

**THE IMPACT OF OUT-DOOR AIR POLLUTION ON RESPIRATORY HEALTH
AND STUNTING IN SCHOOL CHILDREN IN NAIROBI KENYA**

BY

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BSc NURSING

A THESIS SUBMITTED IN THE PARTIAL FULFILMENT OF

MASTERS DEGREE IN PUBLIC HEALTH

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I, Gladys Nyakobo Motende declare that this thesis is my original work. It has not been presented to any other institution for the purposes of obtaining a degree.

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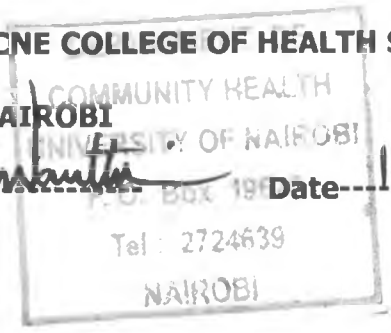
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Dedication

This thesis is dedicated to my late father Caleb Motende for educating me, my mother, Martha Gesare, for bringing up on Christian principles and to my family.

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ABBREVIATIONS

<	Less than
>	Greater than
ARI	Acute Respiratory Infections
BMI	Body Mass Index
CBS	Central Bureau of Statistics
CDC	Centers for Disease Control and Prevention
EHP	Environmental Health Perspectives
GEO	Geographical Environmental Outlook
GIS	Geographical Information System
HAP	Hazardous Products
IMCI	Integrated Management of Childhood Illnesses
IQ	Intelligent Quotient
KMD	Kenya Meteorological Department
l	Liters
M.p.h	Meters per hour
M ³	Cubic meter
Mg	Milligrams
MoH	Ministry of Health
n	Sub sample
NCC	Nairobi City Council
NEMA	National Environment Management Authority
NMVO	Non Movable Volatile Organic Compounds
Nox	Nitrogen Oxides
O ₃	Ozone
°C	Degree centigrade

PEFR	Peak Expiratory Flow Rate
PEV	Peak Expiratory Volume
pH	Measure of acidity or basicity of a solution
Pm	Particulate Matter
Ppm	Parts per million
SES	Socio-Economic Status
So ₂	Sulphur Dioxide
SPM	Suspended Particulate Matter
SPSS	Statistical Package for Social Sciences
TSP	Total Suspended Particulates
UN	United Nations
UNEP	United Nations Environmental Program
UNIDO	United Nations Industrial Development Organization
VOC	Volatile Organic compounds
WHO	World Health Organization
X ²	Chi Square

ABSTRACT

Introduction: Globally urban air pollution is estimated to be responsible for 800,000 premature deaths each year. Acute respiratory infections are ranked fourth in the share of disease burden in Sub-Saharan Africa accounting for 7% of total deaths. Air pollution is a nuisance to industry mostly concentrated in urban centers where majority of the people live. Nairobi was reported to be having high levels of particulate matter SPM_{10} ($239-126m^3$) higher than WHO acceptable level of $150\mu g/m^3$.

Objective: The main objective of the study was to assess the impact of air pollution on the respiratory symptoms among school going children in Nairobi. A questionnaire was sent out to parents using the children. Children in kindergarten were examined for signs of respiratory infection while those attending primary schools were examined for height, weight and peak flow measurements. Only children whose parents gave a written consent were allowed to participate.

Study Design: This was a comparative ecological study intended to find out whether a difference existed in episodes of respiratory symptoms, peak flow reading, BMI and stunting among children in two residential areas. One of the study areas was proximal to industrial area (South C) while the other was 10 kms away that is (Ngummo) estate in Nairobi.

Setting and Time Frame: Seven schools were randomly selected. Data collection took place from January 2004 through to October 2004.

Methods: Data was obtained by making observation and self administered questionnaires. The respondents of the questionnaires were children's parents while the principal investigator carried out the clinical observation and other measurements.

