TRAFFIC POLICE KNOWLEDGE, ATTITUDE AND PRACTICES
CONCERNING MOTOR VEHICLE AIR POLLUTION AT KEY NAIROBI
ROAD JUNCTIONS

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A Research Thesis Presented in Partial Fulfillment for the Award of Doctor of Philosophy in Environmental Governance and Management, University of Nairobi

December, 2017
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This thesis is my original work and has not been presented for a degree in any other university.

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This research thesis is devoted to my wife Emma Mueni Murangiri and children Teddy Muthomi, Tevin Munene, Abigail Kinya and Alvin Mwenda who have always been there with their love, encouragement, and understanding through the occurrence of the study.
AKNOWLEDGEMENTS

I would like to articulate my sincere appreciation to my supervisors Prof. Raphael G. Wahome, Dr. Kiemo Karatu, Dr. Thuita Thenya and Prof. Michael J. Gatari for their support, guidance, encouragement and continued support throughout the course of this work. And much appreciation to Prof. Michael J. Gatari for providing me with machines to measure air quality and particulate matter.

I am also indebted to the Inspector General, National Police Service for granting me the permission to conduct this study among his staff members. My appreciation also goes to Mr Julius Muthama Kitili Assistant Inspector General of police who organized traffic police officers to fill the questioners and much appreciation to all the traffic officers who accepted to participate in this study.
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<tr>
<td>CBD</td>
<td>Central Business District</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>EHHEI</td>
<td>Environmental and Human Health Effects Inc</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FEV</td>
<td>Forced Expiratory Volume</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>FVC</td>
<td>Forced Vital Capacity</td>
</tr>
<tr>
<td>GOK</td>
<td>Government of Kenya</td>
</tr>
<tr>
<td>H₂O</td>
<td>Water Vapour</td>
</tr>
<tr>
<td>HEI</td>
<td>Health Effect Institute</td>
</tr>
<tr>
<td>INTP</td>
<td>Integrated National Transport Policy</td>
</tr>
<tr>
<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
</tr>
<tr>
<td>N₂</td>
<td>Nitrogen</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>-------------</td>
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<tr>
<td>NEEMA</td>
<td>National Environment Management Authority</td>
</tr>
<tr>
<td>NMDA</td>
<td>N-methyl-D-Aspartate</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Nitrogen Oxides</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitrogen Dioxide</td>
</tr>
<tr>
<td>O₃</td>
<td>Ozone</td>
</tr>
<tr>
<td>PEFR</td>
<td>Peak Expiratory Flow Rate</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Respirable Suspended Particulate Matter</td>
</tr>
<tr>
<td>PM₂₅</td>
<td>Fine Suspended Particulate Matter</td>
</tr>
<tr>
<td>SO₂</td>
<td>Sulfur Dioxide</td>
</tr>
<tr>
<td>TPO</td>
<td>Traffic Police Officers</td>
</tr>
<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
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</table>
ABSTRACT

Vehicular air pollution is a growing problem in Kenyan cities due to high growth rates of motorized transport that contribute significantly to the increase in atmospheric particulate matter. Fuel and vehicle engine type are associated with the type and quantity of pollutants released into the environment with diesel engines releasing more particulate matter per kilometer. Exposure to pollutants is harmful to human health and the traffic police are more vulnerable to these emissions because members are constantly exposed to motor vehicle emissions. The objective of the study was to analyze the levels and traffic police awareness, attitude and practices and the health impacts of motor vehicle Emissions pollution in the Nairobi selected road junctions. Data was collected at the Kamukunji, Railways terminals, Uhuru highway and University way roundabouts and also from 127 traffic police officer respondents manning the junctions using self-administered questionnaires. An additional five (5) senior ranking officers were recorded in a key informant discussion. The level of PM$_{2.5}$ at Kamukunji Haile Selassie Avenue direction site measured was 180µg/M$^3$ while University way roundabout State house road direction central site registered the levels of 45.0 – 46 µg/M$^3$. However, concentrations of corresponding sites on different days of measurement varied greatly (135.0µg/M$^3$). The wide variation in the measurements was attributed to the varying traffic, sampling location and weather conditions at the time of sampling. Motor vehicle activity is critical to health wellspring of unsafe outflows of particulate contamination in urban communities. Traffic officers were knowledgeable regarding the undesirable effects of ambient pollution on their health especially respiratory disorders e.g. difficulty in breathing, wheezing sound, lung cancer, skin disease, bronchial asthma, and pneumonia associated to motor vehicle pollution. It was observed that a high number of the traffic police staff spend a long time on the roads (approximately 10 hours/day). Because of inadequate officers, they also frequently repeat a shift. From the studies, it is recommended that policemen be sensitized more on the hazards of motor vehicle air pollution, possibly by integrating the topic in the police course curriculum. Measures to reduce emission from motor vehicles need to be enhanced. In addition, policemen manning road junctions need to be provided with protective kits to minimize their exposure.
CHAPTER ONE

GENERAL INTRODUCTION

TO ANALYZE THE LEVEL OF TRAFFIC POLICE KNOWLEDGE, ATTITUDE AND PRACTICES AND THE HEALTH IMPACTS ASSOCIATED WITH VEHICLE EMISSIONS IN THE NAIROBI SELECTED ROAD JUNCTIONS.

1.0 Introduction

Nairobi is one of the fast growing cities in sub-Saharan Africa. The Kenya national census done in 2009 revealed that Nairobi Central District comprised of a resident population of 3.2 million people at night and 4.2 million during the day (KNBS, 2009). Currently according to the Ministry of Nairobi Metropolitan Development (GOK, 2013), the Nairobi Metropolitan had 6.8 million people, which it projected to rise to approximately 12 million by the year 2030. Much of the expansion is taking place in peri-urban areas as people move away from town to secure affordable housing. The Ministry of Transport and Communications (2004) conceded that this expansion coupled with inadequate investments in the public transport system has contributed to the deterioration of roads and consequently traffic congestion. Congestion arises when a roadway system approaches vehicle capacity, resulting in numerous negative impacts ranging from wasted fuel and time to increases in tailpipe emissions. Although major projects such as the Thika Superhighway and on-going projects exemplified by the construction of bypasses could ease the traffic problem, much still remains to be done.
According to Gupta et al. (2011) air pollution that emanates from road traffic results into health complications such as respiratory illnesses, blocked chest, watery eyes, breathing complications where by traffic police officers who are constantly exposed, may be at an increased threat due to the nature of their job. Mukaria, et al., (2017) investigated the relationship between knowledge awareness, attitude and practices among the traffic police officers who are exposed for long hours controlling traffic along the busy junctions and roundabouts in the city of Nairobi, According to the study Traffic police officer knowledge on pollution was discovered to be higher than the level of practice.

Among the motor vehicles that emit high fumes are big Lorries and public transport buses compared to small cars and taxis (Chattopadhyay and Roychowdhury, 2003, De Paula et al., 2005). According to Chattopadhyay and Roychowdhury (2003) automobile exhaust fumes comprise of particulate matter and gases such as nitrogen oxides, carbon monoxide, and other related waste products, which pose a danger to human health. The Motor vehicle pollution impacts on human health by affecting the bronchioles, obstructive pulmonary and respiratory systems of the body.

Researchers such as Heinrich & Wichmann (2004), Schikowski et al., (2005) and De Paula et al., (2005) assert that people who stay in the pollution affected areas are further vulnerable to the adverse effects of traffic pollution. The researchers identified categories of people such as residents bordering busy roads, children, the elderly, drivers, and traffic police as the most vulnerable groups. In addition, De Paula et al., (2005) noted that traffic police officers were more vulnerable to the negative effects of motor vehicle air pollution.
Traffic congestion which results in air pollution is likely to continue since adequate measures are yet to be put in place to deal with the traffic congestion especially in developing countries. Consequently, traffic police and other vulnerable groups continue to be at risk of negative effects on their health resulting mainly from motor vehicle exhaust fumes. It may be necessary for traffic police to wear ‘pollution masks’ for their own safety and to raise public awareness of the risks brought about by the motor vehicle air pollution. Despite this, it is unclear whether the traffic police have put in place measures to combat the negative effects of motor vehicle pollution. In all likelihood the level of awareness on this challenge may be low.

1.1 Problem statement

A vehicular emission has long term negative health consequences on those who are continuously exposed to them. However, the level of impact varies among the various vulnerable groups of people exposed to this vehicular emission. The impact depends on the direct contact with vehicular emission. Studies done in the past in regard to the vulnerable groups have shown that the traffic personnel are the most vulnerable group De Paula et al., (2005). This is because these personnel are continually exposed to the vehicular emissions since they stand for long periods in a day in city road junctions, highways and bus stops. The levels of awareness among these traffic police on the probable health risks that they are exposed to are quite low. This could be indicated by lack of wearing protective gears. Hence, the traffic policemen do not use the pollution masks when controlling traffic.
Nairobi is the fastest growing city in the third world countries and there is no automated traffic management system so policemen must be deployed on the roads to manually control traffic bearing in mind that most vehicle are second hand imports which are old and pollutes more than the new manufactured vehicles which are locally assembled.

Generally, the traffic policemen’s duty can be categorized into two groups namely; on the roads and off the road (Heinrich and Wichmann, 2004). The group on the road obviously the former involves a far greater health hazard with direct exposure to the vehicular emissions. Duty allocations are determined by the higher authorities without little choice of the policemen themselves. In such a scenario the traffic men can only mitigate their health effects if they take personal measures as the force in Kenya does not provide protective. Few studies have been done in the past in Kenya and more specifically, in the capital city of Nairobi to establish the levels of awareness among the traffic police of health risks associated with the vehicular emissions. It is against this premise that this study set out to analyze the associated health impacts of motor vehicle emissions on the traffic police in Nairobi, Kenya. This study will be useful in improving the welfare for policemen in terms of adoption of pollution protective gear and their health wellbeing.

1.2 Objectives

1.2.1 Overall objective

To analyze the level of traffic police knowledge, attitude and practices and the health impacts associated with vehicle emissions in the Nairobi Central business district and environs.
1.2.2 Specific objectives

The specific objectives of the current study are as follows;

1. To evaluate the effect of the number and flow of vehicles on air quality on selected city of Nairobi road junctions and estimate the level of exposure to policemen on duty at there.

2. To assess the traffic police officers level of knowledge about and attitudes towards motor vehicle emissions and associated health effects.

3. To Analyze the perception of health impact of motor vehicle emissions on traffic police in Nairobi, Kenya

1.3 Justification of the study

Vehicular emission has long term negative health consequences on those who are continuously exposed to it. The traffic policemen engaged in controlling traffic, particularly at heavy traffic junctions, belong to the high risk group to be affected by health hazards of air pollution. Most of the traffic policemen use a mask to prevent the ill effects of air pollution. However, a majority of them remain unaware about the health effects of air pollution. It is upon this premise that the study analyzes levels of awareness, attitude and practices among traffic police as well as the associated health impacts of motor vehicle emissions on the traffic police stationed in the Nairobi Central Business District (CBD) and environs.
1.4 Structure of the thesis

The thesis is structured in six chapters as follows; chapter one presents the general introduction of the study. Chapter two stipulates a comprehensive literature review on motor vehicle emissions and the associated health impacts. Chapter three captures the findings of this study on particulate matter from motor vehicles in Nairobi junctions. Chapter four provides findings on the levels of awareness, attitude and practice among the traffic police on motor vehicle pollution in Nairobi, Kenya. Chapter five presents findings on perception of health impact of motor vehicle emissions on traffic police in Nairobi- Kenya. Chapter six is the final chapter that includes the summary, conclusion and recommendations.
CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter explores the wider literature on the issue of motor vehicle air pollution with a view of identifying existing gaps in research. It has highlighted factors that influence exposure to traffic pollutants as well as vulnerable groups to traffic exposure. The section also analyzes the level of traffic police knowledge, attitude and practices and the health impacts associated with vehicle emissions.

2.1 Air pollution

Air pollution generally refers to the contamination of the air including indoors. Vehicles are estimated to be responsible for approximately 80% of today’s pollution while minor sources of pollution such as lawn mowers, cooking stoves, stationary diesel fuel tanks, heaters, gasoline stations, laundries and other contribute for the remaining 20% (Maina et al., 2006).

2.2 Polluting gases

Air pollution can be described as a complicated mixture of gases, dust, fumes and odours in diverse proportionate amounts, which are detrimental to human health, other species and ecosystems (Chow and Watson, 2002). Pollutants, which are capable of contributing to air pollution, can be either primary pollutants that directly pollute the air, for instance carbon monoxide from car exhausts and sulphur dioxide from the combustion of coal, or
secondary pollutants, which are primary pollutants that undergo a chemical reaction in the atmosphere (Chow and Watson, 2002).

2.3. Common pollutants emitted by motor vehicles

Air pollution is an important emerging public health problem in all developing countries. The gases emitted from motor vehicle tails through unburned fuel combustion, which are detrimental to human health. Among the most common pollutants are respirable particulate matter from smoky diesel vehicles, two-stroke motorcycles and 3-wheelers, burning of waste and firewood, road dust, and stationary industrial sources which are located near road Junctions.

The most known and very dangerous lead aerosol comes from combustion of leaded gasoline. In addition, motor vehicle emissions are a major source of nitrogen oxides and volatile organic compounds, which reacts to produce photochemical smog (ozone) in the presence of sunlight.

Sulfur oxides come from combustion of sulfur-containing fuels and industrial processes. Other pollutants that are directly linked to motor vehicle emission include suspected carcinogens such as benzene, 1.3 butadiene, aldehydes, and poly nuclear aromatic (Seagrave et al., 2001). Secondary particulate matter is formed in the atmosphere by reactions involving ozone, sulfur and nitrogen oxides and volatile organic compounds.
2.4 Motor vehicle pollution and effects on human health

According to the National Academic Sciences (2001), the health impact of the pollutants is dependent on the physicochemical characteristics of the pollutants, their inhaled concentration and the rates and routes by which the deposited pollutants are cleared from the respiratory tract or transported to other organs. WHO (2005) has associated air pollution from motor vehicles with increased mortality risk as a result of cardiopulmonary causes and significant risk of respiratory morbidity. Evidence of the exacerbation allergic reaction like asthma, increased risk of myocardial infarction and adverse outcomes of pregnancy such as premature birth and low birth weight, has been reported following motor exhaust exposure. According to Kunzli et al. (2000) air pollution causes 6% of total mortality per annum, half of which is attributed to vehicle emissions.

A study by Hoek et al. (2002) in the Netherlands associated cardiopulmonary mortality by living near major roads. The study revealed that elevated concentration of ultrafine particles may result in pulmonary inflammation and the release of mediators in the blood yielding increased plasma viscosity, which could lead to cardiovascular events including death. This is supported by the Health Effect Institute (HEI, 2010), who have observed that exposure to motor vehicle air pollution result in premature mortality among exposed populations.

According to Rosenlund et al., (2008) exposure to residential traffic-related air pollution increases the risk of fatal coronary heart disease. Nordling et al. (2008) have associated exposure to vehicle emissions during the first year of life with persistent wheezing, lower
peak expiratory flow and sensitization to pollen at 4 years of age. A study by Ulfvarson
et al. (1987) revealed that exposure to motor vehicle emissions may result in
genotoxicity. This was supported by Lewtas (1983), who concluded that extracted diesel
and petrol organics from motor vehicle particulates provided strong evidence of
mutagenicity in terms of gene mutation, DNA damage and chromosomal aberration.

United States environmental protection agency (2002) has reported that acute exposure to
diesel emissions may result in the irritation of the eyes and respiratory tract, with
associated respiratory symptoms such as cough and phlegm. Neurophysiological
symptoms such as light headedness and nausea have also been reported. A study by Salvi
et al. (1999) demonstrated that short-term exposure to diesel emissions result in systemic
and pulmonary inflammatory response in healthy humans. Significant increase of
neutrophils and B lymphocytes in airway lavage together with histamine and fibronectin
increase have been observed in healthy volunteers exposed to diesel emissions for a
period of one hour. Rudell et al. (1996) associated acute exposure to diesel emissions
with bronchoconstriction symptoms in healthy non-smoking volunteers aged between 20
and 37 years. Again, irritation of the nose, eyes and increase unpleasant smell was
observed.

2.5 Carbon dioxide from motor air emissions and its health effect

Carbon dioxide (CO₂) is a colourless non-flammable gas. It is produced by the
combustion of fuel containing carbon like petrol and diesel. The debate on climatic
change (global warming) has increased public awareness on the subject of CO₂ emissions.
Carbon dioxide CO₂ depletes the ozone layer, which protects the earth against the sun's
UV rays (greenhouse effect). These effects make carbon emissions to be of great concern due to its magnitude and potential impacts on all living things.

Carbon dioxide is removed from the atmosphere when it is absorbed by plants as part of the biological carbon cycle. According to United States Environmental Protection Agency (2015) in conjunction with Netherlands Environmental protection Agency (2015), China was declared to be the greatest carbon emitter with 29% metric tons per capita followed by United States of America. Most developed countries range in the top list of polluters due their industrial growth and manufacturing technology expansion. In comparison developing countries which depend on importation of finished goods from Europe and Asia continents emits less carbon although their rate is increasing on Daily basis due to demand of use of unclean energy and use of imported second hand old vehicles. Kenya in particular emits about 0.3% metric tons per capita and has committed to curb carbon emissions (Ministry of Environment Water and Natural Resources, 2014).

2.2.1 Particulate matter

Particulate Matter (PM), are elements, which comprises soot and metals present as smog in its murky colour. These fine particles less than one tenth the diameter of a human hair pose the most severe danger to human health, as they can infiltrate deep into lungs. Particulate matter exposure is associated with oxidative stress resulting in respiratory and systemic inflammatory responses. Araujo et al. (2008) suggests that this leads to chronic bronchitis, lung cancer, asthma and atherosclerosis. PM is considered directly as both primary pollution and a secondary pollution emanating from hydrocarbons, nitrogen
oxides, and sulfur dioxides whereby diesel exhaust is considered to be the foremost source of PM pollution (Elshout and Léger, 2007).

Solid and liquid aerosols detached in air are denoted as particulate matters (Brauer et al., 2012; Burnett et al., 2014). This occurs when there is grinding of ores, spraying and soil erosion. Aerosols are chemicals, which are released into the atmosphere as vapours. For instance, lead-containing gasoline fumes from automobiles constitute the chief source of lead contamination (Brauer et al., 2012; Burnett et al., 2014).

There are two types of aerosols namely settle-able and suspended particles. The settle-ble dusts have a particle longer than 10µg/M^3 (Belis et al., 2014). These smaller particles have capabilities to remain suspended for long periods in atmosphere. These particulate matter cause irritation of the respiratory tract and produce bronchitis, asthma and lung diseases. Smog is a dark or opaque fog, which is generated by dust and smoke particles triggering condensation of water vapours around them hence attracting chemicals like SO_2, H_2S, NO_2, among others. Smog creates respiratory troubles (Belis et al., 2014).

Fine particulate matter (PM_{2.5}) is influenced by motor vehicle emissions of both PM_{2.5} and particle precursors. Source apportionment studies finding vehicles contributing up to one-third of ambient PM_{2.5} in urban areas in the US, with an even greater contribution if secondary sulfate and nitrate are considered. PM_{2.5} has been associated with premature mortality in multiple studies, and health impact assessments have demonstrated PM_{2.5}-related damages in terms of hundreds of billions of dollars per year. Recently, an expert committee summarized the available epidemiological literature on exposure to traffic-generated air pollution and adverse health effects. They find strong
evidence for a causative role for traffic-related air pollution on mortality, particularly from cardiovascular events.

