Moldova, and Ukraine respectively. Accentuating similar sentiments is an integrated assessment of mortalities due to SLCPs in Latin America and the Caribbean (Riojas-Rodríguez *et al.,* 2016). The study revealed that about 5% of trachea, bronchus, and lung cancer mortality; 1% of mortality in children from acute respiratory infection in urban poor communities and about 3% of adult cardiopulmonary disease mortalities are as a result of air pollution from outdoor PM. The study further indicated that around 64, 000 premature deaths were reported due to exposure to Tropospheric Ozone (O_3). Shockingly, this burden mainly occurs in developing countries of the world with about 65% in Asia alone.

Table 2.1: The number of SLCPs related deaths reported by country by year 2012

#	Countries	Death/Year
1	China	1,000,000
2.	India	600,000
3	Russia	140,000
4	UK	16,355
5	France	10,954
6	Germany	26,160
6	USA	38,043
8	Australia	94
	Total	**1, 831, 606**

Source: World Health Organization, (2015).

Further, Covronick *et al.,* (2015), through their study on deaths due to air pollution arising from SLCPs found five major kinds of respiratory health diseases that result to deaths amongst the urban poor. The study quantitatively showed that about 33% of deaths are as a result of stroke, 17% to Chronic Obstructive Pulmonary Disease (COPD), 8% as a result of Acute Lower Respiratory Infection (ALRI) and 6% to lung cancer, and 36% of the deaths to Ischaemic Heart Disease (IHD). Based on this statistics WHO, (2016b) concluded that more than 7 million people in the world died from the combined effects of ambient air (3.7 million) and household (4.3 million) air pollution with more deaths occurring in developing countries across Asia, Latin America and Africa.

Finally, Beelen *et al.*, (2015), while assessing the air quality situation in the UK, concluded that poor air quality is a significant public health issue and responsible for mortality as a result of long-term exposure to particulate air pollution in the UK. The study showed that death burden of equivalent to nearly 29,000 deaths at typical ages due to particulate air pollution in the UK in 2008 and estimates that there was nearly 340,000 population lives lost every years. Beelen therefore estimated that removing all fine particulate air pollution would have a significant impact on life expectancy in England and Wales.

2.3 Potential prevention interventions necessary for curtailing SLCPs.

The potential prevention interventions necessary for curtailing SLCPs such as cleaner burning fuels, clean cook stoves, behavioural change have been broadly and variously discussed in scholarly literature (WHO, 2016a) . A study by Aman *et al.,* (2014) on the Clean Air Package for Europe focused on the reduction of Particulate Matters (PM) in diesel fuel with the aim of improving air quality and reducing lives lost as a result of air quality degradation in all member states. The study showed that, reducing Particulate Matters (PM) in fuel has the potential to improve the life expectancy of the Europeans besides contributing to economic gains. A similar comparative study by Akintan, (2014) on the role of prevention intervention; cleaner burning fuel in reducing indoor air pollution in Nigeria showed that, urban electrified households recorded 75% lower PM2.5 concentrations than similar un-electrified urban households. Other studies on outdoor air quality deterioration due to Black Carbon (BC) especially from vehicular emissions in rural India, by Patange *et al.,* (2015) concluded that the largest reduction of these pollutants can be achieved by considering four parameters: fuel type, vehicle technology, vehicle

age and conditions of use (traffic). Importantly, the study showed that vehicles with state-of-the-art emission control technologies will necessarily result in lower emissions. Providing further evidence on the use of cleaner burning fuels towards reduced emissions of SLCPs is a study by Hill, (2013) highlighted important factors deemed necessary for curtailing China emissions of Black carbon, a component of $PM_{2.5.}$ The factors included effective vehicles and use of smokeless fuels in industrial and domestic combustions, sustainable vehicles management, and increase in cleaner vehicles. The study stressed the need of promoting sustainable transport to residents and businesses and energy efficiency as well as putting in the necessary infrastructure to enable people to reduce the environmental footprint.

Studies on behavioural change as a potential preventive intervention for curtailing SLCPs have shown some commendable results. A study by Lucas *et al.,* (2016) in Australia on sustainable urban communities focused on sustainable transport where they demonstrated that more sustainable transport methods of public transport along with walking and cycling serve to reduce emission levels by high percentages. The study further showed that introducing a more sustainable transport system will maximize the efficiency of the highway network and also give real time information on traffic delays and journey times, car parking availability, and bus arrival times; not only allow people to make travel choices that are better informed and also serve to reduce vehicular pollution. The study concluded that active walking and cycling as a means of travel, has the potential to cut emissions of black carbon. Providing further evidence is an in depth analysis of existing environmental and economic benefits of proper solid waste management for under developed poor countries (Aparcana, 2017). The study noted that an integrated waste management system involving the expansion of community-based recycling and waste management with a particular focus on compositing of organic waste into manure can halve the amount of methane released into the atmosphere, which acts as a precursor to tropospheric ozone.

Finally, there are a lot of studies in developing countries across Africa and Asia on clean cook stove that have been proven its potential to minimize Household Air Pollution (HAP) by cutting black carbon emission usually arising from the use of biomass and paraffin for cooking, heating and lighting. According Winkler *et al.,* (2013) and Clark (2013) clean cook stove has the potential to reduce substantial amounts of emissions from the use of biomass thus minimizing Household Air Pollution (HAP). Winkler, Clark and their colleagues argued that reduced HAP

will in turn reduce the risks of contracting a range of diseases that has for a long time been linked to SLCPs e.g. cancers, lung, heart disease, cataracts; asthma, adverse pregnancy outcomes, depression, Chronic Obstructive Pulmonary Disease (COPD), bacterial meningitis and widespread of minor ailments from smoke inhalation such as eye irritation and headaches.

2.4 Theoretical Framework: The Social Cognitive Theory

The concept of this theory started through the works of Harold Chapman Brown and Edwin B. Holt in their writings in 1931 that theorizes that actions of all animal are associated with completing a psychological arena of "feeling, emotion, and desire". The apex of interest in their writings was the prediction that people may not learn to copy from others until they are copied. By that, it means that whatever may seem good if it is demonstrated by others. In 1941, John Dollard and Neal E. Miller published a writings that revised Holt's social imitation and learning theory, where they argued that there are some key factors that lead to learning such as responses, ideas, drives, and results. They listed drivers as social motivation and behaviour. They argued that if someone was to imitate a particular behaviour, that behaviour will be learned through observation that will have positive or negative effects. These postulates were further expanded upon by Albert Bandura between 1961 and 1963. In 1977 Bandura published his article and book after a seminal that expanded on the idea of attainment of behaviour, and therefore built on Dollard and Miller's writings. He realized that Social Learning has a complete relationship with a person's anticipated behavioural change and self-efficacy. Meanwhile, Bandura, in 2001, came out with Social Cognitive Theory (SCT) that tells how new behaviour diffuses by society through psychosocial attributes guides the achievement and behavioural approbation. However, Bandura published chapter of his book in 2011 under Social and Policy Impact of Social Cognitive Theory that tend to expand SCT's to health promotion and some major and compelling global phenomena, to provide an understanding into tackling global problems through a macro social lens, with the aim at improving equality of peoples' lives by way of the SCT. He also focuses on the impact of population and health in the face of climate change. He proposed that these issues can be changed showing models similar to viewers performing the desired behaviour.

Social cognitive theory approach will look at the behaviour of various stakeholders, to qualitatively assess policies, strategies, awareness, coordination, and tools, and also look at the role of these drivers in achieving the aims. There appears to be a vivid relationship between this

theoretical approach and the desire to achieve the needed results for mitigating the impacts of SLCPs in the New Kru Town area. Therefore, the SCT becomes the unique tool to back up our conceptual framework which suggests that, instead of being just shaped by inner forces or environments, people are self-regulating and proactive, self-developing, self-reflecting and critical ability. Human being feature is to adopt skills and knowledge from information communicated through a wide array of mediums. By imitating others' actions and its rewarding results, people are able to achieve an understanding of their own activities. The intervening variable in the conceptual framework was therefore formulated entirely based on this theory.

2.5 Conceptual Framework

The conceptual issue in this study is the health impacts of SLCPs on the urban poor communities. SLCPs whether indoor or outdoor, usually have their sources from vehicular emissions, (black carbon/PM2.5), organic wastes decomposition and open air burning of organic waste. SLCPs are the independent variable, Air Quality degradation is the dependent variable whereas the Air Quality Monitoring Programme serves as the intervening variable. These variables were measured using nominal and ordinal scales of measurement. Specific questions on the use of charcoal, the condition of the house ventilation, modes of transport used by the target population, house lighting and waste management practices were designed and administered to the households. Figure 2.1 shows the conceptual application of the study.

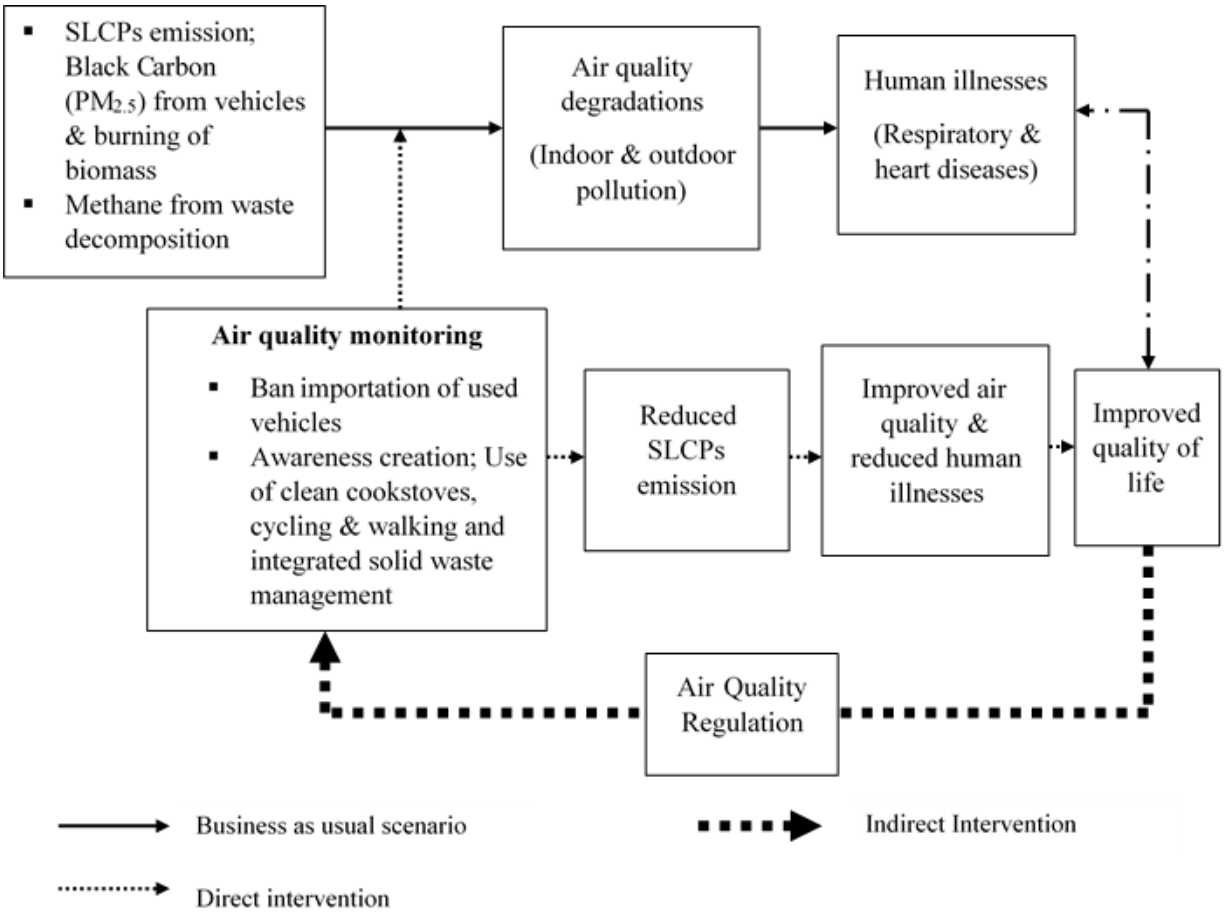

Figure 2.1: Conceptual Framework
Source: Researcher, (2018).

The figure explains the link between SLCPs and Air quality degradation as a cause of human illnesses. The situation can however be contained through the introduction of Air Quality Monitoring Programmes including; vehicles inspection, clean cook-stoves initiatives, clean fuel programmes and integrated waste management system in order to minimize or reduce SLCPs emission which will in turn contribute to improved air quality subsequently resulting in improved quality of life which does influence the human illnesses. In a nutshell, reducing emission of SLCPs must be the goal of Air Quality Monitoring Programmes. However, when the proposed Air Quality Monitoring Programme cannot deliver the desired results, a contingency measure involving the implementation of air quality regulation which is currently in a draft form will be integrated into the intervening variable to ensure reduced emissions.

2.6 Research gap

Currently qualitative research investigating perception has been used widely in several academic disciplines including the field of health, social geography, earth and environmental studies. There is a remarkable concern to investigate the negative impacts of SLCPs on climate systems, agriculture and ecosystem with most available scholarly literature focusing on the global crop production in relation to water and food security. To date, there has been generic assessment of the impacts of SLCPs on our climate system, impacts on crop production and health globally but there has not been direct investigation of the potential health effects of tropospheric ozone and black carbon. Additionally, there has not been any formal investigation on the impacts on SLCPs on human health in Liberia. To date, there has been awareness creation among policy-makers through the CCAC National Planning for Action on the impacts of SLCPs in Liberia and as such there was need to do an investigative analysis of its health impacts on the country. The need to fill this gap was therefore the motivation for undertaking this study.

CHAPTER THREE
STUDY AREA AND METHODOLOGY

3.0 Introduction

This section presents detailed information concerning the study site. It provides information on the study site population, the geographic location, and the topographic and climatic factors that tend to influence air quality and wind direction; additionally, the section highlights the status of the housing infrastructure and economic activities deemed to be the major contributors to the emission SLCPs. It further discusses the research design and the methodology to be used in the study; the target population and sampling design for the study is also provided. It further clarifies the data sources, research instruments as well as the data collection process. Moreover, the section presents the means by which data was analysed and the format for data presentation. Lastly the ethical issues underpinning the study are discussed.