Results: A total of 602 cases were selected, 303 were from Ngummo residential estate while 299 were from South C estate. Out of these, 306 were from primary schools while 296 were from pre-primary schools. The mean age was 7.6 years.

The children came from similar socio economic class, allergic reaction, cooking fuel and smoking patterns were also similar. Response rate was 85%. Reported cough was the highest reported with an overall morbidity at 39.5% and the least reported was high temperature. The most observed symptom was inflamed throat at 52.7% and the least observed was sneezing 0.7%. The results showed more cases of respiratory infection signs in South C compared to Ngummo. For example, observed inflamed throat and blocked nose in kindergarten child were statistically significant respectively ($\chi^2=9.32, df=1, p=0.002$ and $\chi^2=10.41, df=1, p=0.001$) using chi test of significance. The reported symptoms were not statistically significant probably due to inaccurate reported information. Majority of cases recorded abnormal peak flow measurements may be due to poor technique in handling the gadget or the table used to compare was not applicable to Kenyan and African children in general. Abnormal peak flow comparison was statistically significant ($\chi^2=43.506, df=28, p=0.031$). Body Mass Index showed statistically significant with low BMI recorded in a more polluted area. Multiple regression analysis confirmed the exposed zone, assessed as residence, as a risk factor for observed blocked nose (Wald's stat=4.147, $p=0.053$), inflamed throat (Wald's stat=9.270, $p=0.005$), and reported sore throat (Wald's stat=4.205, $p=0.040$).

Conclusion: Proximal human habitation to industrial setup was found to be a risk factor in exacerbation of respiratory infections

Recommendation: The result suggests the need for action in regulating air pollution in the city of Nairobi or else there will be continued increase in disease burden due to air pollution related illnesses(respiratory symptoms) as it is the case in cities of developed countries.

CHAPTER ONE

1.1 Introduction

Pollution, according to the medical dictionary is any unwanted substances that occur in the environment, usually with health threatening effects. Pollutants may exist in the atmosphere as gases or fine particles that irritate the eyes, lungs and the skin. They may also exist as dissolved or suspended substances in drinking water, and as carcinogens or mutagens in foods or beverages (Mosby 1990).

For more than a century, severe air pollution incidents in cities such as London have shown that breathing dirty air can be dangerous and at times fatal. In 1880, 2,200 Londoners died on such an incident when local smoke from home heating and industry combined to form toxic smog of sulphur dioxide (SO₂) gas and air borne combustion particles. But concerns did not translate into action until 1940^s and early 1950^s when air pollution disasters on two continents raised an alarm. As a result, both 1948 'killer fog' in a small town of Donora, Pennsylvania, where 50 people were killed, and particularly virulent London 'smog' of 1952 in which some 4,000 died were associated with widespread use of dirty fuels and were catalyst to government efforts to tackle urban air pollution (Diamond 2005).

There are four major sources of air pollution. These are; industry, fuels for heating and burning, electricity generation, waste disposal and motor vehicles. The scale of the problem and the relative contribution varies from city to city (UN 1989).

Kenya is witnessing a rapidly increasing population growth especially in urban centers with the accompanying environmental, economic and social problems. There has been unprecedented migration of people from rural to urban areas in

expectation of high standard of living. This movement has general social, economic and environmental consequences on health related issues (Ministry of Local Authority 1999).

Urbanization introduces society to a new modern way of life, an improved level of awareness, learning process, efficient and effective ways of production of goods and services among others. However, when the rate of urbanization gets out of control, it poses a great challenge to governance. Institutional capabilities become inadequate and ineffective. Some of the problems experienced due to urbanization include; inadequate housing, accumulation of waste resulting from improper waste management, road traffic accidents, air and water pollution, crime and other social evils (Adepoju et al 1999).