Unsafe air pollutants (toxics) are chemical compounds that have been associated to birth defects, cancer, and other severe illnesses. The Environmental Protection Agency of Kenya for instance NEMA, which was established under the Environmental Management and Co-ordination Act No. 8 of 1999 (EMCA) estimates that the air toxics emitted from cars and trucks which include benzene, acetaldehyde, and butadiene account for half of all cancers related to air pollution (NEMA, 2014).

**Other types of air pollution**

Natural air pollution is contributed by forest wild fires, wind, soil erosion, volcanic eruption, evaporation of volatile organic matter and bacterial disintegration. According to Environmental Protection Agency and the Clean Air Act of 1970 there are different kind and causes of pollution including gases like carbon monoxide (CO), oxides of nitrogen, ethane, ethylene and 3, 4-benzpyrine flow is not good. These gases are emitted as result of incomplete combustion of petrol and diesel. Industrial leading air pollutants emanates from chemical factories, paper and pulp, sugar, petroleum refineries and steel plants. The industrial exhaust comprise gases like Carbon monoxide (CO), Carbon dioxide (CO₂), Sulfur dioxide (SO₂), nitrogen monoxide (NO), Nitrogen dioxide (NO₂), Nitrous oxide, (N₂O), Chlorine (Cl₂), Fluorine (F₂), ammonia (NH₃), and particulate matters (Elshout and Léger, 2007).
2.2.2 Air pollution index

The Air Pollution Index (API) reporting system stands as a commanding instrument of hazard correspondence. This system informs the general society about the level of surrounding air pollution as well as the latent health hazards present, especially on vulnerable groups of people such as the children, the aged, and those suffering from cardiovascular and respiratory infections. The API are used to gauge air suitability of atmosphere for outdoor games.

There are discrepancies when it comes to selection of key air pollutants, as individual countries or prerogatives will seek to prioritize pollutants that create the largest effect on their residents (Elshout and Léger, 2007). Air poisons normally is utilized as a part of API computed by integrating nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃), carbon monoxide (CO), respirable suspended particulate matter (PM₁₀), and lead. Air poison that seems irrelevant in a specific nation might be prohibited by the national AQI/API display. In respect of this, Canada's Air Quality Health Index (AQHI) does not regard the groupings of SO₂ and CO while China’s API bars O₃ from its figures (Cairncross et al., 2007).

Motor vehicle traffic is an important source of harmful emissions of particulate pollution in cities of the developing world, where economic growth, coupled with a lack of effective transport and land use planning is resulting in increasing vehicle ownership and traffic congestion. These factors combine to create air pollution hotspots near roads. Urban growth is expected to continue at a rapid pace in the developing world, particularly in sub-Saharan Africa (UN, 2010) as rural populations continue to migrate to cities in
search of employment and expectations of better living conditions. If nothing is done to reduce emissions and to better plan for urbanization, this trend can be expected to further exacerbate already serious air quality problems in sub-Saharan African cities as well as the health impacts that accompany them. Fine particulate matter (PM$_{2.5}$), generated by fuel combustion like (from motor vehicles) have been linked to a wide range of health effects, including more than 800,000 deaths in cities around the world (Cohen et al., 2004; Pope and Dockery, 2006).

In Nairobi, it has been estimated that 90% of urban air pollution in rapidly growing cities in developing countries is attributable to motor vehicle emissions (UNEP, 2011). While there are many other sources of air pollution in Nairobi, including open air burning of refuse and biomass (Gatari, 2006), industrial operations and domestic cooking fires, motor vehicles play a critical role in the problem. Increasing road congestion, along with a high prevalence of old, poorly-maintained vehicles and of low quality fuels, contributes to this problem. One projection estimates that in a “do nothing” (or business as usual) scenario, the number of vehicle trips between 2004 and 2025 in the Nairobi Metropolitan Area will increase by 148%. The average speed of trips will decrease from 35km/hr to 11km/hr as congestion increases (Japanese International Cooperation Agency, 2006) which makes it reasonable to assume that if nothing is done, urban air quality will worsen.

The mixture of vehicles in Kenya in 2004 was 29% passenger cars, 35% light-duty trucks, 7% heavy-duty trucks, 7% minibuses (Matatus), and 22% others (KNBS, 2013). Most trucks and buses rely on high sulfur diesel fuel (≤5000 ppm S), which leads to high
particulate emissions. A large proportion of newly-registered vehicles in Nairobi are imported as used vehicles from East Asia, with high potential of polluting the air.

An imperative perspective in developing an API implies decision of applying average time(s) for every contamination. As the essential target of an API framework is to convey the health hazard identified in a particular area it is normal in respect of such framework to trail contamination fixations over smaller averages duration. In light of involvement around the globe, estimation of the API is normally in view of 60 minutes, 8-hour, or 24-hour normal observing information, contingent upon the poisons (Ove Arup et al., 2007). It is significant that while the convergences of utmost air toxins are measured by a shorter averaging time (like the 1-hour normal interval) for API estimations, for particulate matter (PM) this is obtained from the middle value of over a 24-hour term. This is because of the absence of logical proof for the presentation reaction association for PM over a one-hour time span (Cairncross et al., 2007).

When PM remains the dominant pollutant, the API system is not reactive enough to reflect a sudden surge in the level of PM, because the index is based on its concentrations averaged over the past 24 hours. There is predictably challenges as there is a time lag between the rise in concentration recorded at the monitoring stations and the rise in API readings; this time lag will delay the issuance of health advisories for impending air pollution episodes (Cairncross et al., 2007).

2.2.3 Most polluted cities of the world

The quality of air that we inhale becomes repetitively contaminated by industrial, household, road traffic, and other kinds of discharges. Massive factories and industrial
plants, billions of cars and public transport units, techno genic disasters, domestic aerosols, detrimentally affect the wellbeing of their citizens. Although, there were numerous endeavours to lessen and manage the rates of air pollution, it still remains one of the crucial difficulties facing humankind. There are some places whose cities ecology in terms of air pollution is so bad that it seems impossible to live there for example New Delhi in India (WHO, 2015).

According to WHO (2014), the most air-polluted city on Earth currently is New Delhi. This is because of a number of factors, such as an exponentially growing population (New Delhi has reached 25 million people), industrialization, and urbanization involving coal-fired power plants, and intense traffic with many cars fuelled with diesel, it is easy to understand why New Delhi is recognized as the city with the worst air in the world. According to EcoWatch (2016) pollution has increased to an extent that (the) outdoors in Delhi resemble a gas chamber (EcoWatch, 2016).

The Iranian city of Zabol is another example of a city with extremely polluted air. The city which neighbours Afghanistan, Zabol city according to the WHO remains one of the most polluted city in the world. The concentration of hazardous particles in Zabol’s air averages 217 micrograms per cubic meter of air, whereas the required limit by WHO is only about 60 micrograms. Nowadays, these dusty winds contaminate the city’s air even more; besides, the loss of Hamoun wetlands has caused a dramatic increase in the amount of respiratory infections among citizens: tuberculosis, for instance, have become one of the most drastic and common problems of Zabol (World Atlas, 2016).
More than 80 per cent of people who live in urban areas are affected by air pollution levels beyond the WHO limits. Despite the fact all regions of the world are affected, populaces in low-income cities are the utmost impacted. According to the latest urban air quality database in accordance with WHO, 98% of cities in low and middle income countries with more than 100,000 inhabitants, including Nairobi, do not meet WHO air quality standards guidelines (WHO, 2001). A study by WHO (2014) made an assessment encompassing a total of 795 cities in 67 countries for levels of small and fine particulate matter ($\text{PM}_{10}$ and $\text{PM}_{2.5}$) during the five-year period, 2008-2013. $\text{PM}_{10}$ and $\text{PM}_{2.5}$ comprised pollutants such as sulfate, nitrates and black carbon, which infiltrate deep into the lungs and into the cardiovascular system, posing the extreme hazards in relation to human health requirements.

Within the African countries, built-up city air contamination evidence is high. available indicate that particulate matter (PM) levels in surrounding airborne contamination, remains an ecological hazard to health contributing in excess of three million unanticipated losses worldwide dependably (McGranahan and Murray, 2001). Africa's metropolitan air is predominantly polluted based on the grounds that the second hand imported motor vehicles from Japan and Europe pollutes more because they are old. In this context, threat prevails due to the effect of turning Africa into a dumping place for the world's old auto mobiles, which do not meet rich nations' air quality benchmarks (McGranahan and Murray, 2015).
2.2.4 Nairobi City, Kenya

Nairobi city is the biggest metropolitan town in Kenya as the nation's capital city. It covers a region of about 700 km$^2$ and had a population of more than 3.2 million according to KNBS (2009), which now stands above 4 million. According to the urbanization growth rate (2016) Nairobi built up city is purported to be the fastest growing city in the World after Guadaloupe, Mexico City (Mexico) and Maputo (Mozambique).

Nairobi built has no air standards administration framework so far, and no estimations of air pollution have been done. Assessment of 20 developing nations that were examined by UN think tank on air quality administration ability, Nairobi's ability was evaluated as the most exceedingly harmful (UNEP/WHO, 2013). In spite of the fact that the present temperament of airborne in Nairobi City does not present uncomplicated health or ecological issue, accessible information demonstrates that air quality has been quickly deteriorating (Karue, et al., 1992). Thynell (2013) states that the measure of tumour causing components noticeable in Nairobi city remains 10 times greater with regard to WHO standards. Thynell (2013) further noted that on the greater part of Nairobi's air contamination is unrestrained and especially fatal in ghetto areas and along busy roads it poses threat to drivers, other road users and traffic police.

According to Gatari, (2015) predictions indicate that Kenya will have a very sick population in the near future. Even with limited data there is indication that Nairobi is around 30 times worse than in London, and that Kenya is building up an immense health problem. Thirty percent more diesel is being burned in Nairobi compared to five years
ago. Hence, without doubt, the pollution will have a huge economic and health impact. There is likelihood that there will be more and more cancers and heart disease, many more asthma cases and respiratory disease.

2.2.5 Mitigating pollution

There is pressing need to vigorously authorize the Air Quality Regulations passed by the National Assembly and gazetted in 2014 to secure the valuable air that Kenyans inhale from further contamination. The controls envisaged in the law are intended to check contamination of air by vehicles, production lines and different sources by guaranteeing least air-quality measures to secure human health and permit a sufficient edge of health. There are several approaches available to mitigate effect of pollutants on the air. For example, enacted carbon is declared as the most prevalent types of air pollution control methods among other known categories. This category of reduction mechanism includes reducing the extent of size of toxins that are permitted to escape into the airborne (Bond et al., 2013).

Bio filtration is another compelling sort of air pollution control. It utilizes microorganisms, frequently microscopic organisms and growths to break up toxins. Ventures that utilize bio filtration frameworks incorporate sustenance and throw away plants, pharmaceutical organizations, and fritter away water administration offices. While this technique for air pollution control works rather well, an extensive room is required to operate a bio filtration framework. Numerous businesses don't have enough space to make use of this technique. Change in fuel is used as method that involves consumption of less contaminating energy to reduce airborne pollution. Utilization of minimal sulfur
fuel other than the maximal sulfur fuel is the new approach in reducing air pollution. It is essential to note that low sulfur fuel is remarkably expensive than high sulfur fuel, thus posing a limitation in shifting (Prasad and Bella, 2010).

The other choice for fuel usefulness could be the consumption of petroleum fume as energy. Utilization of fuel containing less residue constituent or flammable fume to reduce particulate matter remains another modality in this procedure. Presentation of packed flammable gas, propane, ethanol and oxygenated energizes for motor vehicles have helped in decreasing of air toxins. Nuclear power plants are moderately contamination free when contrasted with the coal control plants though this is contested in terms of potential ecological effect (Sydbom et al., 2001).

2.3 Traffic as a source of pollution in Nairobi

Motor vehicle related air pollution has become a problematic issue both within and outside Nairobi. It is evident that air crises in cities continue to rise partly because of the increasing levels of motor vehicle emissions. With the expansion of the economic base in Nairobi, the numbers of motor vehicles have also increased. Given that exposure to pollutants is harmful to human health, the traffic police are more vulnerable because they are constantly exposed to motor vehicle emissions when during traffic flow (Cohen et al., 2005).

The Nairobi metropolitan town is predisposed by high rates of ambient pollution and natural debasement instigated by the poor transport framework. Accessible measurements demonstrate that ambient pollution in Nairobi is great with a daytime convergences mean of fine particles extending 10.7μg/m3 in peri-urban area to 98.1μg/m3 on a walkway in
the CBD. Air worth inspections indicates that there is a concrete connection between fine particulates and engine vehicles \((r = 0.93)\), demonstrating that vehicular fumes is the primary fountain of fine particles noticeable all around (Odhiambo et al., 2010). In reality, the vast majority of the respiratory issues and other health issues are related to vehicle exhaust.

### 2.3.1 Motor vehicle pollution in Kenyan cities

Motor vehicle activity is critical in determining the wellbeing of any society. The unsafe outflows of particulate contamination resulting from vehicular emissions especially in urban communities, where there is economic growth, combined with an absence of successful transport and land utilization arrangements has brought forth increased vehicle possession and consequently increased traffic congestion. These variables make air pollution particularly worse at road junctions where traffic police are often station thus receiving greater exposure (Maina et al., 2006).

Fine particulate matter \((\text{PM}_{2.5})\), generated by fuel combustion like (from motor vehicles) has been linked to a wide range of health effects, including more than 800,000 deaths in cities around the world (Cohen et al., 2004; Pope and Dockery, 2006). However, little information exists on levels of particulate air pollutants currently experienced by urban residents in Africa (Gatari et al., 2005; Maina et al., 2006; van Vliet and Kinney, 2007).

### 2.3.2 Greening of cities

High levels of pollution caused by motor vehicle and local industries emissions in Kenya remains a misery to the Kenyan population due to inadequacies in the policies to curb this
uncontrolled menace. Many people lack knowledge and awareness to tackle the debilitating effects of pollution (Gatari, et al., 2005).

Greening of cities is one approach that urban communities around the globe are adopting to attempt to enhance their general ecological execution. For example, Kenya have overtime increased planting of trees in urban areas in major cities emulating best greened cities in the world like Stockholm, Sweden. Copenhagen, Denmark. Freiburg, Germany. Malmo, Sweden. Vancouver, Canada. San Francisco, California. Portland, Oregon (Gatari, et al., 2005). Support for space in urban ranges is particularly vital for air cleansing, in light of the fact that urban territories contain the most particulate matter, because of wealth of mechanized vehicles, and as a result of the high frequency of asthma and other breathing issues in internal city urban regions (Gatari et al., 2005).

Air cleansing incorporates not just evacuation of tidy, soil and particulate matter, but also expulsion of essential climatic toxins. Particulate matter under ten microns in breadth has been related with genuine human health impacts, including asthma, cardiovascular ailments and other respiratory diseases and natural harm. Basically, evacuation of tidy, soil and particulate matter by green spaces enhances good human health (Gatari et al., 2005).

2.3.3 Types of vehicle engines and their fuel

Exhaust gases are produced as a result of the ignition of petroleum gas, gas, oil, biodiesel mixes, diesel fuel, fuel oil, or coal. Depending on the category of motor, it is released into the environment through a tail pipe. These exhaust gases are composed of nitrogen (N₂), water suspension (H₂O) in addition to carbon dioxide (CO₂). Carbon dioxide is an ozone
depleting substance that adds to an Earth-wide temperature boost. A moderately small part of ignition gas is composed of toxic material such as carbon monoxide (CO) that results from deficient ignition, nitrogen oxides (NO\textsubscript{x}) from inordinate burning temperatures, and particulate matter (Gatari \textit{et al.}, 2005).

The health effects of inhaling airborne particulate matter have been widely studied in humans and animals and include asthma, lung cancer, cardiovascular issues, and premature death. Because of the size of the particles, they can penetrate to the deepest part of the lungs. A 2011 UK study estimated that 90 deaths per year occur due to passenger vehicle PM. In a 2006 publication, the U.S. Federal Highway Administration (FHWA) state that in 2002 about 1 per-cent of all PM10 and 2 percent of all PM2.5 emissions came from the exhaust of on-road motor vehicles mostly from diesel engines (Vliet and Kinney, 2007).

2.3.4 Nairobi urban area

The city of Nairobi which is regarded to be most conducive for both economical and habitation due to its unique characteristics and geographical location remains and exhibits a lot to be desired. These characteristics includes its geographical location as well as the tourist attractions sites such as the Nairobi National Park make Kenya’s capital the most desired destination for various local and international tourists. Moreover, rural to urban migration majorly in search of employment opportunities and educational facilities has contributed to high level of population growth in most cities of Kenya and especially Nairobi.
2.3.5 Population size and distribution of Nairobi

Nairobi is the capital city of Kenya. The city is located at 1° 16' south and, 36° 48' east, 140 kilometers (87 miles) south of the Equator. The city has an elevation 1,680 meters (5,512 feet) above ocean level with an area of about 689 sq. km (266 sq mi). (Odhiambo et al., 2010)

2.3.6 Climatic conditions

Nairobi has a warm tropical climate with a mean temperature of 17°C, dry season temperature rises to 29°C with cold months of July and August having as low as 12°C. The annual precipitation ranges between 500-1500mm with a mean annual rainfall of 875mm (Odhiambo et al., 2010).

2.3.7 Roads types and lengths

Air studies propose a strong correlation between fine particulates and motor vehicles (r = 0.93), signifying that vehicular emissions is the main origin of fine particles in the atmosphere (Odhiambo et al., 2010). This phenomenon contributes to the worsening quality of urban communities’ health and environment and it is clear that majority of the leading health issues in Nairobi city are related to vehicle exhaust fumes (Odhiambo et al., 2010). Ambient pollution that purely emanate from vehicles and trucks is divided into primary and secondary contamination. This principle indicates that primary pollution is released directly into the atmosphere while secondary pollution results from chemical reactions between pollutants in the atmosphere (Odhiambo et al., 2010).
CENTRAL BUSINESS DISTRICT, NAIROBI, KENYA MAP

Figure 2.1: Nairobi County Map (Source, Kenya Maps, 2017)
Most of the low income earners live in the suburbs of the city. They usually trek to and from work place hence crowding the city. This trekking by the urban poor slows down traffic especially at the zebra crossings to pave way for large crowds to cross roads. This is worsened by lack of proper infrastructure to cater for both vehicle and other road users including pedestrians and riders (Odhiambo et al., 2010).

2.3.8 Traffic flow and management

Traffic conditions in Nairobi are characterized by congested and perilous roadways with inconsistent execution. For a city of approximately 3.2 million occupants, Nairobi has couple of opportunities to upgrade so as to match urban areas of comparable size in similar countries with mechanized movement (Katahira and Engineers International, 2013). The city's physical road foundation comprises principally of cleared streets radiating radically from the focal point of the city to encompassing neighbourhoods. Around the down town area of the city, there is no less than 18 crossing points that have been purposeful fitted with movement signals (Katahira and Engineers International, 2013).

The convergences where major arterials from the encompassing neighbourhoods enter the CBD they are normally controlled with vast movement circles such as those along Uhuru Highway, Ring Road, and the Globe cinema area. The conservative downtown area is made out of a matrix like system of avenues.

The management of traffic flowing in and out of city of Nairobi mostly uses traffic light signals as the main technology. Other management methods that are commonly in use is mainly human interceptive methods, which comprises of traffic police officers
situated in strategic areas occasionally frequented by huge congestions or traffic snarl ups. These areas are commonly the intersections such as roundabouts, cross junctions and filter road junctions. It has been observed in the recent past that in Kenya human interception had taken a toll order in determining how the traffic flowed regardless of whether there exists a traffic light signal at the intersection or roundabout or not (Manyara, 2013).