3.1 Study Area

3.1.1 Geographical location, Size and Population

This study research was conducted in New Kru Town; one of the slum communities in Monrovia City. New Kru Town is located on the north end of the Bushrod Island located 5 miles from the city centre. It is bordered by Atlantic Ocean to the west & north, United Nations Drive to the east and the Free Port of Monrovia to the South. Geographically New Kru Town lies between Latitude $6^0\ 22^1\ 24^{11}$ and Longitude $10^0\ 47^1\ 34^{11}$. The community is a home to approximately 5239 people (LISGIS, 2008), where majority are children. New Kru Town is unique to Monrovia as the oldest community whose township status was granted by the National Legislature more than one hundred years ago. Dominated by mainly Kru tribe, the community grew up from old Kru Town that extended beyond the Port of Monrovia, covering West Point to Mamba Point. As development progressed, the community was partitioned to smaller independent communities, leaving the borough of New Kru Town. The area is quite accessible and the cost of access can be underwritten by the researcher without outside intervention. Figure 3.1a and b shows the study area map.

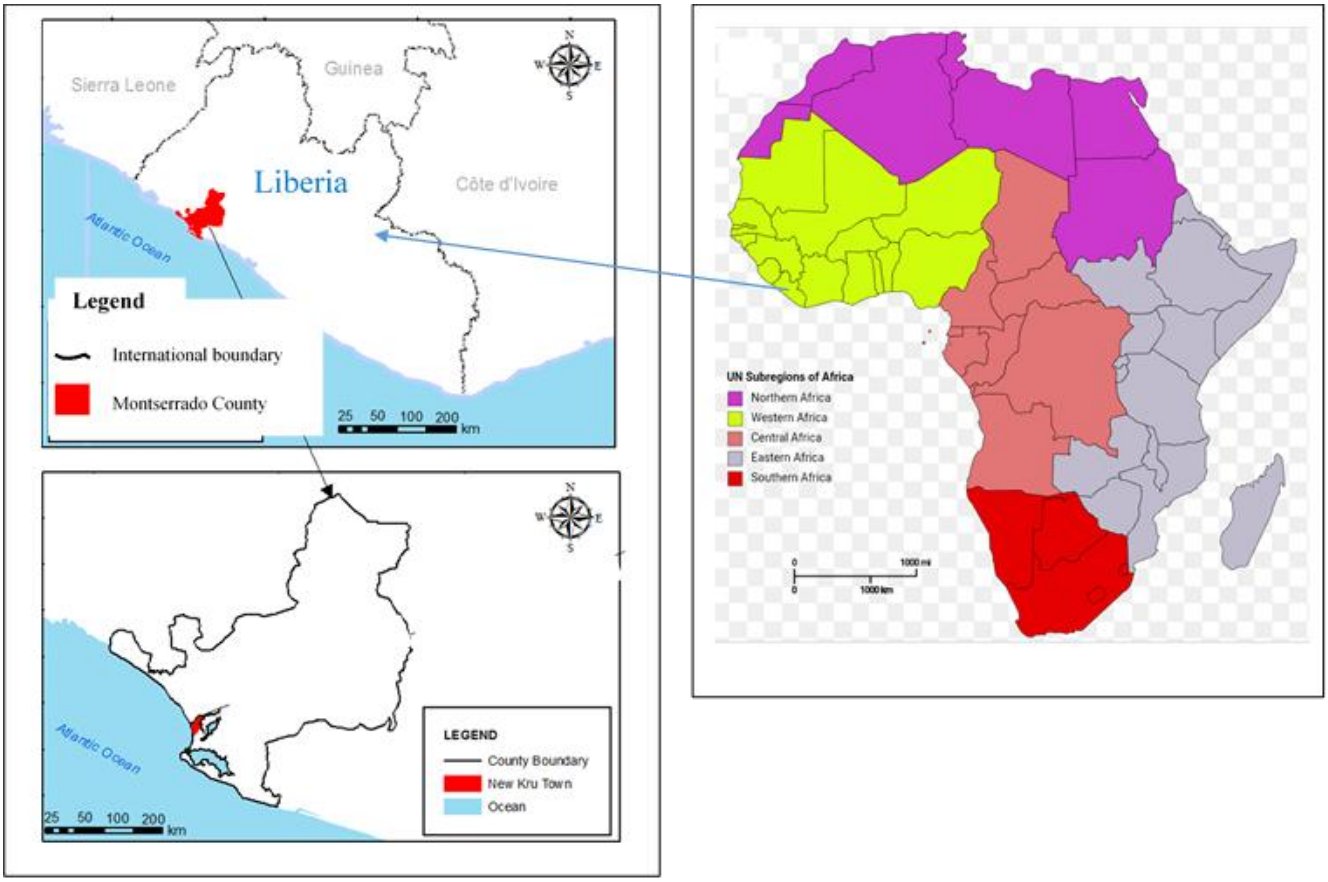

Figure 3.1 a: Study Area Map

Source: Liberia Institute of Statistics and Geo-Information Services (LISGIS)

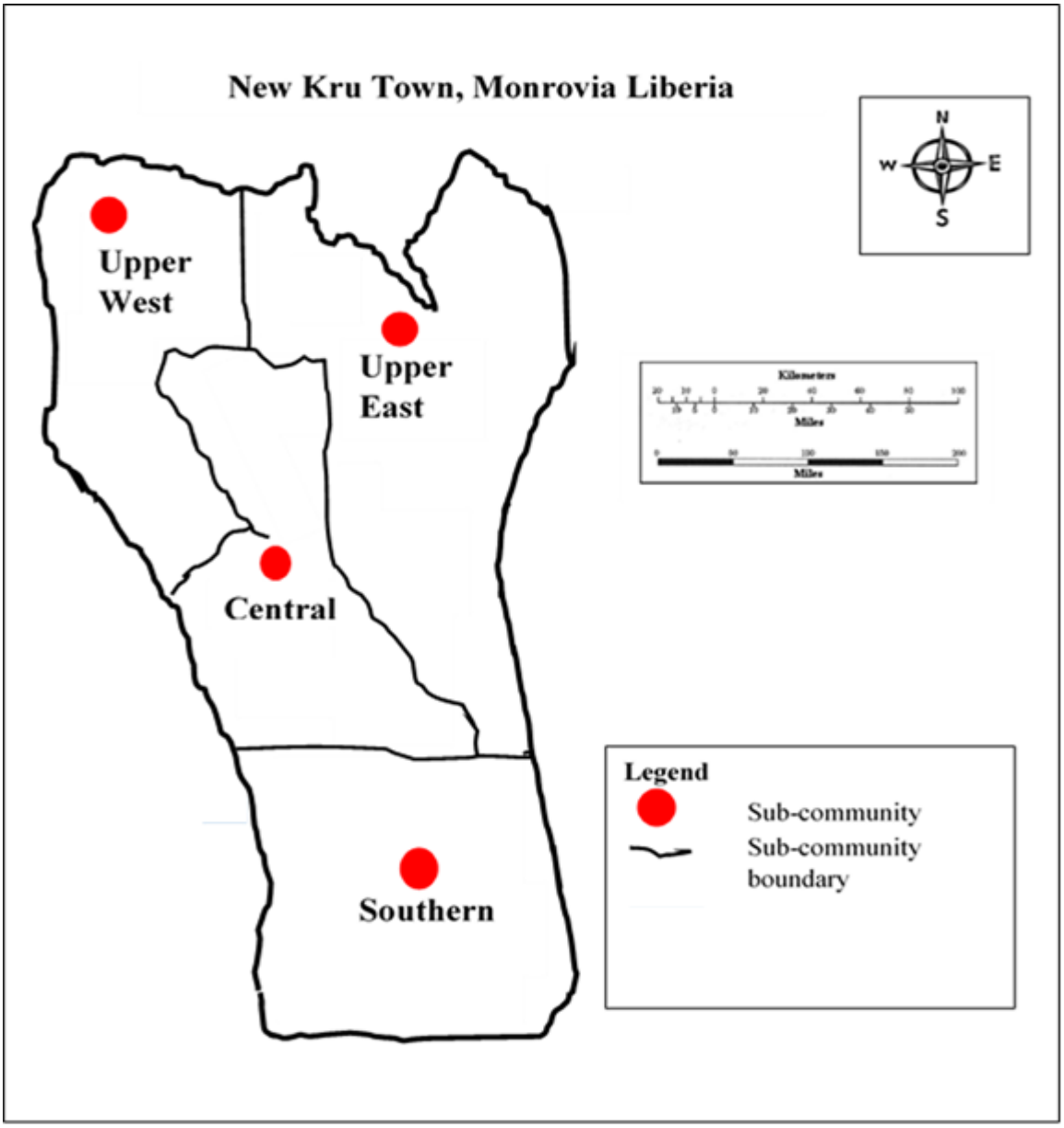

Figure 3.1b: The study area showing the four sub-communities
Source: Liberia Institute of Statistics and Geo-Information Services (LISGIS)

3.1.2 Climate

Predominantly, the climate of the study area is warm and humid year round with an average mean temperature of 25.7^0 C. Temperature tends to increase during early hours of the night due to heat waves from the nearby Atlantic Ocean and drops dramatically as the night falls. The community experiences a mean annual rainfall of 4540mm, with short rains in January and long rains in June. Figure 3.2 below shows the Climograph of Monrovia.

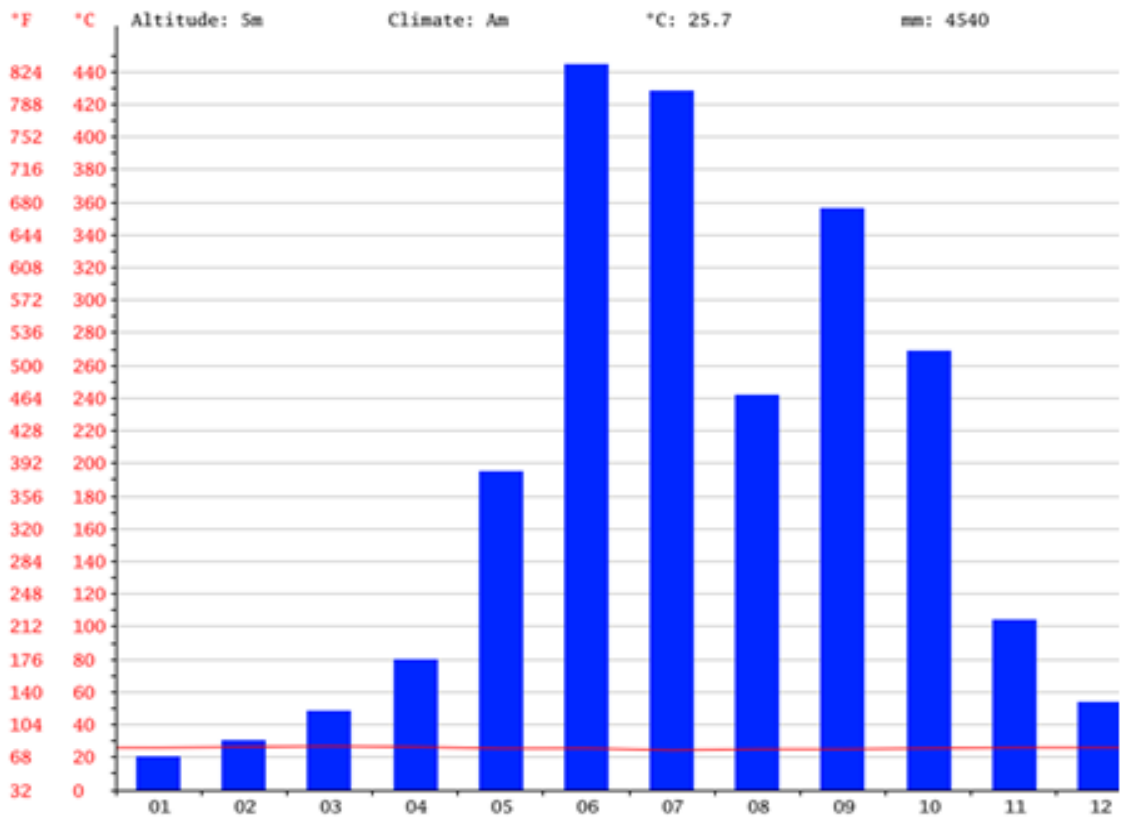

Figure 3.2: Climograph for Monrovia city

Source: https://en.climate-data.org/location/506/

3.1.3 Topography

New Kru Town is a low lying suburb with more winds blowing from the Central Business District of Monrovia as well as the nearby Ocean. In as much as most of the air pollution taking place in the community is generated through improper organic waste management, burning of biomass, vehicular emissions and emissions from Liberia Electricity Corporation (LEC) diesel generators, the topography makes it an essential destiny of pollutants generated from manufacturing and transport industries operating in the CBD.

3.1.4 Economic Activities

New Kru Town has a range of economic activities including commercial trade (sale of fruits & vegetables), transport businesses and fishing. Of importance is the sale of vegetables and fruits in Duala Market, on the roadside and other satellite markets which has led to generation of piles of organic wastes. Most of these wastes are usually left to decompose or burnt hence emitting CH_4 and Black carbon into the atmosphere respectively. The transport industry too has served as a major source of income for the New Kru Town residents, however, the amounts of black carbon and other forms of SLCPs generated from this sector continue to expose the residents to the risks of contracting various respiratory and cardiovascular diseases. The transport industry is mostly dominated by taxis, buses, motor bikes and Keke's which uses diesel and gasoline; a sulphur loaded fuels.

3.1.5 Housing

The housing condition in the community is very poor. More than half of community residents live in old fashion iron/aluminium sheet houses. As such, most of the houses are not electrified hence leaving the residents with no choice but to use candles, Chinese light, Jako lamp, kerosene lamps and tiger generator powered bulbs for lighting. Additionally, almost every New Kru Town residents use charcoal and fuelwood for cooking and heating. This has made them susceptible to exposure to Black Carbon and other particulate matters generated by the dirty energy sources.