Although Africa is the least urbanized, it appears to have the highest rates of urbanization in the world. For example, Africa and Asia recorded urban growth of 4.9% and 4.2% respectively between 1990-1992 (EHP 2005) compared to Europe and North America where the growth rates were 0.7% and 1.0% respectively (EHP2005). In some cities like Abidjan, Dar-es-salaam, Khartoum, Lagos and Nairobi, Population has increased more than six fold within four decades (EHP2005). Based on these statistics, it is most likely that the fast growing urban population would be exposed to dirty air which results in adverse health effects.

Urban air pollution is hardly recognized by majority of individuals and institutions. It is only thought by the few elite or basically disposed to the academic archives as it is only dealt by very few individuals and institutions. High rates of respiratory

diseases are one of the most tangible forms of evidence of increased levels of air pollution in a city, although increase of airborne lead, it shows up in blood tests. When the incidence of cancer and respiratory diseases are graphically demonstrated by geographical information systems (GIS), this normally pinpoints certain areas where residents suffer most from air pollution. This could further demonstrate linkage with industries (UN 1989). African urban cities are characterized by rapid population growth rate, industries are clustered in particular areas and motor vehicle congestions are common. In Kenya data concerning urban outdoor air pollution are scanty and therefore information from this study will be helpful to decision policy makers, as well as other concerned health professionals. It will also contribute to the efforts the National Environmental Management Authority in baseline information collection areas (NEMA 2003).

Air pollution can be an overall indicator of the planet's state of environment. It is therefore of scientific and practical interest (Moslata et al 1992). The five main air pollutants are; sulphur dioxide (SO_2), nitrogen oxides (NO_x), ozone (O_3) and suspended particulate matter SPM including lead, (Moslata et al 1992).

In 1990, it was estimated that worldwide 99 million tonnes of SO_2 , 68 million tonnes of Nitrogen monoxide, 57 million tonnes of SPM and 177 million tonnes of carbon monoxide were released into the atmosphere as a result of human activities. In most industrialized countries, combustion of fossil fuels (coal and oil) at stationary sources is responsible for the majority of man-made sulphur emissions, with contributions from metal smelting and other industrial processes. Nitrogen oxides are primarily emitted by fossil combustion with the transport sector accounting for between one third and one half of natural emissions (Moslata et al 1992). Table 1

gives a summary of the common air pollutants, sources and their health effects while

Table 2 gives the recommended levels beyond which toxicity occurs.

Table 1: Sources of Major Air Pollutants and their Health Effects

Pollutant	Sources	Health effects
So _x	Electric utilities and burning of fossil fuels (coal, oil, during metal smelting, paper manufacturing, food preparation and other Industrial processes)	Respiratory irritation, shortness of breath, impaired pulmonary function, increased susceptibility to infection, illness in the lower respiratory tract infection (particularly children) chronic lung diseases and pulmonary fibrosis, increased toxicity in combination with others.
SPM	Fuel combustion (coal, oil and biomass) transportation and high temperature industrial processes	Irritation, altered immune function, major systemic toxicity, reduced pulmonary function and stress on the heart. Acts in combination with So ₂ ; effects depend on chemical and biological properties of the individual particles.
No	Burning of nitrogen compounds found in fuels, electric utilities and other industrial combustion process.	Eye and nasal irritation, respiratory tract disease, lung damage, reduced pulmonary function and right heart stress.
Co	Vehicles, facilities burning coal, biomass gas	Interferes with oxygen uptake into the blood (chronic anoxia). Can result in heart/brain damage; or in lower doses, weakness, fatigue, headaches and nausea.
Lead	Motor Vehicles, smelters	Kidney disease and neurological impairment, primarily affects children, inhibits hemesynthesis pathway.
O ₃	Sunlight and oxygen reaction	Decreased pulmonary function, heart stress or failure, emphysema, fibrosis and aging of lung and respiratory tissue.