Traffic police report on duty during early hours of the day in order to facilitate vehicular movement in and out of the CBD. Traffic police men through use of communication walk talkies relay traffic information from one location to the other officers to enable and facilitate traffic on a daily basis. The recently established traffic control room, which was funded by Chinese government and Safaricom in Kenya, has started reaping some benefits and Kenyans at large. This is due to the adequate utilization of installed cameras, which guides controller to highlight heavy traffic leading to faster response in resolving the problem (Ogendi and Aysis, 2011).

2.3.9 Causes of traffic jams

Kenya has in the recent past experienced increased registrations of second used motor vehicles, which are imported from Japan with most ending in the city. At the same time there is increased flow of both matatus (public service) and private vehicles that flock the city of Nairobi during the morning and evening peak hours contributing to high congestion (Ogendi and Aysis, 2011). Other sources of congestion include obstacles in the roads that are caused by dual vehicle parks, road work construction in progress.
leading to some lanes being closed as well as road narrowing down in case of occurrence of an accident (Manyara, 2013).

Poor calibration of traffic light and time awarded to each colour is another factor, which slows down vehicular movement in certain areas of the city. Areas with high traffic flow are awarded greener colour timing than less traffic flow roadways. However, there is no satellite area surveillance that have been done in the city to give correct calibration and also consider congested routes to pave way for automated light control systems (Manyara, 2013).

2.4.9.1 Undesignated pedestrians zebra crossing points

In recent past those people who live in the satellite estates bordering city of Nairobi such as Kitengela, Umoja, Mwiki, Kasarani and Mulolongo have the option to use train to commute to the city, although it has limited capacity. On alighting at railways terminals crossing over to town at one designated area causes a lot of traffic snarl up. These areas have been mapped as Nairobi railway terminals where it affects traffic flow along the railway terminals roundabout during morning and evening peak hours. Cycling is appealing, although, only a few individuals cycle to work or school. This is because there is little or lack of arrangement for pathways and cycle tracks in the city (Manyara, 2013).

2.4.9.2 Road transport and congestion

The use of trailers is the main method of transporting freights. The trailers help to transport imported goods to Nairobi and through the city to other parts of the country. These goods include house hold goods and building materials, which are sold in CBD. The trailers use already congested roadways causing a lot of traffic jam (Manyara, 2013).
Lack of construction of new transport routes coupled with absence of expansion overtime since independence has been a major transport challenge in the city of Nairobi. Lack of expansion of roads commensurate with increasing demand to cater for the needs of the city dwellers’ as results of inadequate funding is a major problem in Kenya’s transport network (Manyara, 2013).

The concentration of vehicles onto few streets and through few intersections, along with the limited available routes, makes traffic congestion in Nairobi’s inevitable. In order to drive into or out of the city center, vehicles must pass through one of six gateway traffic circles on the CBD’s edge. When critical parts of the network such as intersections near the CBD are unable to serve the traffic demand, vehicles cannot choose alternative routes to by-pass congestion, this leads to widespread congestion effects.

2.4.9.3 Nairobi traffic officer’s management of vehicle flow

Nairobi is served by various feeder roads Mombasa road, Jogoo road, which joins through Landhies road, Waiyaki road from Westlands, Thika road, which joins through Kirinyaga road. Others are Eastleigh and Pangani road, which joins through ring road and Kariokor, Ngong road and valley road all end to CBD of Nairobi (Gatari et al., 2015).

The traffic officers who man traffic in city of Nairobi are drawn from Nairobi area traffic and central traffic base that operate within the CBD. The officers operate in shifts and interchange on weekly basis depending on location of deployment. However, the time or duration of stay within the station of deployment is not considered. On average each deployed officer works an average of about 15 hours daily basis with an option of an off
duty once in 3 days to 5 days depending the reason and distance of the destination of the officer borrowing permission (WHO, 2016).

Traffic officers are stationed on marked points like intersections and roundabout junction, which include; Kamukunji, Railways terminus roundabout, Uhuru roundabout and University way roundabout among other areas. Other areas where traffic snarl ups that often demand traffic officers enforcement include; Baroda, Ronald Ngara, Tom Mboya intersection, Nyayo house round about, Tom Mboya, Accra road, Bus station, Uyoma road, race course and River road (Gatari et al., 2015).

Traffic officers manning these junctions, intersections and streets manually disregard use of traffic light control system, which could see fewer or no police officers on the Kenyan city streets. The traffic control lights have not been very effective since it is not moderated and controlled to address increased traffic flow (Gatari et al., 2015).

The newly installed CCTV Safaricom cameras have not been fully utilized to man the traffic flow of city of Nairobi. The controllers were trained on how to use the cameras and how to detect traffic violators and communicate to the ground men for immediate arrest. The new County Council traffic marshals are not yet trained on proper mechanisms of traffic control (Gatari et al., 2015).

2.4 Knowledge attitudes and practices regarding air pollution

2.4.1 Knowledge

Air pollution is cited as one of the reasons for the increased global climate changes. There is diversity of air pollutants including greenhouse gases, which contribute to
diverse health complications. The prevailing amount of greenhouse gases has considerably increased owing to the extensive human activities such as increased car emissions and the emission of pollutants from coal-based power plants and diverse manufacturing factories. Carbon dioxide is a prominent greenhouse gas and a common part of the car exhaust, which trap heat from sun in the atmosphere, leading to global warming and climate changes (Bryceson et al., 2008).

Traffic police knowledge about air pollution in cities and their contribution in coming up with the solutions to this problem is a very essential subject. This is because their contribution to the elimination or reduction of air pollution is one of the most significant bases to improve air worth and is directly dependent on the amount of traffic perception to combat traffic snarl ups.

2.4.2 Attitude

Traffic police are considerably exposed to the pollution brought about by slowing down of traffic. This phenomenon has been attributed to the nature of their work, which involves standing in heavy traffic for prolonged periods. A study targeting traffic police done in India revealed that the police who worked up to 8 hour shifts at traffic lights were exposed to elevated levels of respirable floating particulate matter compared to those traffic policemen working in rural environments with considerably less traffic (Starkey et al., 2002).

According to Volpino et al. (2004), study on traffic policemen in a large Italian city showed decreased gross mechanical efficiency and a decrease in the amount of keep fit moment at an anaerobic entrance and maximal endeavour compared to those whose
exposure was less. In addition, those working in chronic air pollution had a higher frequency of respiratory allergies (Volpino et al., 2004).

### 2.4.3 Practices

A study by Bryceson et al. (2008) observed that the use of facial masks could help to lessen consequences of air pollution. A minority of the traffic police implemented rules in vehicles for less emission of gases (Bryceson et al., 2008). This might be due to ineffective rules regarding prevention of vehicular emission. In Kathmandu Valley, vehicular emission is the major contributor to air pollution. A study done by Bhaduri (2012) in Kathmandu Valley indicated that the total estimated emission (CO, CO₂, HC, NOₓ, SO₂, and PM₁₀) was 7,231,053.12 tons/year, majority of which CO₂ was (91.0%) and CO (5.0%). In addition, at the time of this study, demolition of buildings and construction of roads were in progress. This could have aggravated the condition of air, eventually deteriorating the health of the traffic police.

The good health of traffic police and city dwellers can be ensured only if the government implements vehicle inspection and emission testing effectively and implement bans on polluting vehicles (Huang and Ghio, 2004). Moreover, people who sit in the balcony of pubs, restaurants, and entertainments where there are established vehicle picking and dropping zones are not aware of their increased exposure to motor air pollution.

### 2.5 Air pollution and health

Long exposure to air pollution can cause various respiratory diseases including; asthma, bronchitis and unending disruptive aspiratory ailment (COPD). The negative effects of air
pollution to human health have been a general health concern around the world (Cohen, et al., 2005).

2.5.1 Health risks associated to air pollution

Contamination causes harm to people, merchandise, and the environment. Be that as it may, the extent of the pollution quite often is not completely grasped by those who contribute to pollution. As characterized by Heck and Hirschberg (2011), an effect on a group of people or on the environment, which is caused by yet another group which is not completely represented by the contributing group, is called an externality. Hurtful externalities are called 'outside incidentals.

Particulate matter that infiltrates the alveolar epithelium (Ghio and Huang, 2004) and ozone results into lung irritation (Uysal and Schapira, 2003). Affected patients infected by lung sores or lung maladies, continued toxic irritation strength worsen their situation. In addition, air poisons, for instance, Nitrogen oxides increases the vulnerability to breathing contaminations. In the long run continuous depletion of the ozone layer and huge volumes of fine particles weakens lung functions, at the same time contributing to asthma, emphysema, and even lung tumour (Wegmann et al., 2005).

The sensory system is mostly prone to substantial hazardous particles (lead, mercury and arsenic), dioxins and neurotoxicity prompting neuropathies with result to side effects, for instance, memory irritations, fatigue, inflammations, weariness, hand tremors, blurry vision, and slurred speech, have been seen after arsenic, lead and mercury contaminations. Particularly lead damages the dopamine and glutamate systems while N-methyl-D-Aspartate (NMDA) receptor complex which assumes an essential part in
memory power (Lasley and Gilbert, 2000; Lasley et al., 2001). On the other hand, mercury is responsible for specific instances of neurological growth. Dioxin in particular diminishes nerve conduction speed and weakens mental development and capability of kids (Thomke et al., 1999; Walkowiak et al., 2001).

Large amounts of metals particles can instigate kidney damage, for example, an underlying tube-like brokenness confirmed by an expanded discharge of low sub-atomic weight proteins, which advances to diminished glomerular filtration rate (GFR). Furthermore they increase the danger of stone development or nephrocalcinosis (Damek-Poprawa and Sawicka-Kapusta, 2003).

2.5.2 Managing pollution related health risks

Air pollution can be eliminated by turning off your car when stuck in jams. It can be reduced by the reduced combustion of fuel during traffic jams, keeping away from combustion smoke and wood smoke, minimizing the levels of PM that infiltrates into our homes, and decreasing our work environment contaminations (Ganguly et al., 2009). Drive with the windows shut, and set the vehicle ventilation to reuse the air. Channels, room air cleaners and aeration and cooling systems can help decrease indoor PM. More potent measures include wearing a face veil, introducing PM channels in your home, and moving to less polluted neighbourhoods.

The EPA Air Quality Index and mass media alerts makes individuals mindful of the status of air quality in their environments. At the point when air quality is compromised, those with heart or lung sickness, more seasoned grown-ups, and kids ought to maintain a strategic distance from delayed or overwhelming effort like. Others should keep on
exercising yet attempt to stay away from contaminated spots. When deciding, don't bicycle by congested streets or at high speeds. Diminishing presentation has any kind of effect: Decreasing the PM levels in a zone can lessen cardiovascular mortality inside a couple of years.

2.6 Traffic police officers exposure to health risks

Exposure to high levels of air pollution from engine vehicles is mostly associated with the increase in cardiovascular maladies, lung tumour and respiratory ailments, for example, bronchitis and respiratory tract diseases. In addition, it creates the impression that the traffic exhaust could assume a basic part in the enlistment of unfavorably susceptible conditions (Ganguly et al., 2009).

Several epidemiological studies showed an association between exposure to motor vehicle traffic emission and allergic symptoms and reduced lung function. Exposure to air pollutants enhances airway response to inhaled allergens in susceptible groups (Ganguly et al., 2009). A few toxins (NO2, O3, and PM parts) are connected to asthma allergies and may lead to asthma complications. In the majority of the industrialized nations, individuals who live in urban areas have a tendency to be more influenced by unfavourably susceptible respiratory infections than those in rural areas.

Since occupation is a major determinant of health, traffic police personnel face multiple occupational hazards. They are continuously exposed to vehicular emissions; work in noisy and polluted environments. Standing for long hours in a static position makes them vulnerable to ergonomic problems. Managing high volumes of traffic flow results in physical and mental fatigue among traffic policemen making them susceptible to physical
and mental stress. Both physical and mental health manifestations get accentuated with the increasing length of service. Outdoor occupations in general are hazardous in nature due to prolonged periods of exposure to high concentrations of motor vehicle pollution putting the employees at increased risk of respiratory and cardiovascular diseases. Traffic police personnel are at the highest risk for the adverse health effect of air pollution, compared to the general population (Ganguly et al., 2009).

2.6.1 Traffic police officer duties

The purpose of the Traffic Officer in Kenya is to undertake general traffic and road management tasks. The traffic police officers are mandated to; stop traffic and close roads, lanes and carriageways; direct and divert traffic and pedestrians; place and operate traffic signs; Manage traffic at traffic surveys. These involve stopping vehicles and asking drivers about their journeys. The information from these surveys is used to develop and plan future investment in the transport system.

The removal or arranging the towing of abandoned or broken down vehicles which are causing an obstruction or are a safety hazard on the road; and authorizing exceptions and relaxations for other road users from the motorway regulations. The role of the Traffic Officer is to deal with routine incidents including non-injury Road Traffic Collisions (RTC’s) on the network and to assist the emergency services by dealing with traffic management at more serious incidents.
2.6.2 Manning of road junctions

Traffic on roads may is made up of pedestrians, private cars, public vehicles, community animals all automobiles which are used for the purpose of transports and different movements, either driven, led or on their own provided they are using the public road. Traffic laws are drawn from Traffic Act Section 403 laws of Kenya. This is an Act of parliament covering laws related to traffic. The National Transport and Health Profession Act and Insurance Motor third party Act section 405 laws of Kenya. This is an Act of parliament which covers against outsider hazard party dangers emerging out of the use of motor vehicles on the roads. Ordinarily five traffic officers are deployed to man a given road junction each officer controlling the vehicles converging at the junction. In addition there is a senior ranking officer in the rank of sergeant who oversees the overall flow of vehicles. The officers manage the junctions through communicating with each other using walkie talkies giving instructions for vehicles to proceed or to stop.

Traffic violators who change lanes wrongly and other common checks like vehicles documents and those of drivers are regularly checked and offenders prosecuted. This operation takes off from 5.30 AM to late 9.30 PM of every day until the shift is changed weekly to pave way for those officers to be deployed elsewhere like streets and intersections.

2.7 Knowledge gaps and research needs

Air pollution and its associated impacts have gained the attention of Kenyans and the world at large. As more studies have been done to reveal the relationship between air pollution and human health, more people have started paying attention to this issue.
Exposure to vehicle air pollution while undertaking day to day activities has been evidenced to be associated with the increased cases of respiratory diseases. These findings have the potential to impact the daily activities of millions of people living in developing countries.

There is a growing body of knowledge related to the health hazards of ambient air pollution drawn from different scholars all over the world (Cairncross et al., 2007). However, there exists very scanty data on exposure to motor vehicle emissions and the associated health impacts. This necessitated the current study that aims at examining the health impacts of motor vehicle pollution on the traffic police officers in Nairobi, Kenya. Hence, this study aims to contribute to the existing body knowledge on motor vehicle pollution and its associated impacts on the traffic police officers.

It is an essential component of atmospheric air pollution control, as meagre data is accessible about residents' KAP of involving air pollution and health in Kenya. Albeit a few studies have been undertaken and awareness created concerning atmospheric air pollution and its antagonistic health impacts conducted in a few nations, such interventions have not been pursued in Kenya (Arup, 2013). It is also imperative to comprehend and recognize factors related with the citizens' information of current encompassing ambient air pollution, attitudes toward reduction of air pollution, and the acts of assurance in Kenya. This data could be vital for the government since it will contribute to the advancement of more impactful strategies and viable measures to lessen air pollution in the long run. The literature on motor vehicle pollution and its effects is extensive (Derwent, 1999; Holman, 1999, De Paula et al., 2005).
However, few studies have focused on the aspect of knowledge, attitude and good practices among traffic police officers and their immediate cause of action to evade dangerous emissions from motor vehicles. The relationship between knowledge, attitudes and practices is important, given that traffic police are highly exposed to motor vehicle pollution in the course of performing their duties. Exposed individuals have the right to know what they are at risk of as well as the right to actions that reduce their exposure to such emissions. In addition, the concept of knowledge, attitudes and practices in regard to vehicular pollution is even more significant in the traffic department, hence, the need for continuous research focusing on this knowledge, attitudes and practices on vehicular pollution among the traffic police. This necessitated the current study that aims at filling this gap that will also enhance policy formulation based on recent data.

2.8 Conceptual framework

The Conceptual Framework for Assessing Vulnerable Population Exposure to Motor Vehicle Exhaust emissions is created based on the understanding of the connection between motor pollution factors and its effects. A host of factors influences population exposures to motor vehicle air pollution and their associated adverse health outcomes. The conceptual framework summarizes the key factors influencing the degree of exposure from the source of emissions as indicated below in figure 1.

Based on the ecological modernization theory, urbanization tendencies result in an expansion in the number of motor vehicles used. With such developments, the amount of emissions also increase leading to a rise in the risks associated with adverse health effects of motor pollution.
From the diagram, various factors contribute to motor pollution. However, the level of awareness, attitudes and practices among the police officers affect the level of their preparedness in addressing the adverse effects of motor air pollution. Hypothetically, when the levels of awareness of the effects of pollution are high, the traffic police are likely to take protective measures leading to high levels of preparedness. Similarly, a positive attitude among the police officers is likely to influence their responses to the pollution problem. The practices that the traffic police take also influence the level of preparedness they institute against motor air pollution.
Motor vehicles to the receptor population

Figure 2.2: Conceptual framework

<table>
<thead>
<tr>
<th>Factors</th>
<th>Awareness</th>
<th>Traffic police preparedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual vehicle emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collective vehicle traffic emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadway features</td>
<td></td>
<td></td>
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<tr>
<td>Impact on health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td></td>
<td></td>
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<tr>
<td>Practices</td>
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</tr>
</tbody>
</table>
CHAPTER THREE

PARTICULATE MATTER FROM MOTOR VEHICLES IN NAIROBI ROAD JUNCTIONS KENYA

ABSTRACT

Motor air pollution has become a problematic issue both within as it contributes to environmental degradation. It is evident that air crises in cities continue to rise partly because of the increasing levels of motor vehicle emissions. With the expansion of the economic base, cities such as Nairobi also expand paving the way for an increase in motor vehicle ownership and use, which lead to higher rates of pollution. Given that exposure to pollutants is harmful to human health, the traffic police are vulnerable because members are constantly uncovered to motor vehicle fumes.

The survey interviewed a purposive and non-random stratified sample of 127 police officers, according to their seniority, years of employment and work experience, from the target population of traffic police working in major road junctions within the CBD, Nairobi Kenya. The sampled junctions were Kamukunji, Railways terminal, University way and Uhuru roundabouts. In addition, from the leadership rank, five (5) key informants were also interviewed. Data was collected using self-administered questionnaires. Discussions were held with the key informers.

The findings show that there are that the high concentrations of PM2.5 in Nairobi major roundabouts is attributed to vehicular traffic congestion and worsened with poorly maintained and old vehicles. The significantly high values obtained compared to World
Health Organization 24 hour guideline of 25 µg m$^3$ (2000) creates a severe health issues to regular pedestrians and workers around those areas.

The study exposes that there are association between fine particulates and motor vehicles ($r = 0.93$), signifying that vehicular emissions is foremost source of fine particles in the atmosphere.

**Keywords:** Particulate Matters; PM$_{2.5}$; Motor vehicle pollution; Exposure.

### 3.0 Introduction

Motor vehicle road traffic is a critical basis of destructive discharges of particulate contamination in urban areas of the emergent world, where economic development, combined with an absence of powerful transportation and proper land utilization planning is bringing about expanding motor vehicle proprietorship and traffic overcrowding. These phenomenon and components combine to make air contaminations very high near roads.