3.2 Methodology

3.2.1 Research Design

This was a case-study research carried out at New Kru Town Community, Montserrado County in Monrovia. In order to determine the perception of the health impacts of SLCPs among the urban poor communities, the study adopted mixed methodology strategy involving both qualitative and quantitative methods of data collection and analysis. Mixed method approach collects and analyses of data, draws inferences by using both quantitative and qualitative approaches in a same study (Creswell, 2017).

3.2.2 Target population and Sampling Design

The researcher used probability sampling and non-probability/ purposive sampling techniques to select the research sample. Therefore the study was based on a random sample of 132

drawn from a total of 200 households in the New Kru Town Community hence the units of analysis was households. The following steps helped guide the data collection process:

Step 1: Sample size was determined Krejcie & Morgan formula for finite population as shown below (Krejcie & Morgan, 1970).

$$S = \frac{X^2NP\,(1-P)}{d^2(N-1)+x^2P(1-P)}$$

"Where;"

"S = Required Sample size"

"X = Z value (e.g. 1.96 for 95% confidence level)"

"N = Population Size"

"P = Population proportion (expressed as decimal) (assumed to be 0.5 (50%)"

"d = Degree of accuracy/ margin error of 5%, expressed as a proportion (.05)";

The substitution gives 132 households as shown below;

$$S = \frac{1.96^2 200 \times 0.5(1-0.5)}{0.05^2(200-1) + 1.96^2 0.5\,(1-0.5)}$$

$$= 132$$

Step 2: Proportionate stratified random sampling technique was used to proportionately assign samples to the four sub communities as shown in the Table 3.1 using a sampling fraction of 1.52 (N/n i.e. 200/132).

Table 3.1: Sample Size per Sub-Community

Sub-Communities	Target Population		# of Households selected into the sample	
	N	%	n	%
Central New Kru	30	15	20	15.2%
Upper West New Kru	55	35	36	27.3%
Upper East New Kru	70	27.5	46	34.8%
Southern New Kru	45	22.5	30	22.7%
TOTAL	**200**	**100**	**132**	**100%**

Source: Researcher, (2018).

Step 3: Simple random sampling technique was used to select the actual number of household to include in the study. Table of random numbers was used to randomly select households to be included in the study. As such, each actual household was assigned a three consecutive number in the table of random number at which random numbers were generated. All random three numbers greater than the sample size were rejected. Those less than the sample size were selected and questionnaire administered to them.

3.2.3 Data Sources

Both primary and secondary data were employed in the study. The primary data were obtained from the respondents (New Kru Town residents) through field measurements entailing interviewer administered questionnaires, observation checklist and key informant interviews. The secondary data were obtained from published and unpublished documents such as hospital records for the period 2008-2018, Liberia draft air quality regulation, the Environmental Protection and Management Law, National Transport Roadmap, draft Waste management Regulation and National Environmental Policy.

3.2.4 Research Instruments

The data was collected using instruments namely; interviewer administered questionnaires, observation checklist and key informant interviews. The questionnaires were used to assess the types of SLCPs, their sources and health impacts they have had on the selected households. As such, questions were divided into a few categories such as respondent's demographics, energy

sources, solid waste management, energy used and health issues thus the questionnaire were designed to identify variables that could be coded for final analysis. The questionnaires were packaged with a good letter of introduction (Appendix I). Moreover, the questionnaires included clear instructions and an attractive layout to improve the response rate. The interviewer-administered questionnaires allowed the researcher to avoid incompleteness of questionnaires, increased response rate, and facilitated obtaining first-hand information on SLCPs and associated health impacts. Completed questionnaires were promptly collected by the researcher/research assistant for data entry and analysis (Appendix II).

For the indepth interviews, the key informants who were purposively selected because of their knowledge and experience of health issues and relevant regulations included: Medical Officer -John F. Kennedy Hospital, manager of compliance and enforcement department of the Environmental Protection Agency of Liberia (EPA), the laboratory supervisor of the Liberia Petroleum Refinery Company, the Director of the division of Motor Vehicle, Ministry of Transport and the director of municipal city wastes, Monrovia City Corporation. They were interviewed on illnesses treated for and causes of deaths in the community, sulphur contents of the petroleum products imported, age of vehicles, waste management and envisioned potential interventions necessary for curtailing SLCPs. The researcher scheduled an interview with the key Informants and administered it on agreed day. The interviews were audio-recorded. This was done with the consent of participants (Appendix I). To conduct the interviews the researcher used interview guides and schedules throughout the process (Appendix III). Finally, while administering questionnaires the researcher systematically observed waste management practices, emission from vehicles and other petroleum powered generators within the sub communities with the help of an observation checklist (Appendix IV). The findings were recorded in photography and textual formats.

3.2.5 Data Analysis

Both qualitative and quantitative tools were employed to analyse the data obtained from the field. In analyzing qualitative data all voice-recorded interviews were carefully transcribed and divided into preferred categories based on the interview guide (Appendix III). Predominant issues that emerge from the data were then collated and analyzed thematically by identifying recurring issues in the data. Quantitative data on the other hand were analyzed statistically using bivariate methods of analyzing data. The data were coded into acceptable format and entered into

the Statistical Package for Social Sciences (SPSS) Version 21.0 where it was summarized using descriptive statistics such as means, modes, medium, frequencies and percentages and subsequently analyzed statistically using the bivariate methods of analyzing data. In addition, the points scored on the data checklist were averaged for each data category to determine the health status of the respondents.

3.2.6 Hypothesis testing

The hypothesis was tested using Pearson's Chi Square (X^2) Test at 0.05 significance level using the following steps. Since the researcher was testing the independence of the variables from each other, it was appropriate to use Pearson's Chi Square (X^2) Test which is much more suitable for test of independence.

Step 1: Formulation of hypotheses**:** $\mathbf{H_0}$**:** SLCPs do not affect the health outcomes of the urban poor communities and $\mathbf{H_1}$**:** SLCPs do affect the health outcomes of the urban poor communities.

Step 2: Deciding on the rejection level**;** 0.05 significance level.

Step 3: Statistical test: Pearson's Chi Square (X^2)

Step 4: calculation of test statistic

Step 5: determination of critical value

Step 6: Comparison of test statistic and critical value where you either reject or fail to reject

3.2.7 Data Presentation

The presentation of data in the study was in form of graphs, tables, and charts. Additional data will be presented in form of texts (narratives & direct quotations) and photographs.

3.2.8 Ethical Consideration

Various ethical issues were considered and observed before and during the field survey. Introductory letter from the University of Nairobi was acquired and presented to the respondents. Additionally, the researcher presented the letter of introduction to each participant of the study explaining the purpose of the study. Meanwhile, the participants were required to acknowledge and accepted to participate. They were acquainted of their rights to withdraw from the research without fear of consequence. In addition, the participants were informed of the fact that their participation is voluntary and they would not be coerced to participate in the study, neither would there be any monetary compensation. The researcher

also ensured that the confidentiality of data, anonymity, privacy and safety of participants was observed and maintained. Consequently, in writing the interview data collected from the key informants were not attributed to any specific interviewee but were analyzed using identification codes to ensure anonymity. In addition, the raw interview data and recordings were kept securely and destroyed after submission of the final report.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents the detailed discussion of the results obtained from the field. It first gives the overall response from the questionnaire distributed to the household in each sub community in New Kru Town. Each household was analyzed based on the characteristics of that household; that is, the age, education level, marital status, occupation, and number of years the head of the household has stayed in New Kru Town. The findings from the investigation were discussed objectively as per respiratory infections that were common among the population, age group that was mostly affected by SLCPs, the major diseases that caused deaths as well as looked at interventions that are necessary to advert the cause of deaths from SLCPs.

4.1 Response turnout rate

Out of the total of 132 questionnaires that were administered, 124 were returned while 8 were not returned, representing the return at about 93.9%. Table 4.1 shows the questionnaires response rate**.**

Table 4.1: Questionnaire Response Rate

Sub-community	No. of questionnaires administered	No. of questionnaires returned	No. of questionnaires not returned	Rate of Return (100%)
Central New-Kru	20	19	1	95%
Upper West New-Kru	36	35	1	97.2%
Upper East New-Kru	46	42	2	91.3%
Southern New-Kru	30	28	2	93.3%
Total	**132**	**124**	**6**	**93.9%**

Source: Fieldwork data, (2018).

4.2 Characteristics of the households

Table 4.2 outlines the characteristics of the households whom questionnaires were administered to. Almost half of the studied households comprised of female respondents (52.4%) while their male counterparts were (47.6%). This figures could be attributed to the women's high vulnerability to poverty compared to the men. As such, most female tend to live in slum communities with no proper infrastructure. Majority of the respondents were 26 years and above representing 93.5% of the total respondents. This therefore implies that the

households have active labour force to meet its daily needs in a community where survival is basically for the fittest. Surprisingly, majority of the respondents have attained tertiary education (35.5%) meaning they possess various skills and knowledge that warrant employment and better quality of life. However, this has not been the case owing to the increased number of unemployed graduates especially in the developing countries in Africa. This has a direct effect on the marital status as majority have opted to remain single even at the old age representing (46.8%). This can further be attributed to the high cost of living and not being able to support a family. Lastly, the households portrayed a typical economic status in the urban poor communities as majority of the households were obtaining their livelihoods from petty businesses within their respective sub-communities representing (71.8%). These households were appropriate for the study considering that majority of the households have resided in this particular community for more than 5 years (83.1%). This therefore logically means that they have been exposed to SLCPs long enough to show symptoms.

Table 4.2 Characteristics of the respondent

Variables	Category	Gender		Total
		Female	Male	
Sub-community	Central New-Kru	9 (7.3%)	10 (8.1%)	19 (15.3%)
	Upper West New - Kru	22 (17.7%)	13 (10.5%)	35 (28.2%)
	Upper East New - Kru	22 (17.7%)	20 (16.1%)	42 (33.9%)
	Southern New-Kru	12 (9.7%)	16 (12.9%)	28 (22.6%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**
Age	<= 25 years	3 (2.4%)	5 (4.0%)	8 (6.5%)
	26 - 35 years	24 (19.4%)	14 (11.3%)	38 (30.6%)
	36 – 50 years	21 (16.9%)	29 (23.4%)	50 (40.3%)
	>50 years	17 (13.7%)	11 (8.9%)	28 (22.6%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**
Education level	No schooling	10 (8.1%)	2 (1.6%)	12 (9.7%)
	Elementary	13 (10.5%)	6 (4.8%)	19 (15.3%)
	Junior high	6 (4.8%)	12 (9.7%)	18 (14.5%)
	Senior high	17 (13.7%)	14 (11.3%)	31 (25.0%)
	Tertiary	19 (15.3%)	25 (20.2%)	44 (35.5%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**
Marital status	Single	33 (26.6%)	25 (20.2%)	58 (46.8%)
	Married	20 (16.1%)	29 (23.4%)	49 (39.5%)
	Separated	4 (3.2%)	2 (1.6%)	6 (4.8%)
	Divorced	3 (2.4%)	0 (0.0%)	3 (2.4%)
	Widowed	5 (4.0%)	3 (2.4%)	8 (6.5%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**
Occupation	Business	47 (52.8%)	42 (33.9%)	89 (71.8%)
	Motor bike operator	2 (1.6%)	6 (4.8%)	8 (6.5%)
	Driver	0 (0.0%)	6 (4.8%)	6 (4.8%)
	Water vendor	11 (8.9%)	0 (0.0%)	11 (8.9%)
	Employed	5 (4.0%)	5 (4.0%)	10 (8.1%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**
No. of years in New-Kru	<= 5 years	12 (9.7%)	9 (7.3%)	21 (16.9%)
	6 -10 years	20 (16.1%)	28 (22.6%)	48 (38.7%)
	11 – 15 years	15 (12.1%)	10 (8.1%)	25 (20.2%)
	>15 years	18 (14.5%)	12 (9.7%)	30 (24.2%)
	Total	**65 (52.4%)**	**59 (47.6%)**	**124 (100%)**

Source: Fieldwork data, (2018).

4.3 Research findings

4.3.1 The types of SLCPs related illnesses experienced within urban poor communities

4.3.1.1 **Respiratory infections were the most common forms of illnesses.**

SLCPs have been widely linked to respiratory, cardiovascular as well as cardiopulmonary illnesses including Chronic Obstructive Pulmonary Disease (COPD), Ischaemic Heart Disease (IHD), lung cancer, and Acute Lower Respiratory Infection (ALRI) (Chi *et al.*, 2016; Jaggernath, 2013 and Jiang, 2015). In this study respiratory infection was found to be the most common SLCPs related illness. Chest pain and shortness of breath were mostly reported symptoms (51.8%) followed by wheezing (31.8%) and coughing (16.5%) (Figure 4.1). These respiratory infection symptoms could be attributed to exposure to both indoor and outdoor SLCPs.