Source: WHO Fact Sheet No. 187,2000 & Lomb 2005

Table 2: WHO Recommended Levels of the most Common Pollutants 1999

Pollutant	Annual Ambient air conc. Ug/m ³	Guide line value	Conc. at which effects on health start to be observed	Exposure time
Carbon monoxide	500-7000	100,000 60,000 30,000 10,000	Not applicable	15 min 30 min 1 hr 8hrs
Lead	0.01-2.0	0.5	Not applicable	1 yr
Nitrogen Dioxide	10-150	200 40	365-565	1 yr 1 yr
Ozone	10-100	120	Not applicable	8 hrs
Sulphur Dioxide	5-400	500 125 50	1000 250 100	10 min 24 hrs 1 yr

Source WHO Fact Sheet No. 187 2000 & Kyle 2000

Application of the WHO air quality guidelines should help significantly in reducing the burden of mortality and preventable disability from a highly preventable source of ill health.

1.2 Sources of Air Pollution

Generally there are several sources of air pollution. About four sources are the most common and these include, energy generation; industries, solid waste sites and public services while mobile sources include motor vehicles, trains, and airplanes among others (Maina 2004). In this study industry as a stationary source was of particular concern.

Energy sources are grouped as biomass (wood, animal waste, agricultural residue etc), fossil fuels (natural gas, petroleum), and electricity generation, nuclear and solar energies. The latter two are not important as far as pollution is concerned (UNEP 2004).

Approximately 96% of total quantity of energy consumed in Kenya is provided by wood biomass and the significance of wood burning to air pollution cannot be underestimated. For example in households, the dispersion gases are not

controlled rendering majority of the people to be exposed to such gases. In general, indirect fuel boilers, as in industrial activities, institutions have separate stalls for the gaseous byproduct of combustion of such oxides as oxides of nitrogen (UNEP 2004).

Electricity is often referred to as clean energy. Its generation, however sometime does not warrant this tag. The main modes of generating electricity in Kenya are hydroelectric power plants, thermal gas turbines and geothermal. Many premises have also diesel-fuelled generators used only when there is power failure or voltage drop. Generators, unless continuously used, do not generate serious pollution problems except at a local level (UNEP 2006).

Fossil fuels are imported in Kenya either as crude oil or refined products. Refined petroleum products are converted through combustion to various gases. Crude oil is normally 3% sulphur, which is converted to SO_2 at the refinery and emitted into the atmosphere. Refined products emanating from crude oil refinery are emitted in the environs at oil refinery in Mombasa. Some of the industries that use energy extensively include inorganic chemical factories for example sulphuric acid and sulphonic acid, iron, steel foundries and galvanizing plants, paper mills, tea factories and cement production industries (UNEP 2006).

Industries are major sources of air pollutants due to their intensive use of fuels. Industries contribute to air pollution by discharging oxides of sulphur, nitrogen and carbon from their boiler stacks into the atmosphere. In addition tanneries also contribute the release of hydrogen sulphide, an irritant and with offensive smell.

There are several problems associated with industries and these are, air and water pollution, soil and ground water contamination, hazards of waste storage and disposal, occupational health and safety and waste minimization among others. The focus of this study was on air pollution (GEO 2002).

Chemical industries are essential for the formation of a strong and sustainable industrial base. They are also vital in forging the necessary linkages between industry and agriculture, transport and communication sectors. Those that are likely to have significance gaseous emissions are; Metallurgical industries related to steel and iron production, which provide a wide range of materials required by the engineering industry. The industry is important in recycling metal chemical containers that release highly volatile compounds (NEMA2003).

Another type of operation comes from chemical industries that provide fertilizers, pesticides, industrial process chemicals and packaging materials relevant especially for agriculture and food production. The industries release persistent organic products in gaseous form that cause irritation to the throat. Pharmaceutical industries produce medical drugs and vaccines that release complex formulations. Agro-industries such as power alcohol generation, too, produce toxic air pollutants (NEMA 2003).