Urban development is required to proceed at a fast pace in the creating scene, especially in sub-Saharan Africa (UN, 2010) as rustic populaces keep on migrating to urban communities looking for business and desires of better living conditions. In the event that nothing is done to diminish discharges and to better arrangement for urbanization, this pattern can be required to additionally worsen effectively genuine air worth issues in sub-Saharan African urban areas and in addition the wellbeing impacts that go with rising population.

Fine particulate matter (PM$_{2.5}$), produced by fuel ignition (e.g., that of engine vehicles) has been connected to an widespread variety of health complication, putting in mind that
more than 800,000 passing in urban communities around the globe becomes affected (Dockery, 2006). In any case, little data is available concerning levels of particulate air pollutions which occur in urban inhabitants in Africa. This information crevice blocks health sway appraisals, the improvement of financially savvy methodologies to lessen the health burden because of open air contamination and the capacity to impact urban mode of transport and arranging strategies related to air quality and health.

Motor vehicle discharges incorporate a scope of toxins, including particulate matter (PM). PM$_{2.5}$ is of specific hugeness on the grounds that examination on health impacts in urban regions has shown relationship between both here and now and long haul normal surrounding PM$_{2.5}$ concentrations and an assortment of antagonistic health results. These incorporate expanded post neonatal new born child mortality and unexpected losses identified with heart and lung maladies.

On account of their little sizes, PM$_{2.5}$ particles can be inhaled into the lungs where they apply antagonistic impacts. In 2005, the World Health Organization (WHO), in acquaintance of known health impacts, set a 24-hour normal rule of 25μg/m$^3$ and a yearly normal rule of 10μg/m$^3$. PM$_{2.5}$ incorporates dark carbon (BC), or residue, which caused by inadequate burning sources which include diesel and ineffectively modified fuel motors and open flames. Notwithstanding antagonistic wellbeing impacts, BC adds to environmental change.

The city of Nairobi, which is regarded to be most conducive for both economical and good livelihood due to its unique features which include location, geographical attractions for example Nairobi national park and many other carrier opportunities makes
Nairobi the most desired destination for various populous both local and international. This phenomenon of rural to urban migration as contributed to high level of population growth in most cities of Kenya. According to KNBS, (2009), Nairobi leads with about 3.5 million; Mombasa 1.2 million followed by Kisumu city with about 409000 people.

A 2007 Government appraisal analysis from the Ministry of Roads and Public Works demonstrated that albeit just 15.3% of suburbanites in Nairobi utilize private autos, they represent 36% of vehicles on our city streets. Another 29% of suburbanites utilize *Matatus*, which represent 27% of the vehicles on our streets, while an incredible 47% of the city occupants stroll to their work places, which would be something to be thankful for if separations included were less than 6km. This sadly is not the situation, with a critical number of the low-pay workers remaining in Kayole, Dandora, Roysambu and Kawangware ranges, all of which are more than 10km from Industrial territory.

To mitigate the air pollution menace, the Kenya government has drafted an air quality regulation indicated that, The Environmental Management and Coordination (Air Quality) Regulations, 2008 (NEMA, 2013). This policy has air quality guidelines to be adopted and which are intended to reduce air pollution loadings arising from traffic related activities and other sources. However, emissions contribution to air pollution on road junctions has not been documented. Therefore, this study was to determine the connotation between the categories of vehicles and fuel they use and the level of concentration of particulate matter they contribute in road junctions on Nairobi CBD.
3.1 Material and Methods

3.1.1 Study Area

The study was carried out in the city of Nairobi, the capital city and the largest urban centre in Kenya and the one having the highest number of motor vehicles. The city is situated 140 kilometers south of equator and 500 kilometers west of the Indian Ocean at 1°17′S36°49′E. It occupies 696km$^2$ at an altitude registering 1,661 meters exceeding sea level (Nairobi county website, 2016 www.nairobi.go.ke/home/about-the-county).

Nairobi's western part environs stretches from the Kenyatta National Hospital in the upper south to the UN headquarters at Gigiri outskirts in the north direction covering a distance of about 20 kilometers. The city is centered considering the sixteen sides of the compass on the City Square, located in the Central Business District: enclosed by the Parliament buildings, the Holy Family Cathedral, Nairobi City Hall, Nairobi Law Courts, and the Kenyatta Conference Centre. The city traffic is busy and about over 100 traffic police personnel are deployed almost continuously to man traffic in the most crowded city in east and central Africa manually ignoring the installed traffic lights which operates digitally but poorly non rated (Kenya police traffic department data, 2016).

3.1.2 Entire Study population

A descriptive exploratory study was targeted the traffic police working within the CBD and its outskirts. Severely congested roundabouts, within the CBD and its outskirts, were selected purposefully for the study. These are the Kamukunji, Railways terminals, Uhuru highway and University way roundabouts manned by a population of 127 traffic police officers. Self-administered questionnaires were distributed to all the 127 participants. In
addition, five (5) senior ranking officers participated in a key informant discussion. All the officers participated in the study. For the proposed study, the researcher enlisted the services of traffic police leaders that is, the Base Commanders to help in the identification of the Traffic police officers according to their seniority of year of employment and work experience. It provided for equal chances of selection of individuals of similar level of experience.

3.1.3 Research design and methodology

The research design involved identifying the roundabouts with high vehicular traffic and which are manned by traffic police officers most of the days of the week from 5.30 AM to 9.30PM. In these roundabouts, measurements were done on each road which links the roundabout. The activities in these roundabouts are largely human and vehicle traffic. Every specific road was measured twice during the period (11th to 19th January, 2016) except University way which was done once. Samples were collected for 8 consecutive hours during each sampling day and interchangeably in time. In the first phase, each sites’ measurements was from 6:30 AM to 2:30 PM and from 10:00 AM to 6:00 PM. All filters were analyzed for particulate concentrations.

3.1.5 Measures of Particulate Matter

Cleaning of Filter Holder Nozzle

Before the start of each sampling, the filter holder nozzle unit was disassembled and properly cleaned using special earpiece wool with ethanol as solvent to clean some particles which could have earlier entrenched inside. This nozzle is left to dry and be assembled again.
Weighing and loading of filters in the nozzle

The filters used in this project were of Teflon type of pore size 2.5 µM. Prior to loading, the filters were carefully weighed using a 100 µg sensitive research analytical balance (Metler Toledo AT 460) avoiding any form of contamination. The filters were each loaded into the sampler holder ready for sampling.

Calibration of BGI personal aerosol sampler

The most critical parameter in aerosol sampling is the air flow rate. The flow meter used was calibrated using a Standards Gas Flow meter by measuring and comparing readings at different flow rates for linearity test (BGI OMNI 400). Thereafter, the flow meter was used to adjust each loaded BGI aerosol sampler to 4LPM prior to sampling. After sampling, the flow rate meter was also used to determine the final flow rate.

Sampling of PM$_{2.5}$ particulates

Loaded nozzles were affixed onto the metal bar holder and positioned above the ground between one and half meters above the ground and one meter from any adjacent obstruction. The nozzle was then connected to the battery driven pump and sampling done for 8 hours. After each sampling, the loaded filters were carefully removed into clean Petri dishes and kept in a clean environment prior to weighing.

Determination of PM$_{2.5}$ concentrations

The mass determinations of particulates in the loaded filters were achieved by using a same research analytical balance used to weigh filters before loading. Loaded filters were weighed and the new masses noted. The differences in masses of the loaded and
unloaded filters gave the particle mass loading. Concentrations of the particulates were acquired by dividing the quantity figure of particulates by the volume of air sucked through the filter during the sampling period as shown in below;

\[
\text{Concentration (µgM}^{-3}) = \frac{W_f - W_i}{V}
\]

Where;

\( W_f \) - is the weight of filter after sampling

\( W_i \) - weight of filter before sampling and

\( V \) - Volume of air sampled in (M³).

\( V \) - is attained by multiplying the flow rate with the period of sampling.

3.2 Data Analysis Results and Discussions

The categories and numbers of motor vehicles recorded on selected Junctions of Nairobi CBD.

The CBD vehicle movement and area they dominate varies from one place to the other depending on terms of interest, purpose and reason for that vehicle to enter or pass through CBD Junction, intersection and highway. For this reason the articulated and heavy trucks dominate the wayaiki University way toward uhuru high way toward mombasa road. This scenario is demonstrated by reason that much of the tracks transport imported goods from port of Mombasa all the way to neighbouring countries like Uganda which is termed as land locked country.
The second bunch which demonstrate a little number of heavy and articulated vehicles concentrating along kamukunji round about account for goods which are used locally by kenyan populous. These kind of goods are unloaded along Gikomba and Kirinyaga road for users of second hand clothes and vehicle spares delivery among others goods.

Uhuru high way had the highest number of light good carriers. This light good carriers namely box body does not exceed 4 tonnes. These average carriage does not contribute to high levels of pollution as most vehicles are light and easy to move without use of heavy gears.

Most of the light good vehicle showed dominancy in highway road due to its interlinks between satellite cities which link with CBD. The light goods vehicle operate as normal retail and wholesale business fraternity in and outside city of Nairobi and environs.

The university way roundabout registered the highest number of pick ups and vans. This reason suggest multiple commercial business which link both satellite towns and the kenyan city and Airport for both perishable goods. Vans mostly in kenya are used to carry light goods for business purpose. So these is the reason for them being dominant in these part of the CBD.

The large cars, 4DW and Jeeps dominated the railways roundabout being the highest compared to other areas. These is entirely attributed by reason that railway roundabout is apivot point for vehicles which ferry senior and subordinate officers in and outside government offices which are located along harambee Avenue which joins Moi avenue and connect railways roundabout.
The most 4WD and large vehicles most of them are owned by government departments and are entirely used for transport purposes. The peak hours of the morning session are most busy for workers being dropped at their work place to execute their daily chores.

In general car and Taxis seem to be evenly distributed within the CBD although uhuru Highway and university highway registered the highest numbers of these category of motor vehicle. This category of vehicle exhibited the evenly used mode of transport although not the best mode of transportation. These is because these small vehicles carry not more than five passangers at one given time.

Small cars uses high volatile gasline and petrol fuel for locomotion. Unlike those heavy vehicles which uses diseal which is less volatile cars in compation pollute less than those which uses diseal. These kind of penomenon explains why University way round about and uhuru round about has large numbers of vehicles yet is the lowest polluter in compration to kamukunji and railway round about.

Kamukunji round about had the highest number of large buses in comparasion to other areas followed by railways roundabout. These penomenon has been attributed by large buses which operate through Jogoo road, Githurai 45, Ngong and rongai bus passanger terminals which contribute to many many buses bring in and out passangers within the CBD environs.

Railways round about registered the highest number of matatus within CBD. These as been attributed to reasons that railways terminals is feed by many matatus operator including the following routes. Kitengela, Machakos, Athi river, Mulolongo, Rongai,
Ngong, kawangare, harligum, yaya centre, kibera among other matatu operators which have licence transport licence for diverse routes.

The reason for kamukunji contributing to high proportionate of particulate matters is because of the high overriding numbers of vehicles which are large buses and matatus dominating in these areas and using diseal fuel which is more pollutant than any other fuel. Most matatus make frequent trips to and from these marked junctions for their daily business hence making these areas very polluted.

Railways and kamukunji both of them registered the highest number of Motor cycles and Tuk tuk. These was attributed by the fact that middle class people who operate within city stadium are most users of Tuk Tuk to connect to Town CBD after being dropped at city stadium vehicles which enter the famous Muthurwa Market. Muthurwa market stage is not directly connected to CBD so many people about entering town through Muthurwa to avoid walking to their job place.

The motor cycle operators due to fear of county council Askaris does not operate outside there area of Jurisdiction. This is because most of their customers emanate from the Eastland direction who flock at city markets and for small scale business enterprises.

Tuk Tuk in return also uses diseal which also is more polluting than any other kind of fuel. These also contribute to high levels of pollution within Kamukunji area (See table 3.1).
Table 3.1: The categories and numbers of motor vehicles recorded on selected Junctions of Nairobi CBD.

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Kamukunji</th>
<th>Railways</th>
<th>Uhuru Highway</th>
<th>University Way</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>2745</td>
<td>2055</td>
<td>3525</td>
<td>2862</td>
<td>11187</td>
</tr>
<tr>
<td>Light Heavy</td>
<td>1158</td>
<td>1167</td>
<td>2754</td>
<td>2384</td>
<td>7463</td>
</tr>
<tr>
<td>Medium</td>
<td>1358</td>
<td>1268</td>
<td>932</td>
<td>620</td>
<td>4178</td>
</tr>
<tr>
<td>Heavy</td>
<td>1445</td>
<td>1294</td>
<td>951</td>
<td>633</td>
<td>4323</td>
</tr>
<tr>
<td>Very Heavy</td>
<td>62</td>
<td>16</td>
<td>110</td>
<td>303</td>
<td>491</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>6768</strong></td>
<td><strong>5800</strong></td>
<td><strong>8272</strong></td>
<td><strong>6802</strong></td>
<td><strong>27642</strong></td>
</tr>
</tbody>
</table>

Table 3.2: Average particle concentration observed on Nairobi road junctions (μg m$^{-3}$)

<table>
<thead>
<tr>
<th>Road junction</th>
<th>Particle concentration (μg m$^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamukunji</td>
<td>180</td>
</tr>
<tr>
<td>Railways</td>
<td>107.6</td>
</tr>
<tr>
<td>Uhuru Highway</td>
<td>99.1</td>
</tr>
<tr>
<td>University Way</td>
<td>68.3</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>113.8</strong></td>
</tr>
</tbody>
</table>
Concentration of ambient particulate matter (PM$_{2.5}$) on road junctions in Nairobi

Air particulates (PM$_{2.5}$) were sampled continuously for 8 hour periods during the exercise. The table above shows concentration levels in each site during the sampling periods. (See table 3.2 above).

The highest Average particle concentration measured level of PM$_{2.5}$ was 180 µg/M$^3$ observed in River road direction site at Kamukunji and in Haile Selassie Muthurwa road at Kamukunji roundabout. State house road (University way roundabout), Center site (waiyaki highway direction) and stage road (University way roundabout) registered the lowest levels of 45.0 – 46 µg/M$^3$. However, concentrations of corresponding sites on different days of measurement were about three time’s higher (135.0µg/M$^3$). The wide variation in the measurements is majorly attributed to the location of the sampling site in the CBD and weather conditions at the time of sampling. On average, Kamukunji and Railways roundabouts registered a mean concentrations ranging from 101 – 144 µg/M$^3$ and 91 - 135µg/M$^3$ respectively. These areas are located in CBD with high human and vehicle traffic and the roads are not well tarmacked hence continuous dust re-suspension of dust. On the other hand, Uhuru highway roundabout and University way roundabouts registered lower concentration values ranging 68 – 109 µg/M$^3$ attributed to their locality in CBD, better road and tarmac conditions, low human traffic and no dropping and picking passengers at the sites as seen in the other two roundabouts.

The significantly high values achieved compared to World Health Organization 24hr guideline of 25 µg m$^{-3}$ (2000) stances a severe health issues to regular pedestrians and workers around those areas.
The mean PM$_{2.5}$ values obtained in this exercise ranged from 68.0 to 144.0 µg/M$^3$ and correlate with those obtained in a similar study by Kinney et al. (2009). The study which was conducted in the CBD of Nairobi reported mean street values ranging 98.1 to 128.7 µg/M$^3$. This observation may indicate that PM$_{2.5}$ particulate loadings in the air in Nairobi have not changed much over the years although they surpass maximum recommended limit of 25 µg m$^3$, the WHO 24 hour recommendation assessment (2000). This observation of similar results is accredited towards proliferation in the importation and usage of motor vehicles within urban areas which increased from 50 000 units in 2008 to 140 000 units in 2011 (KEBS, 2013b). Although there has been progressive improvement of the road network in Nairobi, increased motorized traffic activities lead to severe congestion problems.

In relation to population health, there is a high symptom of potential health hazards for populaces who commute to the built up metropolitan on daily basis and more so the traffic police officers who man the roundabouts for 8 hours each day. According to Graeff et al. (2010) extreme air contamination contact too many pedestrians takes effect specifically during morning and evening hurry periods of the day.

**Association of vehicle size, type of fuel and particle emissions (particle concentration/number of vehicles)**

The study done clearly implies that heavy vehicle contributes to higher pollutants when you compare to the light, light heavy and medium motor vehicle categories. Those heavy fuels like diesel are less volatile hence burn slowly causing emission of carbon monoxide in atmosphere and which is most dangerous and greatest cause of mortality. Small
vehicles which use high volatile fuel emit less and pollute less in comparison heavy commercial vehicles (Pirjola et al., 2004a,b).

According to study it exposes that heavy-duty trucks and light-duty gasoline vehicles emit a range of pollutants. However, their contributions to diverse types of compounds are dependable of the fuel type and capacity of the motor vehicle. Mostly those vehicles like heavy trucks which uses diesel emit more of certain pollutants (e.g., NOx and PM) and contribute disproportionately to the emissions from motor vehicles. Gasoline-powered passenger cars generally emit more other pollutants (e.g., CO, and benzene, a volatile organic compound (VOC) (Kittelson et al., 2004).

The enormous common and current cars and trucks are propelled by use of internal combustion engines that burn gasoline or other fossil fuels. The technique of burning gasoline to power cars and trucks contributes to air pollution by releasing a variety of emissions into the atmosphere. Emissions that are released directly into the atmosphere from the tailpipes of cars and trucks are the primary source of vehicular pollution. But motor vehicles also pollute the air during the processes of refueling as part of the fuel evaporates due to its volatile property and from the emissions associated with oil refining and distribution of the fuel they burn although this is dependable on the type of the fuel and its volatile properties (See Fig 3.1).
Figure 3.1: Association of vehicle categories, fuel and particulate matter emissions on Nairobi road junctions
Average particle emmision/vehicle number ratio observed on selected road junctions of Nairobi CBD

In current study the results showed that Kamukunji had the highest ratio of particle of about 10.6 followed by Railyways, uhuru highway and university way round about which recorded the lowest ratio despite having highest average numbers of 86.2. These phenomenon is clearly demostrated by the fact that most vehicle which uses university way and uhuru highway were small cars which uses petrol fuel. Small vehicles which use high volatile fuel emit less and pollute less in comparison heavy commercial vehicles (Pirjola et al., 2004a,b). Those heavy fuels like diesel are less volatile hence burn slowly causing emission of carbon monoxide in atmosphere and which is most dangerous and greatest cause of mortality. In this scenario kamukunji had the last heavy vehicles using diseal fuel which is more pollutant to the environment (Kittelson et al., 2004). (See Table 3.3).

Comparison of the level of emissions with those reported locally, regionally and globally and the WHO standards.

Airborne contamination has escalated by 8% worldwide in the previous five years, with the WHO approximating that it causes 3 million untimely deaths a year, making it one of the top greatest environmental menaces to human health in the contemporary world of humanity.