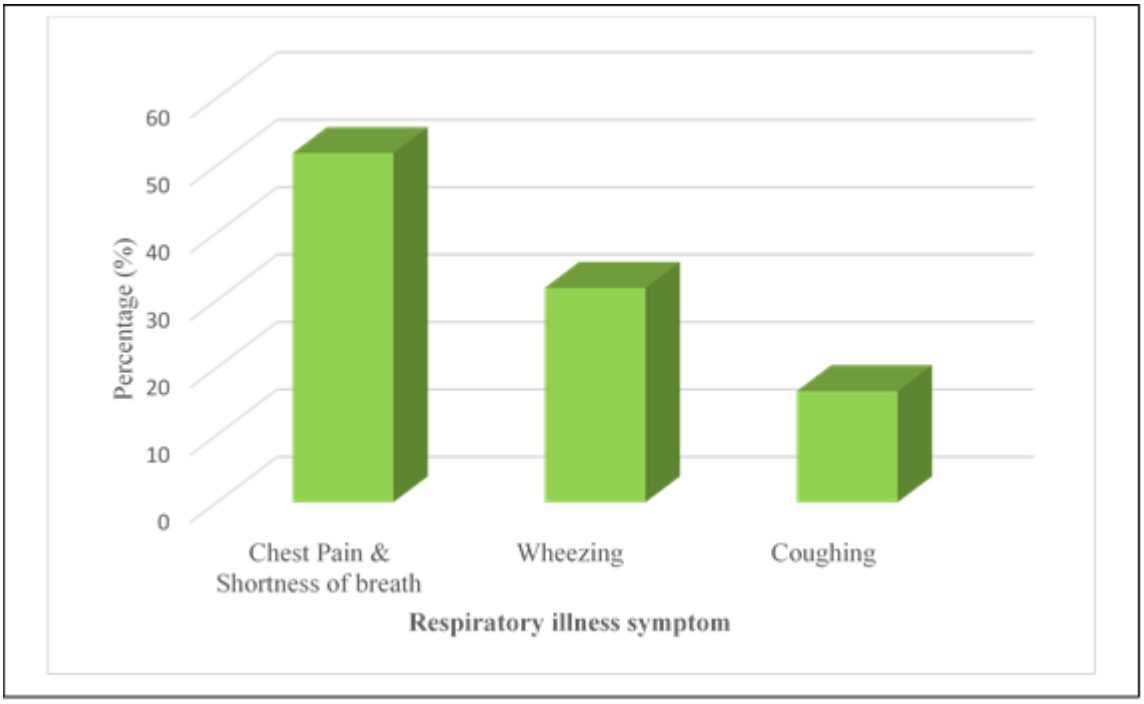

Figure: 4.1 Respiratory Illness Symptoms Shown by Households
Source: Fieldwork data, (2018)

The indoor air pollution could be blamed on the use of charcoal for cooking and heating as well as the use of Jako lamp and candles for lighting. Almost 100% of the studied households overwhelmingly indicated that they use charcoal for cooking and heating (Plate 4.1). On a daily basis, each household admitted to be using close to 5kgs of charcoal. A considerable number of

households (66.9%) stated that they used Jako lamp and candles to light their homes (Figure 4.2). Other than the use of charcoal, Jako lamp and candles were observed to contribute to indoor air pollution. Jako lamp basically involves burning of palm oil placed in a plate with a thread of cloth which produces light together with a considerable amount of black smoke. As for the candles, an overly long wick can cause imbalance between heat and fuel. This throws off a chemical reaction which produces excess soot and smoke. Though a few households seemed to be connected to city power, a considerable number of the households were also using Chinese light which is a cleaner of light compared to candles and Jako lamps.

Plate 4.1: Use of Charcoal: A little girl lighting charcoal in a cook-pad at Upper West.
Source: Research field visits, (2018).

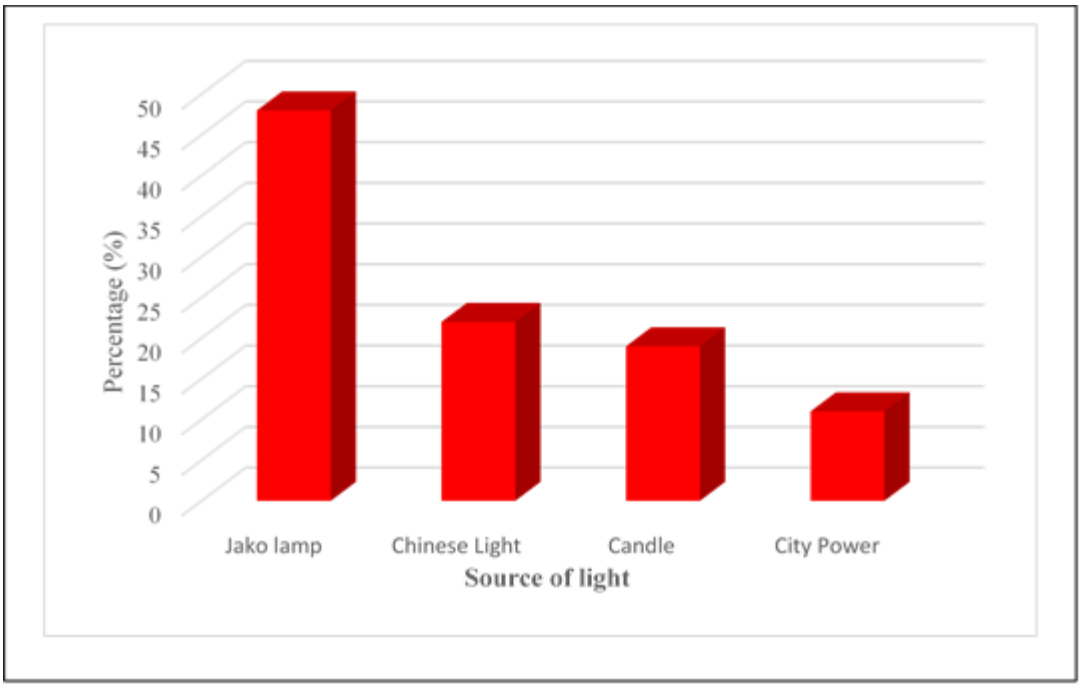

Figure 4.2: Sources of Light for the Household
Source: Fieldwork data, (2018).

Indoor air pollution has however been aggravated by lack of proper ventilation to support free air circulation. 68.5% of the households stated that their houses were not properly ventilated with only 31.5% households indicating that their houses were properly ventilated. Similar conditions were observed during field visits where majority of the houses were built from old aluminium sheets and without windows (Plate 4.2). This therefore logically means that such households were more vulnerable to exposure to black carbon, a form of SLCPs emitted from charcoal burning and use of candles and Jako lamps. This further explains the correlation which was observed between respiratory infection symptoms and housing condition as relates to ventilation. Majority of households whose houses were not properly ventilated were also the most affected in terms of respiratory infection symptoms (Table 4.3).

Plate 4.2: Housing Condition: Houses built with olf aluminium sheets and without proper ventilation

Source: Research field visits, (2018)

Table 4.3: The relationship between house ventilation and respiratory infection symptoms

House properly ventilated	Respiratory infection symptom						Total	
	Wheezing		Chest Pain & Shortness of breath		Coughing			
	N	%	N	%	N	%	N	%
Yes	3	3.5	5	5.9	3	3.5	11	12.9
No	24	28.2	39	45.9	11	12.9	74	87.1
Total	**27**	**31.8**	**44**	**51.8**	**14**	**16.5**	**85**	**100**

Source: Fieldwork data, (2018).

The respiratory illness symptoms expressed by households could equally be attributed to outdoor air pollution more so from black carbon generated from vehicular emissions and poor waste management techniques involving open dumping and burning solid waste. When the plastics are exposed to radiation they emit methane which serves as a precursor to tropospheric ozone (Royer *et al.,* 2018), hence open dumping of plastics contributes to a larger extent to exposure to SLCPs. Households overwhelmingly indicated that 79% of their modes of transport were not in good condition hence emit a lot of black carbon with only 21% households stating that their modes of transport were in good condition. Besides, it was noted through document reviews that there has been increased importation of used cars into the country since 2011. (Figure 4.3). This confirms

an earlier report on Fuel Economy in Liberia, which states that about 89% of vehicles in Liberia are old or used vehicles (UNEP & EPA, 2017). Besides, discussions with the Ministry of Transport revealed that Liberia imports third hand vehicles that are more than 10 years in use due to the high costs of new brand vehicles. Tariff on new vehicles in the country ranges from 150 USD to over 3,000 USD. It is therefore more convenient for majority of Liberians to buy third hand vehicles as compared to a new vehicle. As much as the cost of new vehicles are very much expensive for this lowly poor economy, thousands of used cars are imported into the country every day through the busy Free Port of Monrovia.

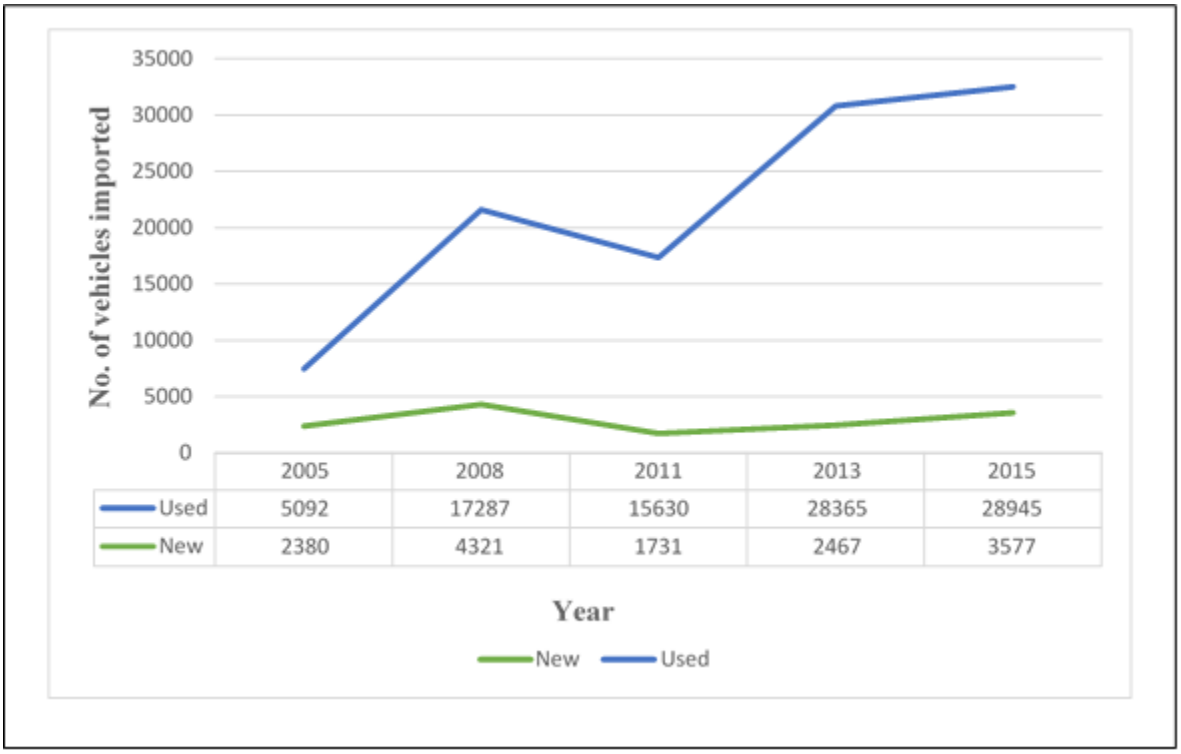

Figure 4.3: No. of used and new vehicles imported from 2005-2015
Source: Fieldwork data, (2018).

Apparently, 100% of the studied households indicated that they were exposed to vehicular emissions. This could further be due to the nature of the slum setting which is strategically situated on the road leading to three countries as well as to the Liberia-Sierra Leone border. Most residential structures are built a few meters from major roads traversing the slum (Plate 4.3a & b).

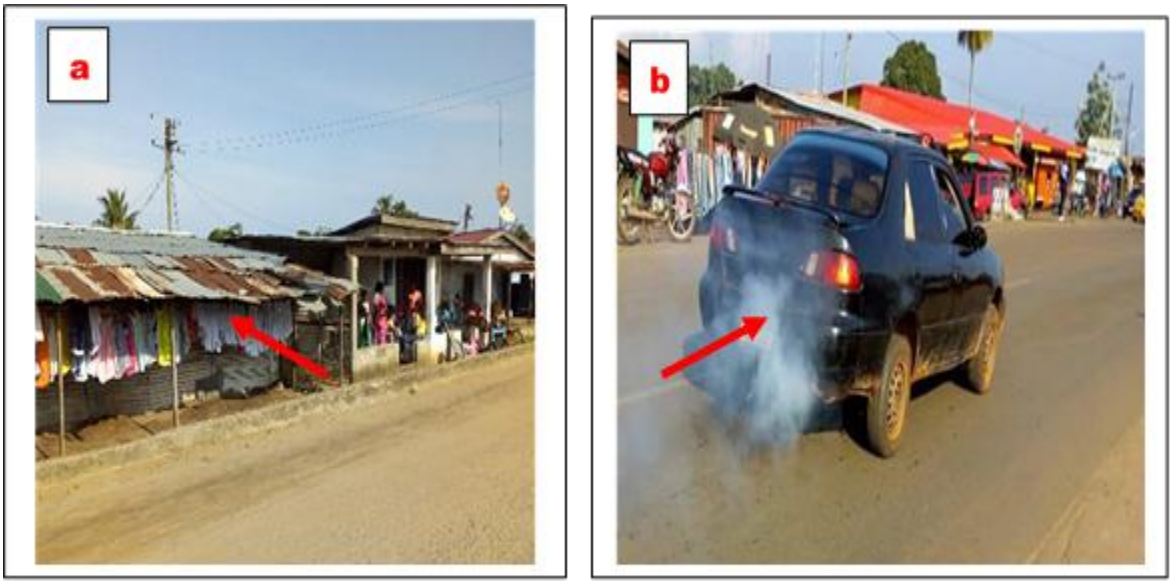

Plate 4.3: Exposure to Vehicular Emissions; (a) a residential house on the road side & (b) a car emitting black carbon

Source: Research field visits, (2018).

Notably, the outdoor exposure to SLCPs among the poor urban households was also due poor waste management. 73.4% of the studied households agreed that most of their wastes are disposed-off through open dumping while 26.6% practiced burning (Plate 4.4 a, c & d). A smaller percentage (2.4%) however indicated that their food waste were disposed through burying in a small hole dug in the sand in front of their houses where the waste are covered and left to decompose (Figure 4.4). Other than solid waste from households, New Kru Town was noted to be littered with huge piles of garbage produced from Duala Market. Burning of old tyres was also a common practice in Duala which is one of the busiest markets which supplies food materials to most of Monrovia as well as to the provisional city of Tubman burg. (Plate 4.4 b) Open dumping of organic waste often results in decomposition of such waste in absence of oxygen thereby releasing methane gas which serves as a precursor of ground-level ozone which is a deadly form of SLCPs mainly responsible for respiratory illnesses. Besides, burning of both organic and inorganic waste especially old tyres and plastics generates black carbon which makes the households vulnerable to health impacts of SLCPs.

Plate 4.4: Waste Disposal Methods: (a) solid waste burning, (b) burning of tyres, (c) & (d) open dumping.

Source: Research field visits, (2018).