Rubber and plastic industries are major sources of volatile organic chemicals (VOCs) and HAP. There are about 100 manufacturers of plastic products in the country. Almost all raw materials from rubber and plastic industry are imported however there are two plants that recycle plastic wastes (UNEP 1999). These industries generate many organochlorine compounds such as vinyl chloride, which are carcinogenic. The top ten chemicals released by the rubber and miscellaneous plastic industry

are 1,1,1, trichloromethane; carbon disulphide; acetone; dichloromethane; methanol; methylethylketone; styrene and xylene. They are suspect in areas where chemicals are heated to vaporization or during open air burning (WHO 2000).

Pulp mills process emits gaseous wastes as part of the manufacturing process. These are mainly sulphur dioxide and particulate mater-dust, soot and other ashes from burning of fossil fuels like coal and oil for energy. Both pollutants can cause respiratory problems, damage to property and reduced visibility. The typical odor of the Kraft pulp mill is due to the presence of sulphur in the boiling liquor, which is responsible for the production of hydrogen sulphide, methyl mecaptan, and methyl disulphide and sulphur dioxide gases. In some mills other additional emission types may come from auxiliary operations. At the Pan Paper mills in Webuye for example, chlorine is released from chlorine washer tower as well as from the caustic soda/chlorine generation plant (UNIDO 2004).

Apart from the odorous gases, the particulate matter is emitted from the stacks of bark boiler, recovery boiler, and lime wood re-burning plant. Dust is collected in three electrostatic precipitations and back to the system. Similarly, the dust carryover from the kiln is scrubbed in a ventri-scrubber with mill water and fed to the clarifies for the separation of sludge which is fed into the system. It therefore becomes very difficult to pinpoint the actual stack that is emitting fugitive gases in the factory (UNIDO 2004).

The pulp and paper industry releases 87% of its toxic emissions into the atmosphere; approximately 10% to water and 2% is transferred to site or disposed off on land (UNIDO 2004).

Air release can be traced to a variety of sources. Approximately 50% are methanol, a by-product of pulp making process. The other major toxic chemicals emitted include chlorinated compounds, sulphuric acid and the catalyst methylethylketone, originating from the bleaching stage (UNIDO 2004).

There are three cement plants in Kenya. The main raw materials for cement production are limestone, pozzolana, and gypsum and are available in adequate quantities in various parts of the country. The main pollutant from cement industry includes; dust particulates, grit and dust (Mulaku 2001). Air pollutants from cement production cause asthma and other bronchial problems.

There are three ceramic plants producing crockery, wall tiles and sanitary ware. The basic raw materials such as silica sand, kaolin, Kisii soapstone, and quartz, among others are locally available. The main pollutants from ceramic industry are dust particulates, grit and dust (UNEP1999).

There are three glass container-manufacturing plants in the country. The basic raw materials for glass manufacture such as soda ash, silica sand, sodium sulphate, and fluorspar are locally available. The central glass industries in Ruaraka are the largest container glass industry in Kenya. It is located near residential areas and currently a major concern to the residents regarding air pollution. The main pollutants are sulphur dioxide, non-movable volatile organic carbons (NMVOC), carbon monoxide, dust and particulates (Wijetilleke 1999).

Working with the raw materials of the above industries predisposes one to respiratory diseases, digestive disorders, rheumatic and nervous conditions, hearing and vision disorders. The building construction and industry including

harvesting and transport of building materials is a major source of particulate release to the atmosphere (Wijitelleke 1999).

Typical activity in this area include sand harvesting, transport and storage, stone crushing and dressing, quarry blasting and construction. Sand harvesting presents a peculiar source of pollutants since it depends on where the sand is mined. The sand from coastal and Machakos area has heavy grains which are not easily air borne. Volcanic sand used in central region of Mt Kenya and that mined around Longonot has got finer grains, which are easily air borne with possible negative impacts to the environment (UNEP 1999).