3.3 Discussion

In the global selected cities in Africa Nairobi city of Kenya ranked 8th in the category of Kampala leading with 104, Cairo Egypt 76,Yaounde Cameroon 49, Johannesburg south.
Table 3.3: Average particle emission/vehicle number ratio observed on selected road junctions of Nairobi CBD

<table>
<thead>
<tr>
<th>Row Labels</th>
<th>Average of Number</th>
<th>Particle/number ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamukunji</td>
<td>70.5</td>
<td>10.6</td>
</tr>
<tr>
<td>Railways</td>
<td>60.4</td>
<td>5.8</td>
</tr>
<tr>
<td>Uhuru Highway</td>
<td>70.9</td>
<td>4.8</td>
</tr>
<tr>
<td>University Way</td>
<td>86.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Africa 41, Tunis Tunisia 38, Dakar Senegal 34 and Casablanca Morocco 26. All this was above the required WHO standards which is 1.8 micrograms per cubic meters. In the world Nairobi city ranked moderately fair with expected increase of pollutants due raise of pollution and demand for industrial production in most part of the city suburb (Mage et al., 1996).

The economic growth marks the milestone of most undeveloped and developed countries failure to control levels of pollution. This phenomenon have been contributed the essence of demand for food and other natural Recourses. There are some places in the world that already appear like a human-caused apocalypse aftermath: cities whose ecology in terms of air pollution is so bad that it seems impossible to live there (WHO/UNEP (1992).

According to pure earth a non-profitable environmental organization, the most air-polluted city on Earth currently is New Delhi. New Delhi is a city where breathing its air is rather difficult. Owing to consideration of many happening, such as an exponentially increasing populace (New Delhi has reached 25 million people), industrialization, and urbanization regarding coal-fired power plants and thrilling traffic with many cars operated by use of diesel, it is easy to comprehend why New Delhi is recognized as the city with the worst ambient pollution in the world. Pollution has enlarged to an extent that the outdoors in Delhi are correspondingly a gas chamber (WHO/UNEP (1992).

The Iranian city of Zabol stands amongst the other cities as a city with exceedingly bad airborne. Neighboring Afghanistan, Zabol is ranked by the WHO being one of the utmost contaminated city all over the world. The concentration of detrimental particles in Zabol’s air reaches 217 micrograms per cubic meter of air, despite the allowed limit
considered safe is only about 60 micrograms. Nowadays, these dusty flying air contaminate the metropolitan atmosphere even more; besides, the loss of environmental protection which has caused a dramatic increase in the amount of respiratory contaminations among citizens: tuberculosis, for instance, have become one of the most severe and common problems of Zabol (WorldAtlas, 2016).

Nairobi is among global cities with deadly escalating air pollution levels. For instance over 80 per cent of people living in urban areas that monitor air pollution are uncovered to air quality levels that exceed WHO limits. Although all over the world every populace is affected by this phenomenon, populations in low-income cities are the most impacted. According to the latest urban air quality database by the WHO, 98 per cent of cities in low and middle income countries with a population recording more over 100,000 inhabitants, including Nairobi, do not meet WHO air standards.

WHO was able to compare a total of 795 cities in 67 countries for levels of small and fine particulate matter (PM$_{10}$ and PM$_{2.5}$). During the five-year period, 2008-2013, PM$_{10}$ and PM$_{2.5}$ included pollutants such as sulfate, nitrates and black carbon, which infiltrates deep into the lungs and into the cardiovascular system, posing the greatest risks to human health (Goto et al., 2016).

In the African region, urban air pollution data remains very scanty. However available data revealed particulate matter (PM) levels are above the median levels of concentration. Ambient air pollution, made of high concentrations of small and fine particulate matter, is the greatest environmental risk to health causing more than three million untimely deaths worldwide every year.
Africa’s metropolitan air is especially bad for reasons that few cars are new, the immense majority having been shipped in as second-hand from Japan and Europe with their catalytic converters and air filters dismantled. It is jeopardy for developing countries becoming a dumping ground for the world’s old cars – importing vehicles that no longer meet rich countries pollution standards (Lin et al., 2016; Wu et al., 2013).

3.4 Conclusion and recommendations.

The number of vehicles and types crossing the road junctions of city of Nairobi CBD were associated with the level of pollution through exhaust emissions. Most vehicles entered the CBD through Kamukunji round about which is characterized by mostly Medium good carries which ferry firm produce to Marigiti market on daily basis. The traffic at this junction consisted of more large and heavy commercial Matatus, and Tuk Tuks. Diesel fuelled vehicles observed to be more pollutant than petrol fuelled vehicles.
CHAPTER FOUR

TRAFFIC POLICE KNOWLEDGE AWARENESS, ATTITUDE AND PRACTICE ON MOTOR VEHICLE POLLUTION CITY OF NAIROBI- KENYA

ABSTRACT

People’s knowledge of awareness, attitudes and practices towards motor vehicle emissions that are dangerous and a requirement is paramount for reducing exposure among people, their impact and response of interventions that are aimed at encouraging behavioral change. This study evaluated the knowledge, awareness, attitude and practice on motor vehicle pollution among the traffic police officers in Nairobi city. The study was directed by the following the objectives: To appreciate the level of knowledge among the traffic police officers about and attitudes towards motor vehicle air pollution and associated health effects.

The survey interviewed a purposive and non-random stratified sample of 127 police officers, according to their seniority, years of employment and work experience, from the target population of traffic police working in major selected road junctions within the CBD, Nairobi Kenya. The sampled junctions were Kamukunji, Railways terminal, University way and Uhuru Highway roundabouts. In addition, from the leadership rank, five (5) key informants were also interviewed. Data was collected using self-administered questionnaires. Discussions were held with the key informers.
The study found that majority 40.2% said that they had a good knowledge of the issue. 96.3% indicated they had Knowledge of the laws on traffic related pollution and traffic regulations training. 98.1% had attended a traffic management course. 76.6% indicated that they had usefulness of motor vehicle air pollution information.

The study concludes that motor vehicle air pollution affects the day to day operation of the officers; especially those working in the traffic department.

**Keywords:** Knowledge; Awareness; Attitude; Motor vehicle pollution

**4.0 Introduction**

Occupational health risks and hazards due to polluted environment have become a serious public health concern where there is unplanned urbanization. Contamination due to road traffic is a solemn health hazard, thus persons like traffic police who are constantly unprotected may be at an augmented threat (Ralte, Ralte, and Lalramnginglova, 2013).

The traffic police suffer a physical pressure in an atmosphere contaminated by fumes emitted from tail pipe of vehicles, use of blustering horns, emission from nearby brick factories, and discharge of dust in the air by a speeding vehicle (Ingle, Pachpande, Wagh, Patel, and Attarde, 2005).

The traffic volume in Nairobi metropolitan CBD has been accumulating year after year and the situation is worsening due to the industrial and commercial development in the sub-urban areas (Weigel & Newman, 2006).
An estimated amount of about 90% of urban ambient pollution in emerging cities of developing nations can be accredited to motor vehicle emissions (UNEP, 2011). The swelling traffic overcrowding in Nairobi, which is dominated by a number of old and poorly maintained motor vehicles, poor road networks and impure or low quality fuels further exacerbate this problem. Nairobi roads are journeyed by a mixture of ever increasing numbers of passenger cars, light duty trucks, heavy duty trucks, minibuses and other types of vehicles. The heavier vehicles (Buses and trucks) rely on fuel diesel that leads to high particulate matter emissions. In addition, most newly registered vehicles are imported as used vehicles which further increase their pollution capacities (Shashidhara, 2005). The high number of roundabouts and junctions on the city roads leads to slowing of vehicles and high congestion which leads to more air pollution.

Previously, slight consideration has been paid to many issues touching the police service. Although a number of reforms have been undertaken within the police force, much still remain to be done. Behind this backdrop, it was anticipated that the level of sensitization, training and the mandate of the entire Police force in addressing health concerns of its members is low. In addition to low level of awareness and knowledge about motor vehicle air pollution, it was anticipated that traffic police officers did not have the right perception or attitudes when it comes to motor vehicle air pollution (Weigel & Newman, 2006).

There is limited evidence on traffic police knowledge, attitude, awareness and practices of motor vehicle pollution in Kenya. Such data is required to inform reform in training curricula and police practice after graduation. It will also inform future larger studies seeking to further clarify effects of motor vehicle pollution on people. Consequently, the
objective of the study was to evaluate the knowledge, attitudes and practice among the traffic police in Nairobi city Kenya. This study provides insights into traffic police perceptions on motor vehicle emissions and what they consider to be their role in addressing air pollution.

4.2 Material and Methods

4.2.1 Study Area

The study was carried out in the city of Nairobi, the capital city and the largest urban centre in Kenya and the one having the highest number of motor vehicles. The city is situated 140 kilometers south of equator and 500 kilometers west of the Indian Ocean at 1°17′S36°49′E. It occupies 696km² at an altitude of 1,661 meters above sea level (Nairobi county website, 2016).

4.2.2 Study population

The descriptive exploratory study was targeted the traffic police working within the CBD and its outskirts. Severely congested roundabouts, within the CBD and its outskirts, were selected purposefully for the study. These are the Kamukunji, Railways terminals, University way and Uhuru Highway roundabouts manned by a population of 127 traffic police officers. Self-administered questionnaires were distributed to all the 127 participants. In addition, five (5) senior ranking officers participated in a key informant discussion. All the officers participated in the study. For the proposed study, the researcher enlisted the services of traffic police leaders that is, the Base Commanders to help in the identification of the Traffic police officers according to their seniority of year
of employment and work experience. It provided for equal chances of selection of individuals of similar level of experience.

4.2.3 Survey instrument

The study used a self-administered English language questionnaire to collect data, all traffic police officers being sufficiently literate as evidenced by the entry qualifications. The questionnaire was pretested with 8 traffic police officers of Kamukunji police Station who were not used in the actual study. The pretesting feedback helped establish internal consistency of the questionnaire. Before the self-administering of the questionnaires, traffic police officers were briefed on the purpose of the study. Thirty to forty five minutes were allowed for each respondent to fill in the answers in the presence of the researcher and his assistants. The questionnaires were collected immediately they were filled and validated and where necessary clarification sought from the respondent.

4.3 Data Analysis and Results

4.3.1 Knowledge and attitudes towards motor-vehicle pollution and health

To understand how well the respondents understand about motor-vehicle pollution the respondents were asked to rate themselves between very good, good, poor and very poor. Most of them (40.2%) said that they had a good knowledge of the issue. Those who rated their knowledge as very good were 19.6%, poor (13.1%) whereas 27.1% of the respondents rated their knowledge as very poor. (See table 4.1).
4.3.2 Levels of knowledge on motor-vehicle pollution

To further understand their knowledge of the laws on traffic related pollution they were asked if they had ever detected motor vehicle emissions violations in their work period and in the past thirty days. (See table 4.1).

They were further asked if they had ever attended any traffic management course. The findings revealed that most of them (98.1%) had attended a traffic management course. The study also wanted to know if the respondents had been trained on motor vehicle air pollution in the course they attended. It was noted that 67.3% reported to have been trained in that area whereas 32.6% had not been trained on motor vehicle air pollution. This is as shown in table 4.2.

The study went further to ask the respondents to rate level of usefulness of the information on motor vehicle air pollution were. This was measured in four categories (very important, important, moderately important and not important), the results revealed that most of the respondents (80.4%) considered the information as very important.

The respondents were also asked to rate how difficult it was for them to access motor vehicle air pollution related information. This was measured in four levels which were; very difficult, difficult, easy and very easy. In this section, 52.3% said that it was easy, 29.9% (difficult), 11.2% (very easy) and only 6.5% said it was very difficult. (See Table 4.3).
Table 4.1: Knowledge and attitudes towards motor-vehicle pollution and health

<table>
<thead>
<tr>
<th>Source of information</th>
<th>Proportion of respondents</th>
<th>Response</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>75.7</td>
<td>Very good</td>
<td>19.6</td>
</tr>
<tr>
<td>Television and radio</td>
<td>9.3</td>
<td>Good</td>
<td>40.2</td>
</tr>
<tr>
<td>Newspapers</td>
<td>6.5</td>
<td>Poor</td>
<td>13.1</td>
</tr>
<tr>
<td>Magazines</td>
<td>4.7</td>
<td>Very poor</td>
<td>27.1</td>
</tr>
<tr>
<td>Scientific journals &amp; publications</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 4.2: Knowledge of the laws on traffic related pollution and traffic regulations training

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes, %</th>
<th>No, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you EVER in your daily traffic duties detected a case of motor vehicle emissions violation?</td>
<td>96.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Have you in the LAST ONE MONTH (30 days) in your daily traffic duties detected a case of motor vehicle emissions violations?</td>
<td>74.8</td>
<td>25.2</td>
</tr>
<tr>
<td>Have you ever attended any traffic management course?</td>
<td>98.1</td>
<td>1.9</td>
</tr>
<tr>
<td>In the course, were you trained on motor vehicle air pollution?</td>
<td>67.3</td>
<td>32.6</td>
</tr>
</tbody>
</table>
Usefulness of motor vehicle air pollution information

The research also sought to find out if the respondents would exactly know motor vehicle air pollution information. Majority of them (76.6%) responded ‘Yes’ to this question whereas only 23.4% answered ‘No.’ They were further asked to say how that information would have looked like, they had the following to say: The information will be in the form of documentaries; The information would come in the form of pamphlets and fliers; The information would have come in the form of television and radio advertisements; The information would have been packaged in the form of lectures; The information would come in the form of police magazines and Publications of information in the local dailies.

Lastly the respondents were asked to suggest ways in which information on motor vehicle air pollution can made more accessible to the traffic police, they had the following to say: A data base of information should be created and made accessible to the police. Topics on motor vehicle air pollution should be integrated in the traffic course; There should be more of information aired on television to sensitize the public; There should be a partnership with National Environmental Management Authority (NEMA) in the development of training materials; Regular seminars should be organized for the police officers and the public on motor vehicle air pollution; Creating a special unit to deal with the dissemination of information on motor vehicle air pollution information etc.
Table 4.3: Importance of motor vehicle air pollution information and ease of its access

<table>
<thead>
<tr>
<th>Rating of the need of information on motor-vehicle pollution</th>
<th>Proportion of respondents, %</th>
<th>Rating of ease of access of the information</th>
<th>Proportion of respondents, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very important</td>
<td>80.4</td>
<td>Very difficult</td>
<td>6.5</td>
</tr>
<tr>
<td>Important</td>
<td>15</td>
<td>Difficult</td>
<td>29.9</td>
</tr>
<tr>
<td>Moderately important</td>
<td>2.8</td>
<td>Easy</td>
<td>52.3</td>
</tr>
<tr>
<td>Not important</td>
<td>1.9</td>
<td>Very easy</td>
<td>11.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Further knowledge on motor vehicle air pollution

After responding to all the questions seeking to measure their knowledge of motor vehicle air pollution, the research asked the respondents to give some suggestions on ways of making traffic management duties safer from exposure to motor vehicle pollution. The following suggestions were put forward: Measures should be put in place to protect the officers working in the traffic department; There should be a crackdown of un-roadworthy vehicles; Giving the officers protective gears such as face masks to lessen the risk of their exposure to motor vehicle air pollution; Decongestion of traffic from the central business district; Ensuring there is regular inspection to eliminate unfit vehicles from the road; Regular maintenance of the streets and cleaning to reduce on the amount of dust emitted; Construction of proper road networks to decongest the city and Sensitization of the public about the effects of motor vehicle air pollution

Causes of motor-vehicle air pollution

The research was also interested in finding out the causes of motor vehicle air pollution. The respondents were therefore asked to list some of the causes that they were aware of. This was also done qualitatively by making them respond by filling in a list of causes they were aware of. What came out most common was the traffic congestion in the city and the many unroad worthy vehicles that are still allowed to operate. However that was not the only one, the following causes were also mentioned:

Additional objective of the study was to find out the attitudes of traffic police officers on motor vehicle emission contamination and the health effects associated with it. Ajzen (1991) theory of planned behaviour states that beliefs – such as espoused in attitudes, are
the greatest predictor of behaviour. This means that attitudes not only define priorities but also determines problem solving activities. As such, traffic police officers were asked Likert-scale type questions on whether they felt that the police administration was taking adequate measures to protect officers from motor vehicle air pollution. 56.6% said that they strongly disagreed that adequate measures were being taken, 32.1% said they disagreed while only 5.7% agreed that the police administration was taking adequate measures to protect police officers from motor vehicle air pollution. On the statement that traffic police officers take precautionary measures to protect themselves from motor vehicle air pollution, 39.6% disagreed, 34.9% strongly disagreed, 19.8% were not sure while 0.9% agreed with the statement. (See table 4.4).

A statement was made that the time police officers spend on roundabouts is enough to make them experience effects of motor vehicle air pollution. 38.7% strongly agreed, 32.1% agreed, 17.0% disagreed while 6.6% strongly disagreed with this statement.

Another statement was made that carrying out traffic duties has more benefits compared to exposure to motor vehicle air pollution. 47.2% strongly disagreed with this statement, 25.5% disagreed, 15.1% agreed while 7.5% strongly agreed with this statement. Respondents were asked ways to reduce traffic police officers’ exposure to motor vehicle air pollution. 62.3% said that they should be issued with protective gear to wear during duty, 21.7% said that their working hours should be reduced, 17.9% asserted that they should have regular free checkups and treatment, 2.8% said frequent breaks would help while 1.9% said that there should be rotational duties.
A statement that the risks posed by motor vehicle air pollution are greater than the risks posed by other police crime control duties was also made. 33% of the respondents said that they agreed with the statement, 27.4% disagreed, 21.7% strongly agreed while 13.2% strongly disagreed. On being asked to rate their police station’s overall preparedness to motor vehicle air pollution, 47.2% of the respondents said it was not at all prepared, 33% said it was a little prepared, 8.5% said it was prepared and 5.7% said it was very well prepared. Overall, the general feeling of the respondents was that motor vehicle air pollution was a problem that traffic police officers are exposed to on their daily duties. There was also a general concern that not enough was being done to deal with this problem by police administration as well as individual traffic officers. Most of the officers were not confident in the measures already been taken to curb motor vehicle air pollution.

The study demonstrated that the traffic police were knowledgeable with respect to the adverse effects of air pollution on their health. The study showed they had knowledge that air pollution can cause trouble in breathing, wheezing sound, lung malignancy, skin ailment, bronchial asthma, and pneumonia. Studies directed in India have additionally discovered that there is expanded danger of getting distinctive respiratory issues when traffic police are presented to polluted air for a longtime. It is basic for traffic police to know about the issues particularly identified with breath in urban communities like Nairobi.
Table 4.4: Perceived causes of motor-vehicle air pollution

<table>
<thead>
<tr>
<th>Causes of motor-vehicle air pollution</th>
<th>Frequency</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive smoke emitted by motor vehicles.</td>
<td>35</td>
<td>33.1</td>
</tr>
<tr>
<td>Mixing of different types of fuel</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Modification of exhaust pipes that tampers with normal air flow from the engines</td>
<td>15</td>
<td>14.2</td>
</tr>
<tr>
<td>Undisciplined public vehicle crew members who keep on hooting and making noise</td>
<td>13</td>
<td>12.6</td>
</tr>
<tr>
<td>Poor road conditions characterized by countless pot holes and dust</td>
<td>11</td>
<td>10.2</td>
</tr>
<tr>
<td>The use of low quality fuels that emit a lot of smoke during driving</td>
<td>10</td>
<td>9.4</td>
</tr>
<tr>
<td>Failure by motor vehicle owners to conduct routine maintenance of their vehicles</td>
<td>6</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>107</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 4.5: Association between working experience and knowledge awareness on level of pollution

<table>
<thead>
<tr>
<th>Road Junctions</th>
<th>High pollution, %</th>
<th>Low pollution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamukunji</td>
<td>49.7</td>
<td>51.7</td>
</tr>
<tr>
<td>Railways</td>
<td>48.3</td>
<td>50.3</td>
</tr>
<tr>
<td>Uhuru highway</td>
<td>36.5</td>
<td>63.5</td>
</tr>
<tr>
<td>University way</td>
<td>27.9</td>
<td>72</td>
</tr>
</tbody>
</table>
A similar report affirms that there assist a prevalence of chronic bronchitis and asthma in traffic police presented to vehicle toxins in fixations higher than WHO prescribed rules, subsequently prompting noteworthy increment in respiratory problems (Rachou, 1995). Diverse inquiries in Ethiopia, Mozambique, and Kenya discovered fundamentally sophisticated cases of asthma in urban individuals presented to activity contamination contrasted with rural child (Mavale-Manuel 2004 and Ng'ang'a 1998).