Discussions with Monrovia City Corporation (MCC) revealed that the mechanisms to transfer the wastes to its final landfill site is quite challenging and the huge garbage has overwhelmed the ability of the MCC to collect them due to low budgetary allocation. This informed singling out of wastes as a key challenge in the National Determined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

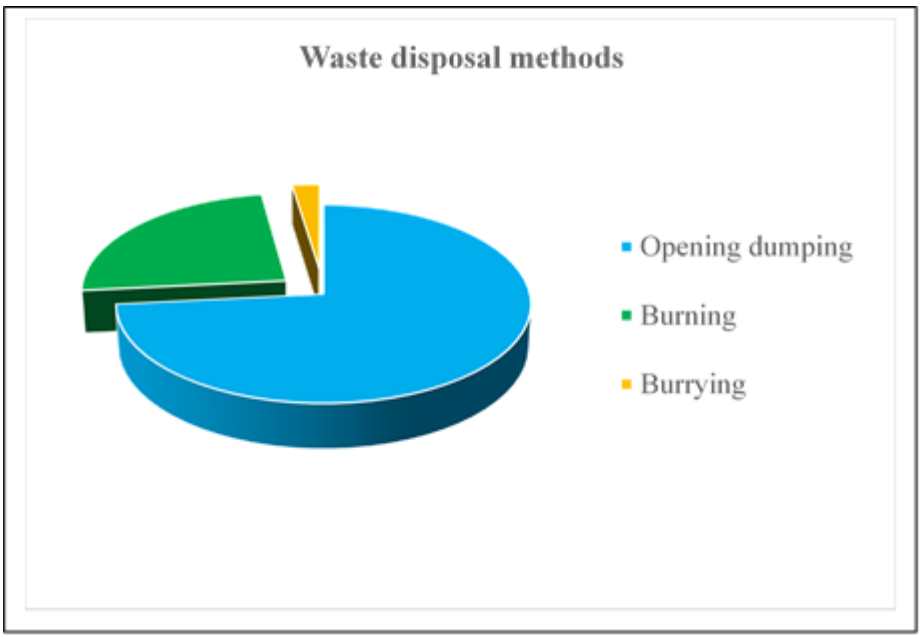

Figure 4.4: Methods of Waste Disposal Practiced by Household
Source: Fieldwork data, (2018).

The findings of this study concurs with the results from a previous study by Sancini *et al.*, (2014) in Milano, Italy which investigated health impacts of high concentrations of particulates in the air by observing cardiac gene expression and lung alterations in mice exposed to winter fine Sancini *et al.*, concluded that exposure to extremely high contaminated air may lead to respiratory infections symptoms such as: wheezing, coughing, chest tightness, breathing difficulties as well as irritation of the eyes, nose, and throat, and worsening of existing lung and heart problems. Sancini and his colleagues further argued that long-term exposure to degraded air can cause damage to the immune, neurological, reproductive, and respiratory systems and cancer while in extreme cases, can even cause fatality. Similarities were also drawn from a study by, Stohl *et al.*, (2015) which found out that exposure to tropospheric ozone (O_3), a highly reactive oxidant can harm human health leading to impacts such as shortness of breath and coughing to more serious impacts such as a decrease in lung function and respiratory symptoms and aggravated asthma. Stohl argued that air quality degradation is independently and consistently related to the most problematic health impacts, including cardiopulmonary and lung cancer and other diseases, the nature of which may vary with the pollutant constituents.

These results also concurred with the findings of an assessment by World Health Organization, (2016a) on the types of diseases attributed to Ambient Air Pollution (AAP) and Household Air Pollution (HAP) across all the regions of the world in 2012 which found out that lower respiratory infection, Ischemic Heart Disease (IHD), COPD and lung cancer were among the five highest illnesses in the world due to air pollution. However, this study was somewhat a general assessment of health impacts of air pollutants unlike the current study which focused only on the urban poor communities.

The respiratory infections were strongly linked to indoor and outdoor air pollution emanating from SLCPs emissions in the form of black carbon and tropospheric ozone. Other external factors such as lifestyle habits involving smoking of cigarettes was strongly disregarded due to the fact that majority of Liberians do not smoke. A study by WHO, (2014) on global cigarette consumption by WHO regions 1999 – 2016, noted that Liberia is among the 20 countries in the world that smoke the fewest cigarettes per capita; just 104 per adult per year as compared to Montenegro which recorded 4, 124.53 cigarettes per adult per year.

Noticeably, the symptoms of respiratory infections were clearly expressed in the elderly respondents as opposed the younger respondents (Table 4.4). This observation could be attributed to difference in the immune system of the respondents which is largely determined by age. The younger respondents tend to have stronger immune system hence were not showing symptoms of respiratory infections. This logically means that the signs of these respiratory infections developed over time as population gets older.

Table 4.4: The relationship between age and respiratory infection symptoms

Age of respondents	**Respiratory infection symptoms**						**Total**	
	Wheezing		Chest Pain & Shortness of breath		Coughing			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
<25 Years	0	0.0	0	0.0	0	0.0	0	0.0
26 - 35 Years	10	11.8	9	10.6	4	4.7	23	27.1
36 - 50 Years	11	12.9	18	21.2	8	9.4	37	43.5
> 50 Years	6	7.1	17	20.0	2	2.4	25	29.4
Total	**27**	**31.8**	**44**	**51.8**	**14**	**16.5**	**85**	**100**

Source: Fieldwork data, (2018).

Apparently, the length of time a respondent was exposed to SLCPs played a major role as to whether the respondent showed the symptoms of respiratory infetions or not. Symptoms of exposure to air pollutants are not uprightly experienced; it is developed over time. This was mainly in terms of the length of time a household had used charcoal and the length of time a household had lived in the slum community. As such, households who had lived in New Kru Town community for more than 5 years expressed symptoms of respiratory infections as compared to those households who had lived in New Kru Town for less than 5 years. (Table 4.5). Similarly, households who had used charcoal for more than 5 years experienced symptoms of respiratory infections as opposed to other households who had only used charcoal for less than 5 years (Table 4.6). Prolonged period of exposure to SLCPs therefore means high concentrations of various forms of SLCPs in the blood hence increased likelihood of showing symptoms.

Table 4.5: The relationship between the number of years a member of a household lived in New-Kru Town and respiratory infection symptoms

No. ofyears a member of household lived in New-Kru Town	**Respiratory infection symptoms**						**Total**	
	Wheezing		Chest Pain & Shortness of breath		Coughing			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
<=5 Years	1	1.2	3	3.5	3	3.5	7	8.2
6 -10 Years	9	10.6	19	22.4	3	3.5	31	36.5
11 - 15 Years	12	14.1	8	9.4	1	1.2	21	24.7
> 15 Years	5	5.9	14	16.5	7	8.2	26	30.6
Total	**27**	**31.8**	**44**	**51.8**	**14**	**16.5**	**85**	**100**

Source: Fieldwork data, (2018).

Table 4.6: The relationship between the number of years a household used charcoal and respiratory infection symptoms

No. of years a household used charcoal	Respiratory infection symptoms						Total	
	Wheezing		Chest Pain & Shortness of breath		Coughing			
	N	%	N	%	N	%	N	%
<= 5 Years	0	0.0	0	0.0	0	0.0	0	0.0
6 - 10 Years	4	4.7	3	3.5	1	1.2	8	9.4
11 - 15 Years	9	10.6	15	17.6	2	2.4	26	30.6
> 15 Years	14	16.5	26	30.6	11	12.9	51	60.0
Total	**27**	**31.8**	**44**	**51.8**	**14**	**16.5**	**85**	**100**

Source: Fieldwork data, (2018).

These findings were similar to those of a previous study by Jaggernath, (2013) and Jiang, (2015), on health impacts of SLCPs including particulates and tropospheric ozone on the most vulnerable and sensitive populations which found out that particulates and tropospheric ozone were the major causes of heart and lung sicknesses among adults, older people and children. Unlike in the current study Jaggernath and Jiang equally assessed the health impacts of SLCPs among children. Another study presenting similar results on the length of exposure was that by Beelen *et al*., (2015) on the effects of long-term exposure to particulate air quality degradation on health in the UK which pointed out that inhalation of particulate pollution even at minimal quantities can have adverse health impacts. The study revealed that long-term exposure to $PM_{2.5}$ exacerbates heart and lung conditions, mainly impacting the quality of life, and increases hospital admissions and deaths. The study further noted that the elderly and children were known to be more vulnerable to the health impacts of air pollutants. Epidemiological studies conducted by Frumkin, (2016) on the health impacts of a range of SLCPs such as Tropospheric Ozone (O_3), Black Carbon (BC) and Methane (CH_4) noted that these SLCPs have had immensed contribution to both acute and chronic heart and respiratory diseases. Tropospheric Ozone was particularly noted to be deadly for the elderly, children and people with lung or heart illnesses; it can worsen emphysema, asthma, bronchitis, and may for ever scar lung tissue. Heart disease, strokes, congestive heart failure, heart attacks and possible reproductive and developmental abnormalities were mainly associated with the exposure to long - and short -term ozone. The study went on to

stressed that formation of air polluting particulate matter, mainly BC and co-emitted pollutants are strongly associated with both short- and long-term health impacts. $PM_{2.5}$ has been specifically associated with a number of health impacts as well, including early deaths in children, in adults with heart and lung diseases, from heart attacks, acute lower respiratory infections such as pneumonia, strokes, chronic respiratory disease such as bronchitis, cardio-respiratory, aggravated asthma and other symptoms.

4.3.2 The SLCPs related disease-causing deaths reported within urban poor communities

4.3.2.1 Stroke was the leading cause of death.

Stroke was the leading cause of death among the households who reported to have lost a family member to respiratory/cardiopulmonary diseases at 33.9% followed by HBP and Lung diseases at 16.9% and 7.3% respectively (Figure 4.5).

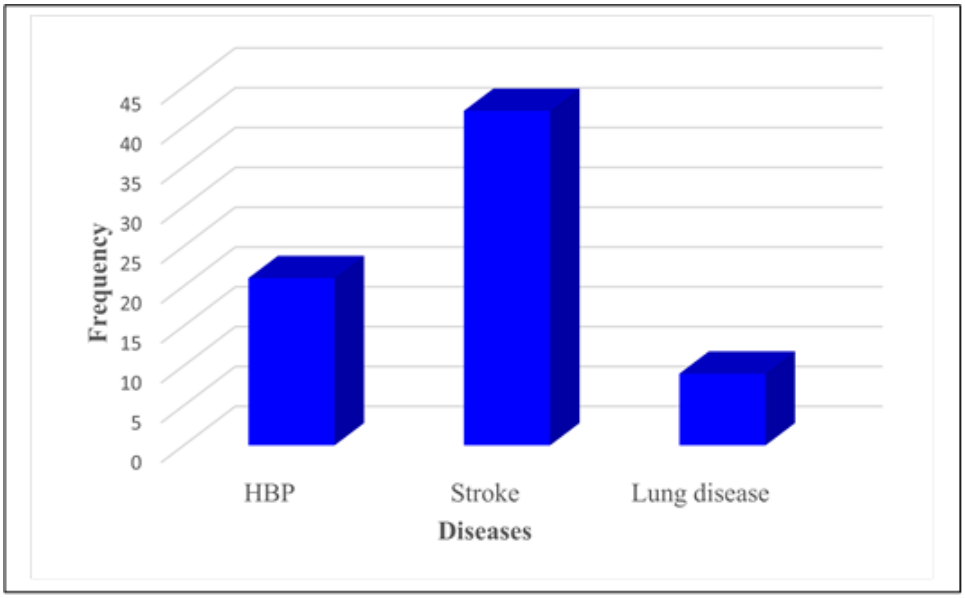

Figure 4.5: Diseases causing deaths among households
Source: Fieldwork data, (2018).

Similar results were observed from a review of copy of burial permits from a local hospital; John F. Kennedy Hospital on the causes of deaths among adults for the period 2011 – 2017 which revealed that the primary cause of many deaths was strokes followed by respiratory dysfunction and cardiopulmonary diseases (Figure 4.6).

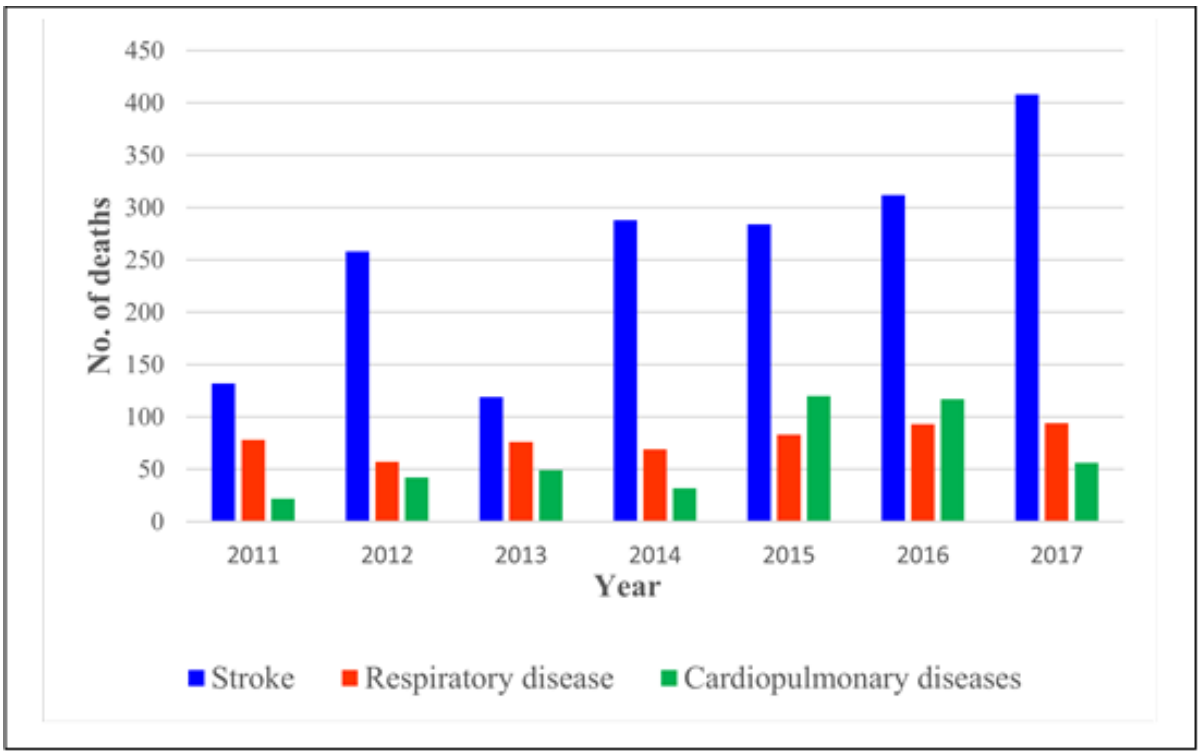

Figure 4.6: Diseases responsible for deaths among adults as recorded at Joh F.Kennedy Hospital for the period 2011- 2018

Source: Fieldwork data, (2018).