Particulate matter is emitted from sand and gravel operations and is made up principally of inert crystal materials for example soil and rock particles. Dust emissions in the form of fugitive dust occur during removal of overburden, sand and gravel from the deposit wind blown dust from storage piles, from transport, during material dumping from trucks, front and loaders, and conveyors from screening. The amount of moisture affects the amount of dust emissions that occur. In Kenya the deposit is dry and the materials have high silt concentration making dust emissions significant (UNEP 1999). This is an area where standards are difficult to formulate. Emissions can be reduced by various technological innovations. These include using water sprays to keep materials wet; limiting drip heights of materials, covering Lorries, using enclosures or holding materials at transfer and handling points; and exhausting air from those points to air pollution control systems (UNIDO2004).

Leather tanning industry uses many types of chemicals which when they react together, emit hazardous and offensive smells such as hydrogen sulphide

in addition to generating other toxic chemicals and hazardous wastes. These chemicals when inhaled cause problems on the respiratory system (UNEP 1999).

The industrial production of beef, poultry and pork pollutes waterways and air, fouls the land and gobbles up valuable resources. It is said to be the second after automobiles in environmentally damaging products (Amysapp et al 2001).

Air emissions may arise from a variety sources in canning of fruits and vegetables. Particulate matter (PM) emissions result mainly from solid handling, solid size reduction, during for example citrus peel dries. Some of the particulates are dusts, but others (particularly those from thermal processing operations) are produced by condensation of vapors and may be low micrometer or submicrometer particle size range (Macdade 2001).

Volatile organic products (VOP) emissions may occur at almost any stage of processing, but usually associated with thermal processing steps such as cooking and evaporation concentration. The cooking technologies in canning processes are very high moisture process so the predominant emissions will be steam or water vapor. The waste gases from these operations may contain PM or considerable vapors as well as malodorous VOC (Macdade 2001).

There is no emission data sufficient to quantify VOC, HAP or PM emissions for the canned fruit and vegetable industry. Data on emission from fruit and vegetable canning are extremely limited making regulation of the industry next to impossible (Macdade 2001).

1.3 Air Pollution and Human Health

Millions of children living in the world's largest cities, particularly in developing countries, are exposed to life threatening air pollution from two to eight times more above the maximum WHO guidelines. Indeed more than 80% of all deaths in developing countries are attributable to air pollution induced lung infections among children under five years (Debra 1999). Air pollution has both short-term and long-term health effects. Different individual groups are differently affected by air pollution and some individuals are more sensitive than others. Young children and elderly people suffer more often from the effects of air pollution compared to the general population. People with health problems such as, heart and a variety of respiratory chronic conditions such chronic obstructive pulmonary disease (COPD) may also suffer from air pollution. The extent to which the individual is adversely affected depends on total exposure to the damaging chemicals. Thus the duration of exposure and the concentration of air pollutants are factors of great concern (Natural Resources Defense Council 2006 [NRDC]).

The concentration levels of industry related air pollution depends on the type of industry, the level of process technology and emission control, as well as emission conditions. Sulphur dioxide, particulate matter and heavy metals are the most significant pollutants from industrial sources.

The exposure outcome is experienced in two types of health effects. These are known as short-term and long-term health effects. The short-term effects include irritation of the eyes, nose and throat, and upper respiratory tract infections for example bronchitis and pneumonia. Other effects include headaches, nausea

and allergic reactions. Furthermore, short-term exposure can aggravate the health conditions of individuals with asthma and emphysema.

The long-term effects include chronic respiratory disease, lung cancer, heart disease, brain and nerve damage, liver and kidneys. Continued exposure to air pollution affects the lungs of growing children and may predispose the elderly to chronic medical conditions. Children represent the largest subgroup of the population susceptible to the effects of air pollution. Over the last ten years, a considerable number of scientific studies have reported adverse health effects that are associated with air pollution (Devra 1999).