The present study exhibited that education affected the level of knowledge in prevention of respiratory health problems among traffic police. However, there was no association between education and level of practice to prevent respiratory problems. The poor practice of the traffic police, despite better knowledge, has not been fully understood. This study also showed that working experience had association with the level of practice but not with the level of knowledge.

The table above on cross tabulation indicates that areas with high pollution levels are railways and Kamukunji. In railways there is high concentration of Matatu (23) unladen (35.4%) and Large bus (45 seaters) unladen (31.2%). Kamukunji also had high concentration of Matatu (23) unladen (11.9%) and Large bus (45 seaters) unladen (16.5%) (See Table 4.5).

Areas found to have low pollution were University way and Uhuru highway. University way has high concentration of Car & Taxi (46.8%) and large cars 4WD & Jeeps (25.8%). While Uhuru highway was found to exhibits high concentration of Car & Taxi (54.6%) and large cars 4WD & Jeeps (22.7%).
4.4 Discussion

This air pollution conveys critical vulnerabilities for both human wellbeing and the atmosphere at large. The health threats toward air pollution are prominently honest. Poor air quality increases respiratory ailments like asthma and bronchitis, increases the danger of life-undermining conditions like cancer and weights our health services framework with significant medicinal expenses. Particulate matter alone is in charge of up to 30,000 unanticipated deaths every year. Traveller vehicles are a pollution contributor, delivering huge measures of nitrogen oxides, carbon monoxide, and other contamination (Aryal et al., 2008).

This study disclosed that the level of knowledge regarding the prevention of respiratory problems among the traffic police was comparatively higher than the level of practice. Parallel results were achieved in a study done in India; which exposed that level of knowledge was found to be better in majority of traffic police while the level of practice was lower. This might be due to Police regulations CAP. 84 LOK paragraphs 8, force standing orders, which stipulate code of dressing in the entire police force. The entire population of traffic police at the city of Nairobi Never used masks to prevent respiratory problems in this study.

A study revealed that no such arrangement have ever been suggested nor implemented. In Nairobi city, vehicular emission is the major contributor to air pollution. In addition, at the time of this study, construction of roads was in progress in parts of the city street, intersections and Road junctions which could also be factor for contribution of higher particulate matter dynamic. This could have intensified the condition of air, eventually
deteriorating the health of the traffic police. The good health of traffic police and city dwellers is ensured only if the government implements vehicle inspection and emission testing effectively and ban on polluting vehicles. A research work suggests that, with longer experience, people increase their level of performance. It is better to learn preventive measures against air pollution from experience and practice them in daily life.

This study shows that the Nairobi Central district is one of the highest urban center in terms of car population. Due to the high population there has been increased motor vehicle pollution in the city. The composition of traffic on city roads also affects emission. The future trend in vehicle growth can have serious implications and fuel consumption patterns. A large number of private vehicles for example, are two-wheelers, which are cheap and reliable but also high on emissions. Of significant concern are the abnormal amounts of suspended particulate matter inside the inhalable range. The mean PM$_{10}$ was 239±126 µg/m$^3$ while the range was 66.66 to 444.45µg/m$^3$. These levels are high when contrasted with other contaminated urban communities like Bombay, London, Los Angeles and so on. As far as possible for PM$_{10}$ is 150 µg/m$^3$.

Spigot and Sevingny (1998) have contended at a similar assumption that ineffective conveyance is the noteworthy offender of air contamination representing more than 80% of aggregate air toxins. This is an unmistakable sign that vehicle emissions are a major source of encompassing ambient air pollution. The type of urban development in most creating nations has tended to build the utilization of mechanized transport, especially road transport, which prompts increment environmental effects.
Not all pollutants which is emitted from cars is the same; there are two sorts of contamination released by petrol vehicles. These incorporate; evaporative emissions, which happens when vapors of fuel are discharged into the climate, without being copied, and deplete outflows, including risky gasses, for example, carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. The real poisons are particulate matter, hydrocarbons, nitrogen oxides, carbon monoxide, sulfur dioxide, perilous air toxins, and nursery gasses, all of which are to a great degree hazardous for people.

The present study exhibited that the traffic police had knowledge regarding the negative effects of air pollution on their health. They had knowledge that air pollution can cause difficulty in breathing, wheezing sound, lung cancer, bronchial asthma, and pneumonia. This study concurs with a studies conducted in India by Faucet and Sevingny (1998) which have also revealed that there is increased risk of getting different respiratory problems when traffic police are uncovered to polluted air for a longer time. It is indispensable for traffic police to be aware of the problems especially related to respiration in Kenya. Although majority of the traffic police had knowledge that they need to use antipollution mask, fewer of them felt like going for regular health checkup. Regular checkups spare lives notwithstanding when there is no particular issue, since the nonappearance of symptoms does not really ensure that one is healthy. This is in accordance with ponders by Goldberget et al. (2001) and Rainham et al. (2005) WHO have likewise indicated diminished rates of intrusive growths and diminished mortality in individuals who experience consistent therapeutic checkup. Therefore, awareness creating activities and policies relating to regular health checkup and protection from polluted environment should be launched effectively.
In Kenya, traffic police department have presented that the level of knowledge regarding the prevention of respiratory problems among the traffic police is comparatively higher than the level of practice. Similar results were obtained in a study done in India by Babisch (2000) and Fogari (2014) that showed that the level of knowledge was found to be better in majority of traffic police while the level of practice was average. This criterion might have been due to financial difficulties faced by the traffic police as studies have suggested that socioeconomic factors play a role in the health seeking behaviors. In addition, in sufficient time management during duty periods could avert attending regular health checkup. Nonetheless, they should be motivated to have healthy and safe practice against the pollution. Furthermore, the government should draft sustainable policies addressing such issues.

The present study showed that education affected the level of knowledge in prevention of respiratory problems among traffic police. However, there was no association between education and level of practice to prevent respiratory problems. The poor practice of the traffic police, despite better knowledge, has not been fully understood.

The Kenyan government has been endeavoring in react to the ecological issues, in which a few successful contamination control measures were started. The measures point at exhaust gas emission controls as well as at the change of fuel and vehicle determinations, usage of being used vehicle inspection and support program, mass travel systems, and traffic management. In Kenya, legal Notice No. 60 of 2007 (GOK, 2007) provides the recommended long term exposure limits as follows, 50 ppm for CO, 5000 ppm for CO2, 3 ppm for NO2 while short term exposure limits are given as 300 ppm for CO, 15000 ppm for CO2 and 5 ppm for NO2 respectively. WHO (2000) also provides long term
exposure limits for CO and NO2 as 9 ppm and 0.072 ppm respectively while short term exposure limits for the same gases are given as 26 ppm for CO and 0.12 ppm for NO2.

4.5 Conclusions

It is conclusive enough that motor vehicle air pollution affects the day to day operation of the officers; more so those working in the traffic department. Police officers think that heavy traffic and the use of un-road worthy vehicles are great contributors to motor vehicle air pollution. It is evident that very little has been done to mitigate the effects of motor vehicle pollution.

It is noted that there is very little knowledge about motor vehicle pollution and its effects both to the public and the policemen. Little effort has been made to disseminate knowledge on motor vehicle pollution. Therefore recommends the following:

1. There should be more training to the policemen on motor vehicle air pollution through seminars and integration of the topic in the police course curriculum.
2. The public should be sensitized on motor vehicle air pollution prevention to reduce the risks to them as well as the police men. The information on motor vehicle air pollution should be packaged in such a way that they are easily accessible to the public and the policemen.
3. There should be structures to take care of police officers who have suffered from the effects of motor vehicle air pollution.
CHAPTER FIVE

ANALYSIS AND PERCEPTION OF HEALTH IMPACT OF MOTOR VEHICLE EMISSIONS ON TRAFFIC POLICE IN NAIROBI, KENYA

ABSTRACT

Clean air is important for human health and well-being, air pollution has increased in many parts worldwide and thus posing a significant threat people’s health. In Kenya, the traffic police officers who constantly uncovered stand on road junctions continuously expose themselves to motor vehicle emissions, greatly risking their health.

This study collected qualitative data and quantitative data analysed police person’s perceptions of the health impact of motor vehicle emissions on traffic police in Nairobi, Kenya. The respondents were sampled from among the traffic police officers who normally control traffic in Nairobi CBD. Pretested questionnaires were used to collect data.

The study showed that police officers were aware of the effects that the motor vehicle air pollution could have on their health. About 98.1% of respondents indicated that they are affected by motor vehicle pollution. On average, about 30% of the police officers are off duty due to sickness while 82.2% had been greatly affected by exposure to motor vehicle pollution. 58.9% new cases of the health effects related to motor vehicle emission constant though majority did not take any measures. They obtained this knowledge and experience from their colleagues suffering from respiratory diseases; reporting frequent occurrence of health problems thought to arise acquaintance to motor vehicle emissions.
The study accomplishes that there is an association between the amounts spent manning traffic and contact to high levels of pollution. The traffic officers have associated illnesses such as respiratory problems, asthma, cancer and other diseases that are pollution related to the high emissions of motor vehicle pollution in the Central business district.

**Key words:** Health effects; Traffic police; Motor vehicle emission; Respiratory diseases.

5.0 Introduction

Dominant part of the present vehicles utilize inward combustion engines that consume gas or other petroleum products; and disregard to supplant worn or deteriorated segments by Motorists which result in poor engine performance, higher fuel utilization, motor harm and excess emissions (Prather, 1995; Martin, 2003). During combustion, various vaporous materials and pollutions are produced. These ignition side-effects are discharged into the environment as fumes gasses. Among the gasses stand nitrogen oxides, carbon monoxide, sulfur dioxide, lead and particulate matters that contaminate the atmosphere. It has been affirmed that, in creating nations of the world, vehicular development has been to a great extent unchecked by natural managing bodies making large amounts of contamination (Hans, 2006). One of the main worries of air contamination is the unfavourable wellbeing it has on wellbeing. Confirmation focuses to air contamination that shoots from transport as an essential supporter of ill health.

In Kenya, every person is eligible to a clean and healthy atmosphere and he or she is indebted to enhance it. The entitlement to a clean and healthy environment includes the access by persons in Kenya to the various public elements or segments of the
environment for recreational, educational, health, spiritual and cultural purposes (GOK, 2009). World Health Organization battles that perfect air is a fundamental necessity for human wellbeing and prosperity despite the fact that air contamination keeps on representing a noteworthy risk to wellbeing around the world. As indicated by their appraisal of the weight of ailment because of air contamination, more than two million unexpected losses happening every year can be ascribed to the impacts of urban open air and indoor air contamination caused by the consuming of petroleum products (WHO, 2002). The greater part of these ailment troubles, specifically respiratory complexities, are borne by the populaces of creating nations Kenya included (WHO, 2002), currently urban air pollution is increasing.

The traffic police department’ mandate ensure that drivers on the road comply with the traffic Act and related subsidiary legislations. A majority of the traffic police staff have to spend much of their time on the roads while on duty. In these circumstances therefore, they are exposed to particulate matter and exhaust gases emitted by the vehicles on the road. This situation is worsened during peak hours when the traffic is heavy and more pollutants are released into the ambient air. This may affect their health in a variety of ways including irritation of eyes, nose and throat (Anderson et al., 2001).

Vehicular emission has long run negative health consequences for those who are continuously exposed to it. This is a rather broad group including almost all the citizens of a metropolis. However, the impact varies and it depends on the direct contact with vehicular emission. The traffic police personnel’s of the city are a very vulnerable group in this regard. Standing long time in the city junctions facing the vehicles directly has a direct negative effect on them (Barman et al., 2010).
The environment conscious is very low in developing countries such as Kenya. Pollution hazard rarely come into the rational choice of the traffic men. Moreover the policemen’s duty is divided between on the road and off the road periods. Obviously the former involves a far greater health hazard with direct exposure to the vehicular emissions. These duty allocations are determined by the higher authorities with little consideration of the policemen health. Given this scenario, it is only the traffic officers themselves that can mitigate their health losses by taking measures to ameliorate the detrimental effect of air pollution. It is alongside this contextual that this study required to analyze the perception of motor vehicle emissions pollution impact on the health of traffic police in Nairobi, Kenya.

5.1 Material and Methods

5.1.1 Study Area

The study was carried out in the city of Nairobi, the capital city and the largest urban centre in Kenya and the one having the highest number of motor vehicles. The city is situated 140 kilometers south of equator and 500 kilometers west of the Indian Ocean at 1°17’S36°49’E. It occupies 696km² at an altitude of 1,661 meters above sea level (Nairobi county website, 2016 www.nairobi.go.ke/home/about-the-county).

5.1.2 Study population

The descriptive exploratory study was targeted the traffic police working within the CBD and its outskirts. Severely congested roundabouts, within the CBD and its outskirts, were selected purposefully for the study. These are the Kamukunji, Railways terminals, University way and Uhuru Highway roundabouts manned by a population of 127 traffic
police officers. Self-administered questionnaires were distributed to all the 127 participants. In addition, five (5) senior ranking officers participated in a key informant discussion. All the officers participated in the study. In respect of the proposed study, the researcher enlisted the services of traffic police leaders that is, the Base Commanders to help in the identification of the Traffic police officers according to their seniority of year of employment and work experience. It provided for equal chances of selection of individuals of similar level of experience.

5.1.3 Survey instrument

The study used a self-administered English language questionnaire to collect data, all traffic police officers being sufficiently literate as evidenced by the entry qualifications. The questionnaire was pretested with 8 traffic police officers of Kamukunji police Station who were not used in the actual study. The pretesting feedback helped establish internal consistency of the questionnaire. Before the self-administering of the questionnaires, traffic police officers were briefed on the purpose of the study. Thirty to forty five minutes were allowed for each respondent to fill in the answers in the presence of the researcher and his assistants. The questionnaires were collected immediately they were filled and validated and where necessary clarification sought from the respondent.

5.2 Data Analysis and Results

Working duration and perception on personal health

It was noted that on average an officer spends 10 hours manning traffic on a roundabout every week. About 98.1% of respondents indicated that they are affected by motor vehicle pollution whereas only 1.9% said that they are not affected. For those who agreed
that manning the roundabout exposed them to motor vehicle air pollution, they gave the following as their reasons; The police execute their duties for extended hours along the roundabout and therefore are most of the time vulnerable to smoke from vehicles (proportions); Traffic police officers work at the roundabout without any protective gear hence making them unprotected to things like smoke and dust (proportions); During work the police are exposed to a lot of smoke from moving vehicles (proportions); The fact that there are many traffic police officers working at the roundabouts who have had respiratory problems.

On average, at any one time, about 30% of the respondents are off duty due to sickness (Figure 5.1) for period 1-3 days per week, which translate to about 4-12 days, were month on sick leave.

Majority of the respondents (82.2%) said that they had been greatly affected by exposure to motor vehicle pollution, 15% (moderate), 0.9% (Small) and 1.9% had not been affected (See fig 5.1).

Compared to other police officers performing other core duties, the traffic officers are at a higher health risk. The findings revealed that 75.7% of the officers rated their risks as very high as compared to other officers, 23.4% (high) whereas only 0.9% rated their risks as low. See fig 5.2.

Most of the respondents agreed to have known another traffic officer who have had illnesses related to motor vehicle air pollution in the past one year (58.9%) and in the past three months (40.2%). (See Table 5.2).
On assessment of other air pollution that could affect their health the results indicated that 12.1% of the respondents were smokers among which 42.9% had once been advised by health professionals to quit smoking and 28.6% had been smoking first thing in the morning as an ‘eye opener’ and smoking an average of 6 sticks of cigarettes per day (See Table 5.3).
Days on sick leave in last one week

Figure 5.1: Days on sick leave in last one week

![Days on Sick leave in a Week](image)

Figure 5.2: Risk compared to other officer

![Percentage Risk compared to other officers](image)
### Table 5.1: Chances of Negative Effects

<table>
<thead>
<tr>
<th>Chances of Negative Effects</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/already affected</td>
<td>88</td>
<td>82.24</td>
</tr>
<tr>
<td>Moderate</td>
<td>16</td>
<td>14.95</td>
</tr>
<tr>
<td>Small</td>
<td>1</td>
<td>0.93</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td>1.87</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>107</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### Table 5.2: Knowledge of another officer who suffered

<table>
<thead>
<tr>
<th>Knowledge of another officer who suffered</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>63</td>
<td>58.9</td>
</tr>
<tr>
<td>No</td>
<td>44</td>
<td>41.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>107</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
A cross tabulation was made to establish the relationship between smoking and the effects of motor vehicle pollution. Of the 39.3% people who had ever had diseases associated with motor vehicle air pollution, 16% of them did smoke. This means that 61.5% of those who smoked had ever suffered from a disease associated with motor vehicle air pollution. The 12.3% of the officers who smoke may in general look like a small number compared to those who don’t smoke. However, taken on their own, and comparing them to those who have ever suffered a disease associated with Motor Vehicle air pollution, it becomes clear that smoking can be a cause for their illnesses. (See fig 5.3).

On preparedness of adverse health effects it was found that majority 47.7% were not prepared for adverse health effects that could result from motor vehicle emissions, 32.7 indicated they were little prepared, 8.4% were prepared. (See fig 5.2).

On preparedness on motor vehicle pollution, about 50.5% indicated that their stations were not prepared, 34.7% (a little prepared), 8.9% (prepared) while only 5.9% claimed to have been very prepared, 5.6 were well prepared while another 5.6% were unaware of any effects. (See fig 5.4).

The traffic department is a department within the Kenya Police Service that is charged with ensuring that drivers on the road comply with the traffic Act and related subsidiary legislations. A majority of the traffic police staff have to spend much of their time on the
Table 5.3: Use of cigarettes and alcohol

<table>
<thead>
<tr>
<th>Smoking and alcohol issues</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you smoke?</td>
<td>12.1%</td>
<td>87.9%</td>
</tr>
<tr>
<td>Have you ever been advised during the past year (12 months) by a health professional to stop smoking?</td>
<td>42.9%</td>
<td>57.1%</td>
</tr>
<tr>
<td>Have you ever had a smoke first thing in the morning to steady your nerves (Eye opener)?</td>
<td>28.6%</td>
<td>71.4%</td>
</tr>
</tbody>
</table>
roads while on duty. Traffic officers spend the about eight hours or more on the road while only few spend 8 hours or less while discharging their duties. The average hours spent on the road by traffic officers is 10 hours. However, when an officer falls sick or has to leave because of other reasons, his or her duties must be taken over by other officers. Due to the limited number of officers, at times one repeats a shift. Majority of the officers interviewed stated that they spend most part of their day manning traffic.

This study is in line with a study carried out by Bell, (2006), that demonstrated that the health effects of any pollutant in an individual is directly dependent on the exposure period and toxicity of the pollutant. Nanda Kumar et al. (2009), in their study among 80 TPO’s in Tirupati, India observed that there was a significant statistical correlation between period of exposure and an increase in admission rate for respiratory disorders. They observed that traffic police personnel who were occupationally exposed for longer period in their life reported to have more number of admissions than traffic police with less exposure periods. (See Table 5.4).