Discussions with the medical officer at John F. Kennedy Hospital revealed that the laboratory analysis of the specimen extracted from the patients who suffered stroke showed traces of particulate matter a major component of Black carbon. Exposure to black carbon was noted to be responsible for stroke which more often leads to multiple organ failure by paralyzing the body.

Similarities on the contributions of Black Carbon to stroke, respiratory and cardiopulmonary diseases in humans were drawn from a number of studies. A study by Burnett et al., (2014) showed that unchecked open air burning of domestic waste could lead to chronic exposure to ambient $PM_{2.5}$ which is responsible for early mortalities in adults. Covronick *et al.*, (2015), on their assessment of deaths among the urban poor due to air pollution arising from SLCPs found similar results. The study quantitatively showed that about 33% of deaths are as a result of stroke, 17% to Chronic Obstructive Pulmonary Disease (COPD), 8% as a result of Acute Lower Respiratory Infections (ALRI) and 6% to lung cancer, and 36% of the deaths to Ischaemic Heart Disease (IHD). It was based on this statistics that WHO, (2016b) concluded that

more than 7 million people in the world died from the combined effects of ambient air (3.7 million) and household (4.3 million) air pollution with more deaths occurring in developing countries across Asia, Latin America and Africa.

4.3.3 The potential prevention interventions necessary for curtailing SLCPs.

4.3.3.1 Clean cook stove was the most preferred measure to curtail SLCPs due to use of Charcoal.

Nearly more than three quarter of the households (85.5%) indicated that they preferred to use clean cook stoves to reduce their exposure to Black carbon and particulate matter from the use of charcoal. However, some households indicated that for them to realize a reduction in the rate of exposure to SLCPs charcoal should be replaced with LPG & electricity representing 11.3% and 3.2% respectively (Figure 4.7). Observably, majority of the households preferred to use clean cook stoves since they use charcoal which is much affordable compared to the cost of LPG and electricity. Besides, the condition of their houses were not good enough for electrical installation. Discussions with LPG distributors revealed that it was close to impossible for people of low income to use LPG. Shockingly, a complete 6 kg gas cylinder retailed for approximately $60 USD while the cost of refilling the same cylinder ranges between $10-20 USD. This cost seems exorbitant for the ordinary Liberians least to say people living in slum communities. These exaggerated prices has since made Liberia's consumption of LPG to be negligible. This was according to Global Economy Report dating back to 1986 where Liberia was ranked 118th in the world when it comes to consumption of LPGs. During the said year Liberia consumed 0 barrels of LPG and up to 0.1 thousand barrels in 2013. The clean cookstove consumes less charcoal and does not emit SLCPs. The sulfur produced during cooking are burnt out in the cookstove which makes it environmentally friendly and healthy for use. Using a clean cookstove, a $5LD plastic bag of charcoal can cook a meal or heat a bucket of water other than the traditional cooking stove that uses more charcoal and emit a lot of SLCPs.

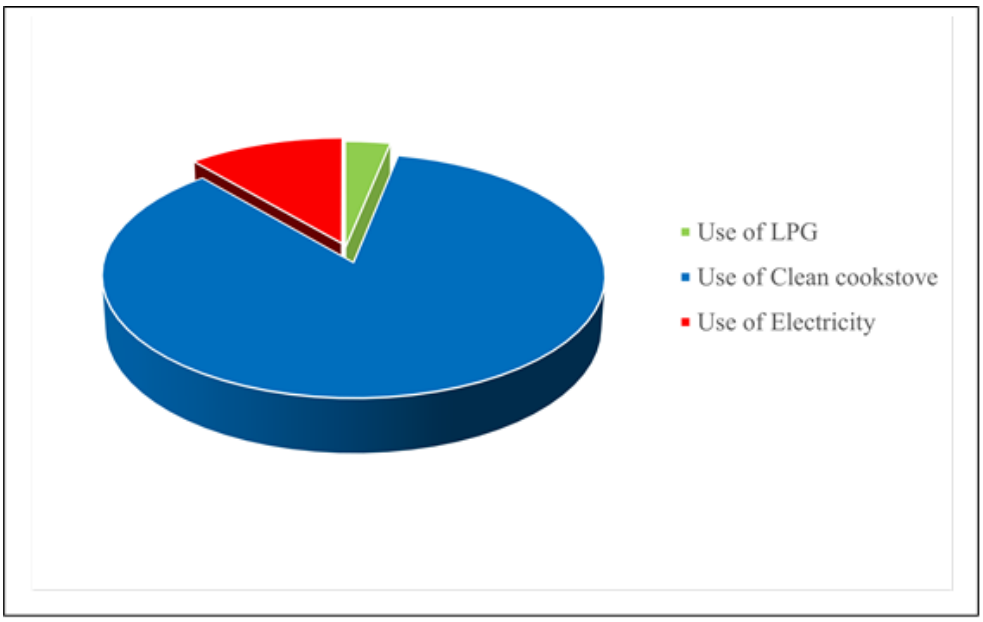

Figure 4.7: Potential Intervention to reduce SLCPs emission from use of charcoal.
Source: Fieldwork data, (2018).

Similar studies have been carried out in the past especially in developing countries across Africa and Asia on clean cook stove that have been proven its potential to minimize Household Air Pollution (HAP) by cutting black carbon emission usually arising from the use of biomass and paraffin for cooking, heating and lighting. For instance, a study by Winkler *et al.*, (2013) and Clark (2013) on the potential of clean cookstove to minimize Household Air Pollution (HAP) by reducing substantial amounts of emissions from the use of biomass found similar results to the current study. Winkler, Clark and their colleagues argued that concluded clean cookstoves have the capacity to reduce the black carbon and $PM_{2.5}$ to harmless products before emitting into the atmosphere. Reduced HAP will in turn reduce the risks of contracting a range of diseases that has for a long time been linked to SLCPs e.g. cancers, lung, heart disease, cataracts; asthma, adverse pregnancy outcomes, depression, Chronic Obstructive Pulmonary Disease (COPD), bacterial meningitis and widespread of minor ailments from smoke inhalation such as eye irritation and headaches.

4.3.3.2 Banning importation of used car to reduce excessive vehicular emissions

Close to half of the households (49.2%) were of the opinion that banning importation of used cars was the best strategy to reduce SLCPs due to vehicular emissions whereas 24.2% indicated that introducing cleaner burning fuels with low Sulphur content would help to a greater extent in

reducing SLCPs due to vehicular emissions with 26.6% proposing behavioral change involving cycling and walking to reduce overdependence on vehicles especially when going about their activities within the community (Figure 4.8). New Kru town being traversed by major and busy roads like UN Drive, and most residential houses located a few meters away from the road, necessitates the need to reduce vehicular emissions so as to reduce exposure to black carbon and $PM_{2.5.}$ Reports at the Department of Motor Vehicles showed that most of the vehicles brought into the country were around 89% used vehicles from Japan, Belgium and other country with just a fraction from the United States. Most of these diesel vehicles imported to Liberia though affordable, are the major emitters of SLCPs. This explains the astoundingly high number of households suggesting the ban on used vehicles. On the contrary, having new vehicles with high Sulphur content fuel doesn't make any tangible difference unless the vehicles are installed with a technology that can dilute the pollutants before being emitted into the atmosphere. As such, introduction of cleaner burning fuels alongside new vehicles is necessary just as expressed by the households. A report by UNEP on cleaner fuels indicated that Liberia diesel fuel is well over 550 PPM in content with higher content in gasoline. Discussions with the laboratory supervisor at Liberia Petroleum Refinery Company (LPRC) revealed that the company's major concern has always been the availability of fuel in the Liberian market for consumption and not necessarily the sulfur content of the fuel. This was however blamed on the loss and destruction the company experienced during the civil war. The LPRC, Liberia's government arm responsible for the provision and regulation of petroleum products in the country came under heavy destruction during the Liberia civil war (Huband, 2013). As a result, the entity has not been able to provide those services it used to provide. An official of the Ministry of Commerce and Industries said the LPRC has now turned into a super filling station that only distributes petroleum products to local filling stations; it does not refine anything. It just stores the petroleum products and redistributes it to local filling station. This assertion was rejected by a technician at the LPRC Lab on the Bushrod Island, who said that the LPRC was working hard to restore the entity to its pre-war status but failed to give details of the works that are performed in the lab which supposed to ascertain the level of chemical composition in petroleum products. However, many technicians we talked to blamed the LPRC for the not checking the sulfur contents in petroleum products that enter the country. While deliberating on the same with the manager of compliance and enforcement department of the Environmental Protection Agency of Liberia (EPA) he mentioned

in 2015, countries of West Africa and the Secretariat of the Climate and Clean Air Coalition met in Abidjan, Ivory Coast and agreed on an action plan to stabilize the content of sulfur in petroleum products to 50 part per million but up to now, Liberia is yet to take a step to implement the said agreement. This has been attributed to non-compliance on the part of LPRC which have failed to refine its petroleum products despite purchasing the unrefined products in bulk from other countries in the West Africa region such as Senegal.

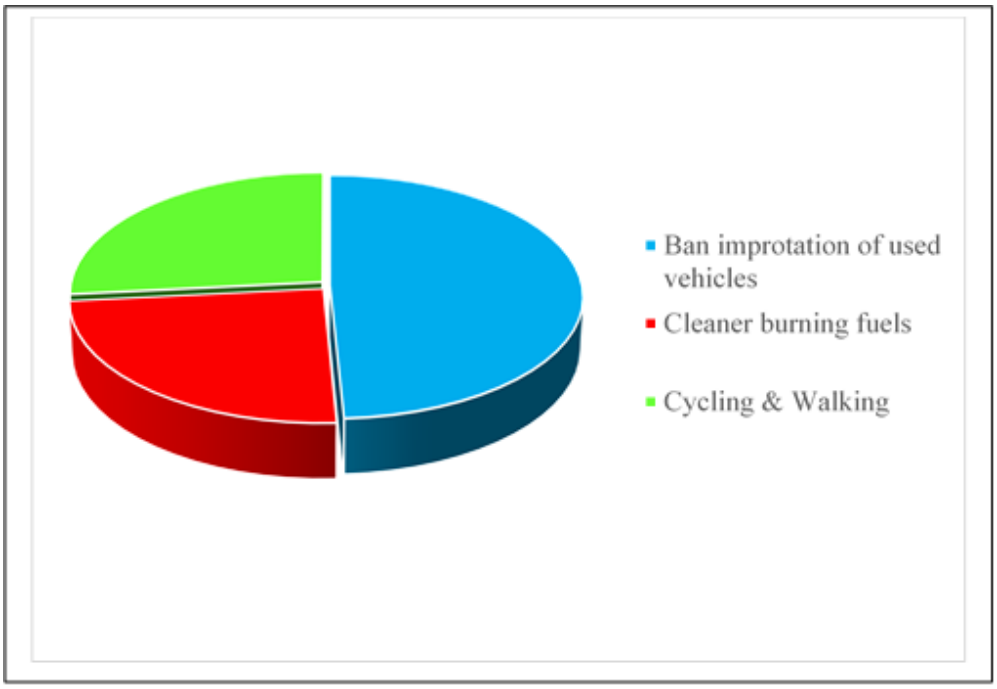

Figure 4.8: Potential intervention to reduce SLCPs due to vehicular emissions
Source: Fieldwork data, (2018).

Similarities were drawn from a number of previous studies suggesting the potential interventions necessary for curtailing SLCPs. For instance, a study by Aman *et al.*, (2014) on the Clean Air Package for Europe focusing on the reduction of Particulate Matters (PM) in diesel fuel so as to improve air quality and reduce lives lost as a result of air quality degradation in all member states. The study showed that, reducing Particulate Matters (PM) in fuel has the potential to improve the life expectancy of the Europeans besides contributing to economic gains. A similar comparative study by Akintan, (2014) on the role of potential intervention; cleaner burning fuel in reducing indoor air pollution in Nigeria showed that, urban electrified households recorded 75% lower $PM_{2.5}$ concentrations than similar un-electrified urban households. Other studies on outdoor air quality deterioration due to Black Carbon (BC) especially from vehicular emissions

in rural India, by Patange *et al.,* (2015) concluded that the largest reduction of these pollutants can be achieved by considering fuel type, vehicle technology, vehicle age and conditions of use (traffic). Importantly, the study showed that vehicles with state-of-the-art emission control technologies will necessarily result in lower emissions. Providing further evidence on the use of cleaner burning fuels towards reduced emissions of SLCPs is a study by Hill, (2013). Hill highlighted important factors deemed necessary for curtailing China emissions of Black carbon, a component of $PM_{2.5.}$ The factors included effective vehicles and use of smokeless fuels in industrial and domestic combustions, sustainable vehicles management, and increase in cleaner vehicles. Lastly, on the findings on behavioral change mechanisms similarities were drawn from a study by Lucas *et al.,* (2016) on sustainable urban communities in Australia focusing on sustainable transport where they demonstrated that more sustainable transport methods of public transport along with walking and cycling serve to reduce emission levels by high percentages. The study further showed that introducing a more sustainable transport system will maximize the efficiency of the highway network and also give real time information on traffic delays and journey times, car parking availability, and bus arrival times; not only allow people to make travel choices that are better informed and also serve to reduce vehicular pollution. The study concluded that active walking and cycling as a means of travel, has the potential to cut emissions of black carbon.

4.3.3.3 Recycling and Reuse to reduce emissions of SLCPs from open burning of plastics

Nearly more than half of the households (66.1%) mentioned that the appropriate way to deal with emissions from burning of plastics in the open air was to encourage the households to collect the plastic bags and bottles for recycling whereas more than quarter of the households proposed plastic ban with only a few households mentioning reuse at 25.8% and 8.1% respectively, (Figure 4.9). Recycling appeared to be the most preferred as much as imposing ban on plastics would be the best since it works by eliminating the plastics completely from the environment. This could be attributed to the households trying to protect their livelihood sources while creating more livelihood sources. Recycling has been a very lucrative business venture especially for the jobless youths in the community where they collect the plastics and collaborate with the recyclers to take the plastics at a cost. The opposition of ban on plastics was directly linked to the

livelihood sources of many households who survive on petty businesses involving the use of plastic bags such as water vending and charcoal selling, (Plate 4.5).

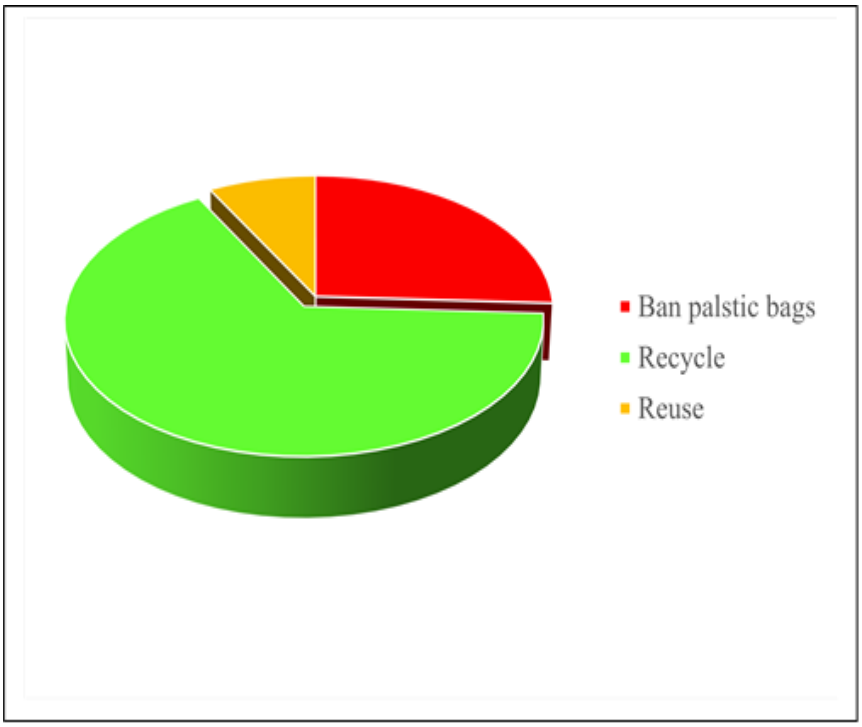

Figure 4.9: Potential intervention to reduce SLCPs due to burning of plastics in open air.
Source: Fieldwork data, (2018).

Plate 4.5: Drinking water packaged in small plastics bags.
Source: Research field visits, (2018).

When contacted for comments on the huge piles of garbage in New Kru Town and what the corporation plans to do efficient waste management, an official from Monrovia City Corporation indicated that the Corporation has provided many bins to the community for storage of garbage awaiting collection but instead, community dwellers have opted to continue dumping everywhere. He said unscrupulous members of the community usually set fire to the garbage in the bins thereby causing the MCC not to be able to collect those wastes for final disposal. He further added that, the budgetary allocation for the corporation was reduced in the last financial year and that affected most of their activities including waste collection since in some areas the solid waste was overflowing from the MCC collection bins. The official concluded by saying that the low budgetary allocation has affected their plans of collaborating with EPA to bring waste management awareness to the people of Monrovia, New Kru Town included.

4.4 Hypothesis testing

The study hypothesized that SLCPs do not affect the health outcomes of the urban poor communities. To test the hypothesis the aspect of Black Carbon and $PM_{2.5}$ which are the major forms of SLCPs in charcoal were cross tabulated against the length of time the households had used charcoal. The respondents were further asked to indicate whether they experience health impacts due to use of charcoal (Table 4.7).

Table 4.7: Cross-tabulation: Health Impacts vs the length of time the households used charcoal

		The length of time the households used charcoal				Total
		<= 5 Years	6 - 10 Years	11 - 15 Years	> 15 Years	
Health impacts	Yes	0	8	26	51	85
	No	4	6	11	18	39
Total		4	14	37	69	124

Using Pearson's Chi Square (X^2) Test, the test statistic was generated; 10.535 (Table 4.8). The critical value at 0.05 significance level, 3 d.f was 7.82. Since the calculated value is greater than the critical value, the hull hypothesis that SLCPs do not affect the health outcomes of the urban poor communities was rejected hence the alternative hypothesis that SLCPs do affect the health outcomes of the urban poor communities was adopted.

Table 4.8: Chi-Square Tests

	Value	d.f	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.535[a]	3	.015
Likelihood Ratio	11.060	3	.011
N of Valid Cases	124		

As evidenced from hypothesis testing, SLCPs indeed do affect the health outcomes of the urban poor communities. As earlier indicated in the research findings, SLCPs can cause respiratory and cardiovascular diseases especially due to exposure. The respiratory infections are usually accompanied by symptoms such as chest pain & shortness of breath, wheezing and coughing. The cardiovascular diseases are mainly in the form of HBP and stroke.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter gives a brief summary of the findings from the research and a detail recommendation to national government to take actions to curtail SLCPs deaths in the country.

5.1 Summary of findings

The study assessed the perception of the effects of SLCPs on the health of urban poor communities in New Kru Town Community in Monrovia, Liberia. The study was conducted by first determining the illnesses associated with various forms of SLCPs, determining causes of death among the urban poor communities due to SLCPs and lastly establishing the potential prevention intervention necessary to curtail SLCPs. The research findings depicted that SLCPs indeed affect the health of the urban poor communities. The study found out that respiratory infection were the most common forms of illnesses experienced among the poor urban households due to Black carbon emanating from prolonged use of charcoal, diesel and Jako lantern. Chest pain & shortness of breath were the major symptoms mentioned by the respondents at (51.8%) followed by wheezing at (31.8%) & coughing (16.5%). These respiratory infection symptoms could be attributed to exposure to both indoor and outdoor SLCPs. Stroke was noted to be the leading cause of death due SLCPs. Stroke is a cardiovascular disease majorly linked to air pollution. Majority of the deceased (76.4%) were above 50 years old while those between the ages 36 – 50 years were only (23.6%). This therefore means that the elderly were more vulnerable to health impacts due to SLCPs. Finally three key potential interventions were established towards reducing SLCPs emissions. They included; introduction of subsidized clean cook stove, banning importation of used cars and recycling and reuse of plastics.

5.2 Conclusions & Recommendations

5.2.1 Conclusions.

The study concluded that;

i. Respiratory infections were the most common forms of illnesses. This was evident from the respiratory infection related symptoms such as chest pain & shortness of breath

reported symptoms wheezing and coughing which were reported across various households. The respiratory infections were due to indoor and outdoor exposure to air pollutants especially Black carbon, a form of SLCP that is common in the study area considering that majority of the households use charcoal and Jako lamp for cooking and heating and for lighting respectively. Noticeably, the elderly respondents were the mostly affected by respiratory infections compared to their relatively younger counterparts. This was attributed to the difference in their immune systems.

ii. Stroke was the leading cause of death among the urban poor communities. The records on the cause of death including laboratory analysis showed traces of particulate matter a major component of Black carbon to be present in the blood sample. Exposure to black carbon was noted to be responsible for stroke which more often leads to multiple organ failure by paralyzing the body.

iii. Clean cook stove was the most appropriate way to curtail SLCPs such as black carbon arising from the use of charcoal considering the fact that majority of the households are poor hence cannot afford to be connected the national grid. Besides, banning importation of used car to reduce excessive vehicular emissions and adopting the green practice of recycling and reuse to reduce emissions of SLCPs from open burning of plastics would help curtail methane which are generated when these plastics are exposed to radiation. Methane is a precursor of ground level ozone which a dangerous form of SLCPs.

5.2.2 Recommendations

The study therefore recommends;

The Government of Liberia

i. The use of policy instruments such as subsidizing the cost of Clean Cookstoves by abolishing taxes on its import. This will help facilitate quick adoption of clean cookstoves thereby reducing exposure to black carbon and other particulate matter.

ii. Implementation of Sustainable Energy for All Program. This should include increasing access to sustainable power especially electricity. The government should also consider introduction of LPGS and solar power plants.

Environmental Protection Agency (EPA), Liberia.

i. Awareness creation. The EPA should ensure continued awareness creation on the impacts of air pollution on health especially among the most vulnerable groups living in slum areas.

ii. Develop and Enforce Air Quality monitoring Program. This will help regulate emissions more so from vehicles and also emissions due open air dumping of solid waste.

Monrovia City Corporation (MCC)

i. Enforce city ordinance. The ordinance forbids littering.

ii. Adopt integrated solid waste management strategies entailing the 3Rs (Recycle, Reuse and Reduce) towards a reduction in emissions resulting from open burning and dumping.

5.3 Areas for further research

The impacts of SLCPs on the health of human has been purely explained on the basis of past desk studies, observations, and inferences. The study used both quantitative and qualitative techniques based on key informant interviews, questionnaire and hospital records in no way presents this study as an end in itself but rather a mean to an end. It is however important to note that the results from this case study is applicable to other communities with same national circumstances in developing countries like Liberia. Meanwhile, it is imperative for more in-depth studies involving medical examinations to ascertain the level of particulate matters in blood strains in urban poor community dwellers with equal exposure to SLCPs to conclude the theory of death due to SLCPs.

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APPENDICES

APPENDIX I: LETTER OF INTRODUCTION

I am a student of the University of Nairobi in Kenya, conducting a research on the Impacts of Short Lived Climate Pollutant on the Health of Urban Poor Communities in Monrovia, Montserrado County.

You have been therefore selected to participate in this study. Your participation is voluntary and all collected data will be handled so as to protect confidentiality. The information obtained will be used solely for the educational and research purposes.

Thank you for your willingness to participate in the study.

APPENDIX II: QUESTIONNAIRE FOR THE RESPONDENTS

Before starting to answer the questions, please go through the instructions relevant to each question and identify the correct answer for each question. Use (√).

Thank you for accepting to answer the questionnaire

SECTION A: GENERAL INFORMATION ABOUT RESPONDENT

Name..... Sub community: .....

- Gender Female [ ] Male [ ]
- Age : <25 years [ ] 26 – 35 years [ ] 36 - 50 years [ ] >50 years [ ]
- Highest Level of Education: No Schooling [ ] Elementary [ ], Junior High [ ] Senior High [ ] Tertiary [ ]
- Marital Status: Single [ ] Married [ ] Separated [ ] Divorced [ ] Widowed [ ]
- Occupation: Business [ ]
  Operating motorbike [ ]
  Driver [ ]
  Water vendor [ ]
  Employed [ ]
  Other (specify)…….....

1. How long have you lived in this sub-community?
   - <=5 years [ ]
   - 6 – 10 years [ ]
   - 11- 15 years [ ]
   - >15 years [ ]
2. Is your house properly ventilated? Yes [ ] No [ ].

SECTION B: SOURCES OF ENERGY

3. Do you use charcoal/fuelwood for cooking? Yes [ ] No [ ]. If yes, how much do you use per day?
   - <=5 kg [ ]
   - 6-10 kg [ ]
   - >10 kg [ ]

4. How long have you used charcoal/ fuelwood?
   - <=5 years [ ]
   - 6 – 10 years [ ]
   - 11- 15 years [ ]
   - >15 years [ ]
5. What do you use to light your house?
   - Kerosene [ ]
   - Candle [ ]
   - City power [ ]
   - Jako lantern [ ]
   - Chinese light [ ]
6. (a). Which mode of transport do you use frequently?
   - Taxi [ ]
   - Bus [ ]
   - Motorbike [ ]
   - Keke [ ]
   - Others (Specify)……

   (b). Is the condition of your selected mode of transport good? Yes [ ] No [ ].

SECTION C: WASTE MANAGEMENT

7. Do you generate any solid waste? Yes [ ] No [ ]. If yes what type of waste are they? (*Choose one or more from the options provided below*)
   - Paper [ ]
   - Plastic [ ]
   - Food waste [ ]
   - All of the above
8. How do you dispose-off your waste? (*Choose one or more*)
   - Open Dumping [ ]
   - Burning [ ]
   - Burying [ ]
   - Municipal Garbage collection [ ]

SECTION D: HEALTH ISSUES

9. Have you ever lost any of your family member to respiratory/heart related diseases? Yes [ ] No [ ]. If yes, answer part (a & b). If no, please proceed to question number 10 below.

a. Disease

- HBP [ ]
- Stroke [ ]
- Lung disease [ ]
- Coughs [ ]
- Others (specify)…….

b. How old was the deceased?

- < = 18 Years [ ]
- 18 -35 Years [ ]
- 36 – 50 Years [ ]
- >50 Years [ ]

10. Do you experience any negative impact on your health while using charcoal? Yes [ ] No [ ]. If yes, what are some of the impacts?

- Coughing & Wheezing [ ]
- Chest pain & Shortness of breath [ ]
- Shortness of breath & Coughing [ ]
- Other (specify)……

11. Are you normally exposed to the black smoke from vehicles and other modes of transport within your vicinity? Yes [ ] No [ ].

SECTION D: POTENTIAL INTERVENTION for curtailing SLCPs.

12. What do you think should be done to address the following issues

a. Increased indoor air pollution due use of charcoal among the households.

- Use of LPGs [ ]
- Use of clean cook-stoves [ ]
- Use of electricity [ ]
- Other: .....

.....

b. Increased exposure of locals to vehicular emissions

- Ban of used vehicle importation [ ]
- Cleaner burning fuels [ ]
- Cycling & walking [ ]
- Other:

  .....

c. Poor waste management

- Ban on plastics [ ]
- Recycling [ ]
- Reuse [ ]
- Other: .....

Respondent's signature: ..... Date: .....