Areas found to have low pollution were University way and Uhuru highway. University way has high concentration of Car & Taxi (46.8%) and large cars 4WD & Jeeps (25.8%). While Uhuru highway was found to have high concentration of Car & Taxi (54.6%) and large cars 4WD & Jeeps (22.7%). The vehicles in this areas use mainly fuels which has substantial volumes of nitrogen oxides, carbon monoxide, and other pollution. The emissions from cars are low.
Figure 5.3: Number of cigarettes in relation to high effects

Figure 5.4: Preparedness of adverse effects of health
Figure 5.5: Police stations preparedness
Table 5.4: Association between type of vehicle fuel type and category of Road junction on CBD Nairobi City Kenya

<table>
<thead>
<tr>
<th>Road junctions</th>
<th>Pollution levels</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High pollution</td>
<td>Percentage</td>
<td>Low pollution</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Kamukunji</td>
<td>49.7</td>
<td>100</td>
<td>51.7</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Railways</td>
<td>48.3</td>
<td>100</td>
<td>50.3</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Uhuru highway</td>
<td>36.5</td>
<td>100</td>
<td>63.5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>University way</td>
<td>27.9</td>
<td>100</td>
<td>72</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
5.3 Discussions

Comparable studies done demonstrated that overwhelming heavy-duty vehicles tried in Germany and Finland produced around 210mg NOx for each kilometer driven, not as much as a large portion of the 500mg/km directed out by present day diesel autos that meet the most noteworthy "Euro 6" standard. In any case, the transports and trucks have bigger motors and consume more diesel per kilometer, implying that autos deliver 10 times more NO\textsubscript{x} for each litre of fuel.

In this study majority of the traffic police did not smoke cigarette. This is an indication that any health effects were to a great extent attributed to automobile air pollution and not to smoking. These results agree with the 2012 World Health Statistic that indicated that current daily tobacco smoking in Kenya is estimated at 9.3% (Gathura, 2012). These results also concur with the findings of Sharat et al. (2011), who had observed from his study that there was a significant decline in various parameters examined such as forced vital capacity (FVC), forced expiratory volume in one second (FEV\textsubscript{1}), and peak expiratory flow rate (PEFR) on the exposed non-smoking TPO’s when compared with the controls.

On the number of years worked, the study found that on average, traffic police officers worked for 5 years in the traffic department. This therefore exposes them for long periods on daily basis to the effects of automobile air pollution. Thus traffic officers are vulnerable of being affected by the toxins with constant exposure. These results compares well with those of Zemp et al. (1999), also reported in Switzerland, that there existed a relationship amid long-standing exposure to ambient air pollution and
respiratory symptoms. Similar trends were observed by the investigator where there was more number of admissions among the traffic police personnel who were exposed for 6 years. Also Michael and Konstantinos (2008) and Gauderman and others (2000) all argued and demonstrated that the health effects of any pollutant is dependent on the period of exposure and the target organ affected.

The study showed a significant reduction in lung function in police workers working in the high traffic generated pollution (Singh, Sharma, Yadav, & Meena, 2009). Another study found that changes during exercise testing that included decreased gross mechanical efficiency and a decrease in the amount of keep fit period at an anaerobic threshold and highest effort compared to those whose exposure was less. In addition, those working in chronic air pollution had a higher frequency of respiratory allergies (Volpino et al., 2004). Substantial evidence and research involving combustion-related fine particulate inhalation exposure concludes that air pollution is harmful to human health. Long haul exposures have been related with cardiovascular mortality, different blood markers of cardiovascular hazard, histopathological markers of subclinical unending lung damage and subclinical atherosclerosis. Here and now exposures to particulate matter in the atmosphere have been related with cardiovascular mortality and healing facility affirmations, stroke mortality, myocardial areas of localized necrosis, confirmation of aspiratory and orderly aggravation and oxidative anxiety, modified heart autonomic capacity and blood vessel vasoconstriction (Pope & Dockery, 2006).

As Traffic moves slowly, slow moving vehicles emit more carbon monoxide, the problem is more surmounted in Nairobi. This co-effect is toxic to human’s body. It reacts with the hemoglobin of blood and affects oxygen supply to the brain. Thus it causes death
One of the major causes for road congestion and therefore, vehicular emission is the massive increase in the vehicular pollution plying in and around Nairobi city. Due to this huge vehicular pollution growth, the energy demand (both diesel and petrol) increased manifold. One of the major factors that determine vehicular emission is the speed of the vehicles. According to the eminent scientist there exists a critical speed at which the emission is less of the vehicles. If the speed is well below or well above that critical one then the emission will rise significantly. So vehicle emissions are one of the significant constituents in ambient pollution. Citing a study by NEERI (2005) they found that the main concentration levels for various atmospheric pollutants have increased in all the major cities.

In Kenya, legal Notice No. 60 of 2007 (GOK, 2007) provides the recommended long term exposure limits as follows, 50 ppm for CO, 5000 ppm for CO2, 3 ppm for NO2 while short term exposure limits are given as 300 ppm for CO, 15000 ppm for CO2 and 5 ppm for NO2 respectively. WHO (2000) also provides long term exposure limits for CO and NO2 as 9 ppm and 0.072 ppm respectively while short term exposure limits for the same gases are given as 26 ppm for CO and 0.12 ppm for NO2.

Other reports also indicate that cancer among the urban population in Kenya between the periods 2000 to 2002 was on an upward trend (Korir et al., 2008) and malaria was the primary source of illness followed closely by diseases of respiratory infections in the year 2005, 2006 and 2007 respectively (MOH, 2008). Statistics in Kenya also show that about 50 Kenyans die on daily basis from various forms of cancer and about 80,000 cases of cancer are diagnosed each year in the world (Olick, 2011). The reports, however, failed to
give the underlying factors for cancer and respiratory ailments. This phenomenon clearly exposes gloomy situation in Kenya.

The tiny evidence accessible on automobile air pollution in Nairobi suggests great pollution emissions (Gatebe, 1992; Karue et al., 1992 and Gatebe et al., 1996). Similarly Mulaku and Kamau (2001) demonstrated that a similar situation and condition prevailed within Nairobi. In most cases, air pollution increases in direct proportion with the increase of the number of vehicles (Odhiambo et al., 2010) in the absence of clear policies in the management of emissions from these motor vehicles. Vehicle age and lack of regular maintenance, poor infrastructure and economic inability are factors that were found to aggravate air pollution situations in urban centres especially the Central Business District (Maina et al., 2015).

The developing countries suffer more than the developed countries from air pollution which happens from vehicle emissions. Vehicle emissions have high level of leads have led to a great environmental danger in many places in the world. For them the problem is becoming more acute as the numbers of motor vehicles are growing rapidly. Example in Delhi’s, vehicular pollution is responsible for 64 percent of the pollutants thus the inhabitants inhale a lot of polluted air (Bhattacharyya et al., 2002).

5.4 Conclusions and recommendations

The traffic officers have associated illnesses such as respiratory problems, asthma, cancer and other diseases that are pollution related, to the high emissions of motor vehicle pollution in the CBD. The police men take long hours manning their duty stations, and
due to low number, majority does not take their days off and therefore they are highly exposed.

It is recommended that structures be put in place to take care of police officers, who have suffered from the effects of motor vehicle air pollution. The study recommends that the traffic department should establish and implement a system of rotation of duties for the officer’s for example alteration of field work with office work, so as to reduce the exposure.

The study recommends that exposure can also be reduced by providing the traffic police officers with suitable personal protective devices such as masks and plain glasses to prevent lung and eye irritations. They should also be trained on their use, the type of air pollutions and associated health hazards and preventive measures required.
CHAPTER SIX

OVERALL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.0 Overall discussion

Individual transportation choices have an enormous impact on air quality and even the quality of life of those people exposed to the polluted air. The types of vehicles driven on the roads and the fuel they use impacts negatively to the people and the environment through emissions including gases and particulate matter. Emissions can contribute to heart and breathing problems in addition to increased risk of lung cancer (Mavale-Manuel, 2004). It was observed during this research that some health complaints made by traffic police officers could be associated with motor vehicle air pollution. Such complaints constituted a financial burden to traffic police officers, who were forced to part with huge sums of money to meet treatment costs. This study therefore highlighted the need for enhancing of technologies and driving habits that not only could reduce fuel consumption, emissions and exposure of people to environmental pollution (Gatari, 2006).

Government agencies, police administrators and traffic police officers themselves possess sufficient knowledge about motor vehicle emissions and its health effects. Therefore, it is surprising, that very little, if anything is done to fight this menace. Among measures that should be implemented include upgrading of vehicle quality and driving rules, their enforcement and infrastructural interventions to smooth out traffic flow. Where laws and rules exist, their enforcement has been hampered by corruption in government institutions and a lax judicial system (Ramanathan and Carmichael, 2008). Without the full and
unequivocal support of the government, the battle touching motor vehicle emissions in Nairobi and other parts of the country is lost before it even before it is started. Alternative measures that involve all road users all are needed for a holistic approach to fighting motor vehicle air pollution (Aligula et al., 2005).

By and large, the study results reveal that traffic police officers in Nairobi are aware of motor vehicle air pollution. Traffic police officers conceptualize motor vehicle air pollution as a phenomenon that is characterized by indicators such as noise, dust and smoke. Majority of the respondents showed a good understanding of what causes motor vehicle air pollution. Further, the study established that traffic police officers are aware and knowledgeable in ways of preventing or reducing their exposure to motor vehicle air pollution. However, their utilization of these methods remains a challenge as most traffic officers did not use these methods in their daily duties. Traffic police officers are also knowledgeable in the causes of motor vehicle air pollution but assert that not much is being done to deal with these causes.

The study also established that traffic police officers’ level of exposure to motor vehicle air pollution is very high as most of them control traffic at the roundabouts and junctions 7 days a week for at least 10 hours a day. Traffic duties therefore have a very high chance of exposing traffic officers to motor vehicle air pollution and majority of the officers are aware of this fact. Majority of traffic officers felt that the police administration was not taking adequate measures to protect officers from motor vehicle air pollution. However, this did not translate to individual officers taking precautionary measures to protect them as majority conceded that they did not take any measures to protect themselves. Overall,
respondents felt that the traffic police department was not adequately prepared to fight motor vehicle air pollution.

From the study, it is seen that traffic police officers suffer from illnesses associated with motor vehicle air pollution. Motor vehicle emissions are key contributors to health risks and environmental damage in Nairobi CBD. In addition, traffic police officers reported being affected financially by their exposure to motor vehicle hazardous emissions. The study echoed the vulnerability of traffic police officers to argumentative effects associated with motor vehicle air emissions. The prerequisite for addressing this issue was clearly painted by the study.

Studies conducted in India demonstrated increased risk of getting different respiratory problems when traffic police are exposed to polluted air for a longer time. It is essential for traffic police to be aware of the problems especially related to respiration in cities like Nairobi. A similar study confirmed prevalence of chronic bronchitis and asthma in traffic police unprotected to vehicle pollutants in concentrations higher than WHO recommended guidelines, thus leading to significant increase in respiratory problems Rachou (1995). Other studies in Ethiopia, Mozambique, and Kenya found significantly higher prevalence of asthma in urban people exposed to road traffic contamination related to rural child (Bekele, 1997; Mavale-Manuel, 2004; Ng'ang'a, 1998).

Ambient pollution carries substantial threats for human health and the environment. The health risks of ambient pollution are tremendously serious. Poor air quality increases respiratory ailments like asthma and bronchitis, heightens the risk of life-threatening conditions like cancer, and burdens our health care system with substantial medical costs.
Particulate matter singlehandedly is responsible for up to 30,000 premature deaths each year. Passenger vehicles are a major pollution contributor, producing significant amounts of nitrogen oxides, carbon monoxide, and other pollution. This study showed that the level of knowledge regarding the prevention of respiratory problems among the traffic police was comparatively higher than the level of practice. Similar results were obtained in a study done in India; the level of knowledge was found to be better in majority of traffic police while the level of practice was lower. This might be due to Police regulations (Chapter. 84 LOK paragraphs 8, force standing orders) which stipulate code of dressing in the entire police force. The entire population of traffic police at the city of Nairobi never used masks to prevent respiratory problems in this study. A study revealed that no such arrangements have ever been suggested nor implemented. In Nairobi city, Motor vehicle emission is the major contributor to airborne pollution. In addition, at the time of this study, construction of roads was in progress in parts of the city street, intersections and Road junctions which could also be factor for contribution of higher particulate matter dynamic. This could have aggravated the condition of air, eventually deteriorating the health of the traffic police. The good health of traffic police and city dwellers is ensured only if the government implements vehicle inspection and emission testing effectively and ban on polluting vehicles. This research suggests that, with longer experience, people increase their level of performance. It is better to learn preventive measures against air pollution from experience and practice them in daily life.

In Kenya, traffic police department have showed that the level of knowledge regarding the prevention of respiratory problems among the traffic police is comparatively higher than the level of practice. Related study exhibited the same results in India by Babisch
(2000) and Fogari (2014) that showed that the level of knowledge was found to be better in majority of traffic police while the level of practice was average. This might have been contributed by financial problems encountered by the traffic police as studies have suggested that socioeconomic factors play a role in the health seeking behaviours. In addition, lack of time management during duty periods could prevent attending regular health check-up. Nonetheless, they should be motivated to have healthy and safe practice against the pollution. Furthermore, the government should draft sustainable policies addressing such issues.

It has been estimated that about 90% of urban air pollution is rapidly increasing in cities of developing countries which is attributable to motor vehicle emissions (UNEP, 2011) so while there are many causes of air pollution in Nairobi, including open air burning of refuse and biomass (Gatari, 2006), motor vehicles play a critical role in the problematic. Swelling road congestion, along with a high prevalence of old, poorly-maintained vehicles and of low quality fuels, contributes to this problem. One projection estimates that in a “do nothing” (or business as usual) scenario, the number of vehicle trips between 2004 and 2025 in the Nairobi Metropolitan Area will increase by 148% and that the average speed of trips will decrease from 35km/hr to 11km/hr as congestion increases (Japanese International Cooperation Agency, 2006) which makes it reasonable to assume that if nothing is done, urban air quality will worsen. The mixture of vehicles in 2015 was 29% passenger cars, 35% light-duty trucks, 7% heavy-duty trucks, 7% minibuses (Matatus), and 22% others (KNBS, 2007). Between 2012 and 2016, the number of trucks increased by about 60% (KNBS, 2016), reflecting increased activities in the agricultural and industrial sectors. Most trucks and buses rely on high sulfur diesel fuel
(≤5000 μg/m³ S) which leads to high particulate emissions. A large proportion of newly-registered vehicles in Nairobi are imported as used vehicles from East Asia.

There are important health implications of roadway emissions, particularly for highly exposed individuals near roadways and/or for population subgroups that are particularly sensitive to health effects. Motor vehicle emissions include a range of pollutants, including particulate matter (PM), carbon monoxide, sulfur oxides, nitrogen oxides and a wide range of volatile organic compounds, which react with sunlight to form ozone. Many of these pollutants have well-known health effects which may be exhibited with short term exposure, including wheezing, coughing, shortness of breath phlegm and sore throats as well as irritation of existing respiratory conditions such as asthma (Hedley et al., 2003; Frumkin et al., 2004, Schwela et al., 2006). However, PM$_{2.5}$ is of particular significance because research on health effects in urban areas has demonstrated associations between both short-term and long-term average ambient PM$_{2.5}$ concentrations and a variety of adverse health outcomes. These include increased post neonatal infant mortality (Woodruff et al., 2006) and premature deaths related to heart and lung diseases. PM$_{2.5}$ is a complex mixture of solid or liquid organic and inorganic particles that share the property of being less than/equal to 2.5 μm in aerodynamic diameter. Because of their small sizes, PM$_{2.5}$ particles are able to penetrate deeply into the lungs where they can exert adverse effects. In 2005, the World Health Organization (WHO), based on known health effects, set a 24-hour average guideline of 25 μg/m$^3$ and an annual average guideline of 10 μg/m$^3$. PM$_{2.5}$ includes black carbon (BC), or soot, which is emitted by incomplete combustion sources including diesel and poorly-tuned
gasoline engines, and open fires. In addition to adverse health impacts (USEPA, 2002; Bell et al., 2009), BC contributes to climate change (Ramanathan and Carmichael, 2008).

Nairobi is growing quickly without accompanying transportation and infrastructure services or even an urban transportation policy, as indicated in the Kenya Ministry of Transport’s Recommendations on an Integrated National Transport Policy (INTP) (Kenya Ministry of Transport and Communications, 2014). This lack of policy is made manifest by a transportation system characterized by severe congestion, high-polluting vehicles, lack of pedestrian and bicycle lanes, lack of accessible, high quality public transport options, and deteriorating infrastructure (Ministry of Transport and Communications, 2004; Aligula et al., 2005).

6.1 Conclusion

Motor vehicle air pollution is real and could be affecting traffic police officers. The numbers and types of motor vehicles traversing road junctions contribute positively to the extent of emissions. These tendencies will increase and ultimately be costly to society.

Traffic police officers in Nairobi conceptualize motor vehicle air pollution as a phenomenon that is characterized by indicators such as noise, dust and smoke. They are also knowledgeable about ways and means of protecting themselves from exposure to motor vehicle detrimental fumes. Traffic police officers’ level of contact to motor vehicle toxic emissions is high as most of them manned roundabouts and junctions seven days a week for at least 8 hours a day. Knowing these negative effects of their duties, majority of traffic officers blamed the police administration for failing to take adequate measures
to protect them from motor vehicle air pollution. However, individual officers did not take precautionary measures to protect themselves.

Traffic police officers in Nairobi do suffer from illnesses associated with motor vehicle air pollution, being exposed to emissions obtaining in the CBD environment. The suffering results in financial medical burdens.

The study reiterated the vulnerability of traffic police officers to adverse effects associated with motor vehicle air pollution. The need for addressing this issue was clearly painted by the study.

### 6.2 Recommendations

Reduction of individual motor vehicle air pollution will result in total reduction in air pollution.

This can be done by reducing the number of motor vehicles and enhancing flow of traffic. In light of the findings of the study and the above conclusion, the researcher recommends as follows:

a. Exhaust emission reductions for diesel motor vehicles, and petrol motor vehicles through updating regulations and strict enforcement of regular maintenance and the guarantee of proper functioning of the exhaust control devices through spot inspections as well as scheduled inspections of motor vehicles using accurate equipment.

b. A training program on motor vehicle fumes emissions targeting traffic police officers set up. It should focus on such topics as protective measures against
exposure to motor vehicle air pollution and offer a platform for experience sharing motor vehicle air pollution knowledge among traffic officers. As a policy intervention, such training should be integrated into the traffic management course that all traffic police have to undergo before being posted to their stations of duty.

c. Police stations should be provided with equipment and gear for continuous training of traffic police officers on motor vehicle air pollution. Such gear and equipment should be made available for use in protecting the officers. To further encourage their use, regular drills and exercises should be held.

d. The traffic police department must reduce exposure of officers on duty to motor vehicle air pollution through such measures as reduction of hours spent manning traffic, taking regular breaks while manning traffic, rotational duties, providing protective gear as well as regular medical checkups and treatment for traffic officers where necessary.

e. Infrastructural improvement should be planned to smoothen traffic flow and reduce reliance on human traffic control at road junctions, where slowdown causes motor vehicle pollution. The government should explore effective ways of doing away with roundabouts by developing more modern road networks and expanding existing roads.

f. Road users (drivers, passengers and pedestrians) should be sensitized on motor vehicle air pollution and its effects. Creation of awareness will ensure that people observe simple but significant behavioral changes like turning off engines when
their vehicles are not in motion, eliminating unnecessary idling, keeping tyres properly inflated, fixing air conditioning faults, paying attention to dashboard warning lights, driving gently, steadying speeds and correct loading.

g. Use of alternative means of transport toward the City of Nairobi which is friendly to the environment and the entire population. This mode of transport include cycling, walking, use of train and much higher capacity carriers which minimize so much over crowding of small cars which carry fewer passengers hence increasing the levels of pollution due to their large numbers.
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UNEP (2012)


APPENDICES

Appendix 1: Study questionnaire
My name is Samson Murangiri Mukaria, PHD student at the University of Nairobi. I am shepherding a study on the TRAFFIC POLICE KNOWLEDGE, ATTITUDES AND PRACTICES ON MOTOR VEHICLE AIR POLLUTION AS WELL AS EFFECTS OF MOTOR VEHICLE EMISSIONS ON TRAFFIC POLICE OFFICERS IN NAIROBI CITY AND ENVIRONS for my project paper. I kindly request you to be as authentic as possible in filling the following questionnaire to support me collect data. The information you give will be kept intimate and will only be used for the determinations of the study.