Thank you for your participation

APPENDIX III: INTERVIEW GUIDE & SCHEDULE

Main Question	Sub-questions
Officer-In-Charge, John F. Kennedy Hospital	
Out & in-patients services	▪ How often do people report for check-ups for respiratory and cardiovascular related diseases? ▪ What do you think are the causes of respiratory and cardiovascular diseases reported in the community?
Records	▪ Are there any records on the number of reported respiratory and cardiovascular diseases? ▪ How many deaths have the hospital encountered due respiratory / heart related illnesses?
Liberia Petroleum Refinery Company	
Dealer permits	▪ Do you have a quantified number of petroleum dealers in the country? ▪ Do you issue permit to these petroleum dealers in the country?
License	▪ Do you test the chemical composition in a petroleum product? ▪ What are the major chemical components you test for? ▪ Do you have a national petroleum quality standard for Liberia? ▪ What is the level of sulfur content in your petroleum product?
Department of Motor Vehicles	
Policy	▪ What is the age limit for vehicles that must be imported into the country?
License / permits	▪ Are vehicles inspected before plates are issued to it?
Environmental Protection Agency (EPA)	
Air quality monitoring	▪ Is there any air quality monitoring system in place? ▪ Do you monitor the ambient air quality in and around Monrovia?
Inspection	▪ Are your inspectors aware of the presence of smoking vehicles in the city?

	▪ Do you check the contents of fuel and gas imported by the LPRC for Lead and Sulfur?
Information exchange/ public awareness	▪ Do you conduct a joint awareness with MOH on impacts of pollution?
Policy	▪ Do you have a national Environmental Policy? ▪ Is there an air quality regulation? ▪ Do you have a clean air act in place?
Monrovia City Corporation	
Waste collection & disposal	▪ How frequent do you collect solid waste from New Kru Town and its environ ▪ How do you dispose-off the collected waste
Challenges	▪ Is your corporation facing any challenges with regards to waste management?

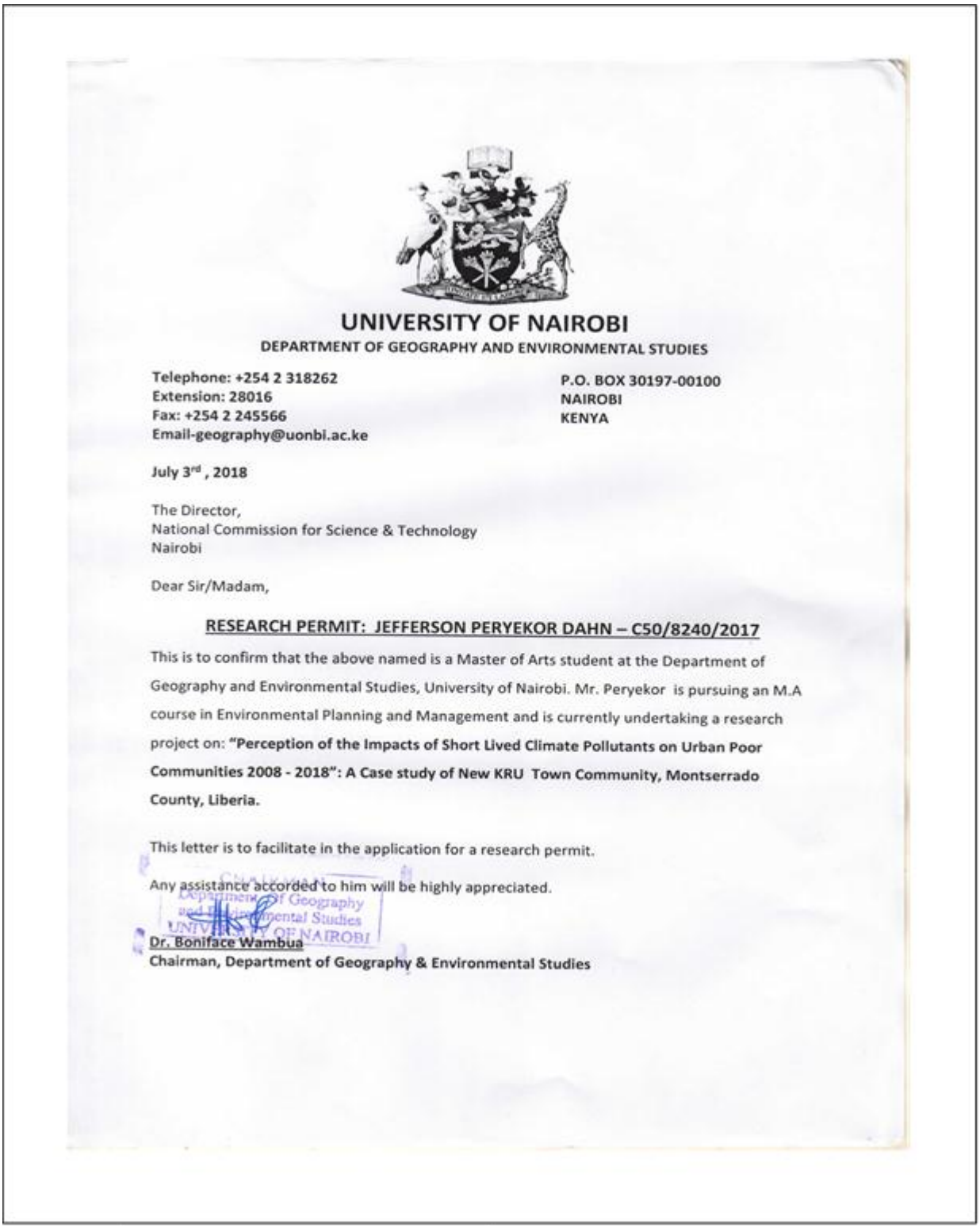
Thank you for your corporation

APPENDIX IV: OBSERVATION CHECKLIST

Sub-Community name.....

Sources of SLCPs (black carbon, CH_4)	Yes	No
1. Solid waste management		
o Open dumping organic waste		
o Open burning of waste (Tyres)		
2. Lighting systems		
o Kerosene lamps		
o Use of candles		
o Small bonfires		
o Jack o lantern (using red oil)		
o Chinese Light		
o Electricity		
o Generators		
3. Cooking systems		
o Use of charcoal		
o Use of fuel wood		
o Liquefied Petroleum Gas (LPG)		
o Electricity		
4. Transport system		
o Are the vehicles (buses and taxis) old?		
o Are the vehicles emitting a lot of black smoke?		
o Are there many motorbikes in the area?		
o Are the "keke's" old?		
5. Housing Condition		
o Are the houses properly ventilated?		
o Comments		
Signature..... Date.....		

APPENDIX V: FIELD INTRODUCTORY LETTER



UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

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P.O. BOX 30197-00100
NAIROBI
KENYA

July 3rd , 2018

The Director,
National Commission for Science & Technology
Nairobi

Dear Sir/Madam,

RESEARCH PERMIT: JEFFERSON PERYEKOR DAHN – C50/8240/2017

This is to confirm that the above named is a Master of Arts student at the Department of Geography and Environmental Studies, University of Nairobi. Mr. Peryekor is pursuing an M.A course in Environmental Planning and Management and is currently undertaking a research project on: **"Perception of the Impacts of Short Lived Climate Pollutants on Urban Poor Communities 2008 - 2018": A Case study of New KRU Town Community, Montserrado County, Liberia.**

This letter is to facilitate in the application for a research permit.

Any assistance accorded to him will be highly appreciated.

Department of Geography and Environmental Studies
UNIVERSITY OF NAIROBI

Dr. Boniface Wambua
Chairman, Department of Geography & Environmental Studies

APPENDIX VI: FEE STATEMENT

Fee Statement Detailed Fee Statement

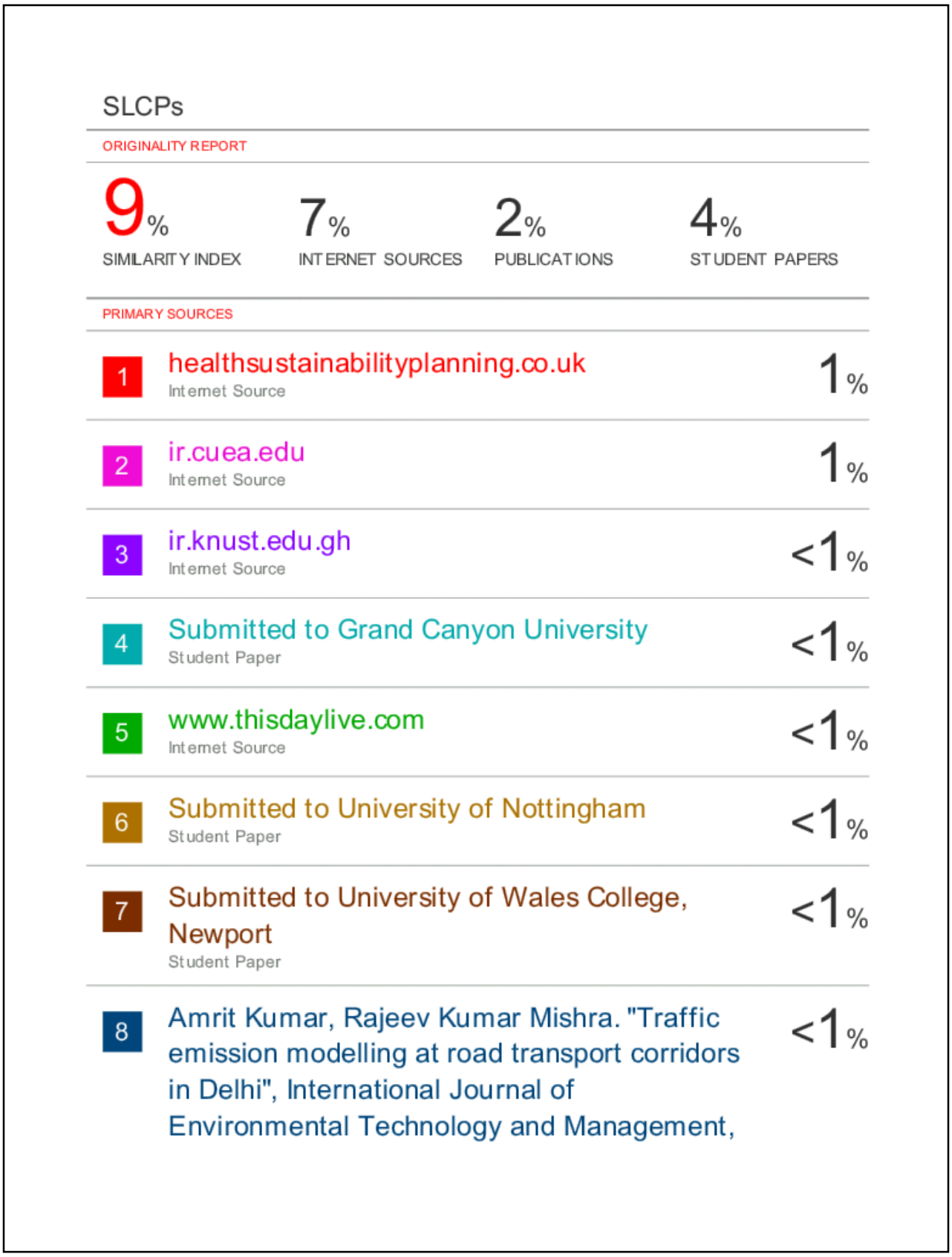
C50/8240/2017 JEFFERSON PERYEKOR DAHN (Nairobi Evening)

Fees Statement

Academic Year : 2017/2018 **Billing Currency :** KSF

Transaction/ Receipt Number	Date	Description	Debits DR	Credits CR	Balance	Cur.Rate
2180206469	2017-09-29	FEES PAYMENTS	0.00	217,052.15	-217,052.15	KES=1
2180265035	2018-05-25	FEES PAYMENTS	0.00	1,870.00	-218,922.15	KES=1
C50/8240/2017-2017/2018-SEM1	2017-11-07	FEES PAYABLE FOR SEM1	99,375.00	0.00	-119,547.15	KES=1
C50/8240/2017-2017/2018-SEM2	2018-02-11	FEES PAYABLE FOR SEM2	76,500.00	0.00	-43,047.15	KES=1
C50/8240/2017-2017/2018-SEM3	2018-08-27	FEES PAYABLE FOR SEM3	77,500.00	0.00	34,452.85	KES=1
C50/8240/2017-RCT2180265035 USD	2018-05-28	RCT2180265035 USD	1,870.00	0.00	36,322.85	KES=1
C50/8240/2017-RCT2180265035KSH	2018-05-28	RCT2180265035KSH	0.00	189,002.96	-152,680.11	KES=1
		Academic Year Totals :	**255,245.00**	**407,925.11**	**-152,680.11**	
Closing Balance : -152,680.11						
Academic Year : 2018/2019						
Opening Balance			0.00	152,680.11	**-152,680.11**	
C50/8240/2017-2018/2019-SEM1	2018-10-08	FEES PAYABLE FOR SEM4	93,125.00	0.00	-59,555.11	KES=1
		Academic Year Totals :	**93,125.00**	**152,680.11**	**-59,555.11**	
Closing Balance : -59,555.11						

APPENDIX VII: ANTI-PLAGIARISM REPORT



SLCPs

ORIGINALITY REPORT

9%	7%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	healthsustainabilityplanning.co.uk Internet Source	1%
2	ir.cuea.edu Internet Source	1%
3	ir.knust.edu.gh Internet Source	<1%
4	Submitted to Grand Canyon University Student Paper	<1%
5	www.thisdaylive.com Internet Source	<1%
6	Submitted to University of Nottingham Student Paper	<1%
7	Submitted to University of Wales College, Newport Student Paper	<1%
8	Amrit Kumar, Rajeev Kumar Mishra. "Traffic emission modelling at road transport corridors in Delhi", International Journal of Environmental Technology and Management,	<1%

Declaration Form for Students

UNIVERSITY OF NAIROBI

Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for examination.

Name of Student:	Jefferson Peryekor Dahn
Registration No:	C50/8240/2017
College:	Social Sciences & Humanities
Faculty/School/Institute:	Arts
Department:	Geography & Environmental Studies
Course Name:	Env. Planning & Management
Title of the work:	Perceptions of the Effects of Short Lived Climate Pollutants on Urban Poor Communities: Case Study of New Kru

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this Project (Thesis , project, essay, assignment, paper, report etc) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work, or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work.
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own.
5. I understand that any false claim in respect of this work shall result in disciplinary action in accordance with University Plagiarism Policy.

Signature: .....

Date: 02/11/2018