A. DEMOGRAPHIC DATA

1. Work number (optional):
2. Position/ Rank:
3. Station of Work:
4. Years of Service:
5. Level of Education:
6. Sex of officer:
7. Age:

B. GENERAL QUESTIONS

a. How many roadblock sites are under your station?
b. For how long have you been in the traffic police service?
c. How many busy roundabout and intersections are under your station?
d. How many years have you worked at the current Traffic base office?
e. How many years in total have you worked in the traffic department?
C. QUESTIONS ON KNOWLEDGE/AWARENESS OF MOTOR VEHICLE AIR POLLUTION AND RELATED HEALTH EFFECTS BY TRAFFIC POLICE OFFICERS

1. In your opinion what is motor vehicle air pollution?

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

2. Which types of vehicles pollute most? (Tick as it is mentioned DO NOT READ OUT TO RESPONDENT).

(a) Lorries ( )
(b) Buses ( )
(c) Commuter vans ( )
(d) Taxis ( )
(e) Personal cars ( )
(f) Trains ( )

Why? Explain your answers above

……………………………………………………………………………………
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3. Some people say that diesel vehicles pollute more than petrol vehicles. Do you agree and why?

(a) YES ( )
(b) NO ( )

Why?

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4. In your view, which areas of Nairobi have high motor vehicle air pollution than others?

   (a) CBD                  (  )
   (b) Highways              (  )
   (c) Roundabouts          (  )
   (d) Checkpoints          (  )
   (e) Outside the CBD     (  )
   (f) Everywhere         (  )

Explain your answer
........................................................................................................................................
........................................................................................................................................
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5. Which negative health effects arise from motor vehicle pollution?

   (a) Bronchitis           (  )
   (b) Asthma               (  )
   (c) General cough       (  )
   (d) Skin rash           (  )
   (e) Eye problems       (  )
   (f) Running nose       (  )
   (g) Blotted nose       (  )
   (h) Headaches          (  )
   (i) Dizziness          (  )
   (j) None               (  )
   (k) I don’t know       (  )
6. Are you aware that exposure to motor vehicle air emissions causes the following health problems?

<table>
<thead>
<tr>
<th>Disease</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>Cardiovascular diseases</td>
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<td>Respiratory diseases</td>
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<td>high blood pressure</td>
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<td>Imbalance in automotive systems.</td>
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<td>Chronic Obstructive Pulmonary Disease (COPD)</td>
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<td>Skin rash</td>
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<tr>
<td>Persistent blocked or running nose</td>
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</tbody>
</table>

7. Which groups of people do you think are affected most by motor vehicle air pollution?

(a) Old people ( )
(b) Children ( )
(c) The sick ( )
(d) Police men ( )
(e) Street vendors ( )
(f) Pedestrians ( )
(g) Everyone ( )
(h) I don’t know ( )
8. Do you know that air pollution affects the health of traffic police officers?
   (a) YES ( )
   (b) NO ( )

9. IF YES what effects do you know? (Can be multiple answers) **TICK AS ANSWERED**
   (a) Bronchitis ( )
   (b) Asthma ( )
   (c) General cough ( )
   (d) Skin rash ( )
   (e) Eye problems ( )
   (f) Running nose ( )
   (g) Blotted nose ( )
   (h) Headaches ( )
   (i) Dizziness ( )
   (j) Others ( ) Specify…………………………………………
   (k) None ( )
   (l) I don’t know ( )

10. From which sources do you get information on motor air pollution among the traffic police? (Can be multiple answers) **TICK AS ANSWERED**
    (a) Health workers ( )
    (b) Television and radio ( )
    (c) Newspapers, journals and publications ( )
    (d) Internal health department ( )
    (e) Other sources (please specify) ( )
D. QUESTIONS ON ATTITUDES OF TRAFFIC POLICE OFFICERS ON
MOTOR VEHICLE AIR POLLUTION AND RELATED HEALTH
EFFECTS

1. Do you care about reducing motor air pollution?
   (a) YES ( )
   (b) NO ( )

2. Do you take care to reduce your exposure to the motor pollutants?
   (a) YES ( )
   (b) NO ( )

3. IF YES, what actions do you take? /Can be many answers
   (a) ………………………………………………………………………….……….
   (b) ………………………………………………………………………….……….
   (c) ………………………………………………………………………….……….
   (d) ………………………………………………………………………….……….
   (e) ………………………………………………………………………….……….

4. What do you generally think of your traffic control area (roadblock/ roundabout)
   air quality?
   (a) Very good ( )
   (b) Good ( )
   (c) Average ( )
   (d) Bad ( )
   (e) Very bad ( )

5. Do you care about improving the police officers’ health?
   (a) Yes ( )
   (b) No ( )
E. QUESTIONS ON THE LEVEL AND NATURE OF EXPOSURE OF TRAFFIC POLICE OFFICERS TO MOTOR VEHICLE AIR POLLUTION

1. What is the frequency of short breaks for police manning roadblocks or roundabouts?
   (a) 4 times and above per day ( )
   (b) 2-3 times per day ( )
   (c) once per day ( )
   (d) Not at all ( )

2. How many hours do you take while manning a roundabout or roadblock per day?
   (a) 1-2 hours ( )
   (b) 3-4 hours ( )
   (c) 5-6 hours ( )
   (d) 7-8 hours ( )
   (e) 9-10 hours ( )
   (f) 11-12 hours ( )
   (g) None ( )

3. How many days in a week do you man a roadblock or roundabout?
   (a) 1-2 days ( )
   (b) 3-4 days ( )
   (c) 5-6 days ( )
   (d) 7 days ( )
   (e) None ( )

4. What is the frequency of using protective gear while on traffic patrols/ duty?
   (a) Every day ( )
   (b) 2-3 days a week ( )
   (c) 4.5 days a week ( )
   (d) 6-7 days a week ( )
   (e) 7 days a week ( )
   (f) Never ( )
F. QUESTIONS ON THE EFFECTS OF MOTOR VEHICLE AIR POLLUTION
ON TRAFFIC POLICE OFFICERS

1. How many times have you suffered from any of the mentioned illnesses in the last year?
   (a) Cardiovascular diseases
   (b) Respiratory diseases
   (c) Lung cancer
   (d) Respiratory tract infections
   (e) Heart attack
   (f) high blood pressure
   (g) Imbalance in automotive systems.
   (h) Chronic Obstructive Pulmonary Disease (COPD)
   (i) Coughing
   (j) Wheezing of chest
   (k) Asthma
   (l) Eye problem
   (m) Skin rash
   (n) Persistent blocked or running nose

2. How many times and in the last 3 months have you suffered from the below mentioned illnesses?
   1. Cardiovascular diseases
   2. Respiratory diseases
   3. Lung cancer
   4. Respiratory tract infections
   5. Heart attack
   6. high blood pressure
   7. Imbalance in automotive systems.
   8. Chronic Obstructive Pulmonary Disease (COPD)
   9. Coughing
   10. Wheezing of chest
11. Asthma
12. Eye problem
13. Skin rash
14. Persistent blocked or running nose

3. Please state the causes of respiratory illnesses you suffered from in your opinion
   ……………………………………………………………………………………..
   ……………………………………………………………………………………..
   ……………………………………………………………………………………..

4. Did the police department cater for the treatment of the illnesses you suffered from
   (a) YES
   (b) No

5. Do you know any traffic police officer who has suffered from the below mentioned illnesses in the last one year?
   1. Cardiovascular diseases   ( )
   2. Respiratory diseases  ( )
   3. Lung cancer   ( )
   4. Respiratory tract infections  ( )
   5. Heart attack   ( )
   6. high blood pressure  ( )
   7. Imbalance in automotive systems. ( )
   8. Chronic Obstructive Pulmonary Disease (COPD) ( )
   9. Coughing   ( )
   10. Wheezing of chest  ( )
   11. Asthma   ( )
   12. Eye problem   ( )
   13. Skin rash  ( )
   14. Persistent blocked or running nose ( )
6. Which illnesses did they suffer from? (Tick as mentioned)

1. Cardiovascular diseases ( )
2. Respiratory diseases ( )
3. Lung cancer ( )
4. Respiratory tract infections ( )
5. Heart attack ( )
6. high blood pressure ( )
7. Imbalance in automotive systems. ( )
8. Chronic Obstructive Pulmonary Disease (COPD) ( )
9. Coughing ( )
10. Wheezing of chest ( )
11. Asthma ( )
12. Eye problem ( )
13. Skin rash ( )
14. Persistent blocked or running nose ( )

7. Do you know of traffic police officers who have died in the last one year because of the below mentioned illnesses?

1. Cardiovascular diseases ( )
2. Respiratory diseases ( )
3. Lung cancer ( )
4. Respiratory tract infections ( )
5. Heart attack ( )
6. high blood pressure ( )
7. Imbalance in automotive systems. ( )
8. Chronic Obstructive Pulmonary Disease (COPD) ( )
9. Coughing ( )
10. Wheezing of chest ( )
11. Asthma ( )
12. Eye problem ( )
13. Skin rash ( )
14. Persistent blocked or running nose ( )
8. Do you know of traffic police officers who have died in the last 3 months because of the below mentioned illnesses?

1. Cardiovascular diseases ( )
2. Respiratory diseases ( )
3. Lung cancer ( )
4. Respiratory tract infections ( )
5. Heart attack ( )
6. high blood pressure ( )
7. Imbalance in automotive systems. ( )
8. Chronic Obstructive Pulmonary Disease (COPD) ( )
9. Coughing ( )
10. Wheezing of chest ( )
11. Asthma ( )
12. Eye problem ( )
13. Skin rash ( )
14. Persistent blocked or running nose ( )

QUESTIONNAIRE FOR KEY RESPONDENTS

QUESTIONS ON THE MEASURES TAKEN TO LOWER MOTOR VEHICLE AIR POLLUTION AND THEIR EFFECTIVENESS

1. Do you as a department or station measure the levels of motor air pollution?
   (o) YES ( )
   (p) NO ( )
   (q) DON’T KNOW ( )

2. IF you measure the level of pollution, please tell me the minimum and maximum levels recorded in the last exercise.
   (a) Minimum
   (b) Maximum
   (c) Don’t know
3. Are the pollution levels same or different during the cold/rainy or hot seasons? Explain

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4. Please tell us what you do to improve the protection of traffic police officers from exposure to motor air pollution

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5. What percentage of your annual work time do you spend specifically on air pollution health preparedness and response activities?

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6. Does the police station office have a committee or team that specifically deals with motor vehicle pollution preparedness and response issues? Explain

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7. Does the police station have a health preparedness coordinator, and if so, is it a full- or part-time position?

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…………………………………………………………………………………………
8. What type of event do you think is most likely to occur in or around police station in the future regarding health preparedness on motor vehicle pollution?

9. State the range of health impacts that the police station has experienced in the last three years, including financial impact, human casualties, and any damage related to motor vehicle pollution

10. Using a scale of 1 (Not at all prepared) to 5 (Very well prepared) rate the police station’s preparedness in each of four areas of preparedness: Explain
   - Planning
   - Exercises
   - Training
   - Equipment and supplies

11. Rate your police station’s overall preparedness for motor pollution effects using a scale of 1 (Not at all prepared) to 5 (Extremely well prepared). Explain

12. Does the police station participate in planning for the city and/or county on controlling motor pollution? Explain

What are the sources of funding for police station’s motor air pollution preparedness activities?

IF an officer got respiratory diseases more than once, do you find out the cause of illness? (a) Yes ( ) (b) No ( )

Thank you very much for your time.
Appendix 2: Interview guide for key informants

My name is Samson Murangiri Mukaria, PHD student at the University of Nairobi. I am shepherding a study on the TRAFFIC POLICE KNOWLEDGE, ATTITUDES AND PRACTICES ON MOTOR VEHICLE AIR POLLUTION AS WELL AS EFFECTS OF MOTOR VEHICLE EMISSIONS ON TRAFFIC POLICE OFFICERS IN NAIROBI CITY AND ENVIRONS for my project paper. You are therefore being requested, as a key stakeholder, to spare some time to answer questions in this questionnaire. Your responses shall be used in strict discretion, and shall not be attributed to any one without your express permission. Please feel free to end the interview at any time if you feel uncomfortable with it. Thank you in anticipation of your cooperation.

QUESTIONS

1. What is the status of motor vehicle air emissions in Nairobi?
   - Motor vehicle fume emissions have increased tremendously bearing in mind the increase of vehicles entering city of Nairobi.
   - The condition of the roads leading to city is poorly maintained hence making vehicles to slow in traffic Jams and then polluting more.
   - Un maintained vehicles which some are old have high chances of polluting more due to current trends of importing old used vehicles from Japan.
   - Un regulated levels of pollution which sometimes is escalated by modified exhausts which blows more smoke and noise which is more common with matatus and yet no action is taken by police and NEMA.
   - Due rise of population of city of Nairobi many vehicles have been forced to make several trips to and back to meet the demand of customers hence causing high levels of traffic snarl and consequently causing more pollution.
   - Use of un clean fuel which sometimes is mixed with lower volatiles fuels like paraffin which is less expensive hence maximizing profits without proper measures and checks and balances for possible prosecution. This un clean fuels never burn to its maximum hence contribute to black smoke and Tar which is pollutant.
2. Which areas manned by traffic police officers do you suspect have high motor vehicle air pollution?

- Kariokor round about, Kamukunji round about, Railway Round about, Uyoma street and Baroda street.

**Why?**

- High traffic jams is experienced in this areas
- Road condition in this areas is poor and wanting for repairs due to pot holes hence slowing movement of vehicles.
- Large buses and matatus which carry passengers pass this routes and also those lorries which brings farm produce to market all uses diesel which is less volatile and more pollutant than other fuels.

3. Are there types of vehicles that cause greater air pollution in Nairobi

   If YES which ones?

4. Kindly comment on the relationship between the following aspects and motor vehicle air pollution in Nairobi

   I- Hours of the day
   
   II- Days of the week
   
   III- Temperature
   
   IV- Humidity

5. Are there particular health effects of motor vehicle air pollution on traffic police officers?

   If YES which ones and how do you know?

6. Comment on the enforcement of the traffic act on excessive emissions and whistling exhausts (probe level of enforcement, challenges with enforcement, and possible solutions to those challenges)

7. At the administration level have you ever come up with a mechanism to protect police officers from traffic air pollution?

   If YES which ones?
8. How do you rate your department’s use of safety measures to reduce traffic police officers’ exposure to motor vehicle air pollution?
   1 Very poor     2 Poor     3 Good     4 Very good
   Why?
9. Please tell us what you do to improve the protection of traffic police officers from exposure to motor air pollution
10. How do you rate the relevance of your annual air pollution health preparedness and response activities?
11. Does the police station office have a committee or team that specifically deals with motor vehicle pollution preparedness and response issues?
    1- Yes   2- No
    Explain your answer above
12. Does the police station have a health preparedness coordinator?
    1- Yes   2- No
    If YES, is it a full- or part-time position?
13. What type of event do you think is most likely to occur in or around police station in the future regarding health preparedness on motor vehicle pollution?
14. Using a scale of 1 to 4 rate the police station’s preparedness in each of four areas of preparedness: Explain
    1-Not at all prepared     2- A little prepared
    3-Prepared     4- Very well Prepared
    Planning ( )
    Exercises ( )
    Training ( )
    Equipment and supplies ( )
15. State the range of health impacts that the police station has experienced in the last three years, including financial impact, human casualties, and any damage related to motor vehicle pollution
16. IF an officer got respiratory diseases more than once, do you find out the cause of illness?
17. What are the sources of funding for police station’s motor air pollution preparedness?

18. Using a scale of 1-4, express your opinion about PRACTICES AND MEASURES in the following statements.

Scale: 1- Strongly disagree  2-Disagree  3-Agree  4-Strongly agree
a- Pollution levels are the same during the cold/ rainy and hot seasons
b- The police station participates in planning for the city and/or county on controlling motor pollution
c- The traffic police department is adequately prepared to carry research on motor vehicle air pollution
d- The traffic police department is adequately staffed with qualified personnel to carry out research on motor vehicle air pollution
e- There is a dedicated committee that looks into traffic air pollution in the department
f- There exist enough measures and practices to protect police officers from exposure to traffic pollutants

19. What are the two most critical constraints to research about motor vehicle air pollution in the police department?

20. Suggest ways to address the constraints above.

Thank you very much for your cooperation
Appendix 3: Photos

Traffic police officers filling questionnaire
Measuring particulate matter in traffic congested area accompanied by the supervisors.
Measuring particulate matter in traffic congested area while the traffic boss is watching practically.
Vehicle producing excessive smoke in CBD Nairobi
Traffic police controlling vehicles in CBD
A vehicle producing excessive smoke from its exhaust while passing a traffic officer at a road block
A truck producing smoke in traffic
Appendix 4: Data collection forms (Tally Sheet)

Feasibility and detail design of all classes of motor vehicle entering through CBD (1) Kamukunji roundabout (2) Railway terminus (3) Uhuru Hway/Haile Selassie Rd (4) University way Round about IN NAIROBI, LINES 3W, 4W AND 3E

MANUAL CLASSIFIED TRAFFIC COUNTS (MCC) FORMAT

<table>
<thead>
<tr>
<th>Vehicle Type/Hour starting</th>
<th>Motorcycle</th>
<th>Tuk tuk</th>
<th>Car &amp; Taxi</th>
<th>Large cars,4WD &amp; Jeeps</th>
<th>Pick up &amp; Van</th>
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Prepared by Mr. Samson Murangiri Mukaria A82/96487/2014-PhD Student University of Nairobi
Feasibility and detail design of all classes of motor vehicle entering through CBD (1) Kamukunji roundabout (2) Railway terminus (3) Uhuru Heway/Haile Selassie Rd (4) University way Round about IN NAIROBI, LINES 3W, 4W AND 3E

MANUAL CLASSIFIED TRAFFIC COUNTS (MCC) FORMAT

<table>
<thead>
<tr>
<th>Vehicle Type/ Hour starting</th>
<th>Matatu (&lt;23) unladen</th>
<th>Minibus/Small (24-45) unladen</th>
<th>Large bus(&gt;45seaters) Unladen</th>
<th>Light Good Vehicles (LGV)</th>
<th>Medium good (2axles) 1st Load unladen</th>
<th>Heavy Trucks (3-4 Axles, rigid)</th>
<th>Articulated Truck(5-6 Axles)</th>
<th>Others (Agricultural/Earth moving Equipment, Tractors)</th>
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