A recent study in the United States of America noted that approximately 64,000 people die from heart and lung diseases every year due to air pollution particulates. This figure is much more than those who die each year due to road accidents. Among children, air pollutants are associated with increased acute respiratory illness, increased incident of respiratory symptoms and infections, episodes of long duration exposure result in decreased lung function (Devra 1999).

In industrialized countries including the U.S.A, asthma is the most common chronic disorder in children and is on the increase. During the 1980s, the prevalence of childhood asthma increased by nearly 40%. Many different factors have been associated with asthma, including genetic makeup, environmental tobacco smoke, dust, mites, cockroach allergens and both indoor and outdoor air pollution. Several studies have linked ozone and particulate air pollution with exacerbations of asthma in children already afflicted with the disease (Murray 2005).

Due to their greater respiratory rates, children breathe proportionately greater volume of air than adults. Consequently, children inhale more pollutants per kilogram body weight than the adults. They also spend more time engaged in vigorous activities than adults and so inhale more air. Young children's height and play habits (crawling/ rolling) are more likely to expose them to pollutants or aerosols that are heavier than air which tends to concentrate in their breathing zone near ground level. Children's physiological vulnerability to air pollution arises from their narrower airways and the fact that their lungs are still developing. Irritation caused by air pollutants that could produce only a slight response in an adult can result in potentially significant obstruction in their airways (Kleinmam2000).

1.4 Types and Trends of Air Pollution in Kenya

In Kenya the following pollutants are identified by virtue of their abundance in the air and their potential impact on the people, animals and ecosystem in general. They are; oxides of sulphur, oxides of nitrogen, oxides of carbon, dust particles, vaporous organic compounds, and inorganic air pollutants (Maina 2004).

The early incidence survey of air pollution levels in Nairobi and other parts of the country were conducted in 1982. The industrial areas of the parts of the country had the highest levels of concentration of total suspended particulate pollutants. The observed trend was that the suspended particulate pollutants levels fell with increase in distance from industrial area (UNEP 1999).

In the same year (1982) measurements of acid rain water in selected stations in Kenya revealed that rain water is acidic in Kenya. By acidity it meant that the pH of rain water was less than 5.6. The acidity was higher in the vicinity of Nairobi

than in the remote areas. This was to be expected since Nairobi had a large number of emission sources of acid gas, which is an air pollutant, compared to the rest of the country (UNEP 1999).

The average ambient carbon monoxide concentration levels in Nairobi are partially due to motor vehicle exhaust emissions. Vehicles without emission control devices were found to emit carbon monoxide with concentration as high as 15ppm (UNEP 1999). However, the situation may be worse since there are no air quality regulations in place. On the average, the concentration levels were found to be highest, approximately 5PPM, a time when traffic congestion is at its peak (UNEP 1999).

Results of a study released and conducted in Nairobi in 1993 estimated the combination of nitrogen oxides and hydrocarbons at the city center found the highest computed concentrations at 517mg/m³ on Moi Avenue during morning traffic peak. The lowest traffic values were along city hall way 162mg/m³ and parliament road 158mg/m³ (Maina 2004).

In 1992 a study conducted in Nairobi city indicated that lead levels from motor vehicles and smelters fall within WHO guide lines of 0.5-15mg/m³ (UNEP 1999). These levels are of public health concern because of the potential adverse effects. Lead causes high blood pressure, impairs growth and neurological development, and consequently results in low intelligent quotient (IQ) in children. It also inhibits heme-synthesis and impairs iron and calcium absorption (Maina 2004).

CHAPTER TWO

2.0 THE STUDY AREA

The study was carried out in Nairobi the capital city of Kenya. It is said to be one of the most rapid growing cities in the world after Guadeloupe, Mexico City and Maputo. Nationally it has the greatest concentration of industrial and vehicle air pollutant sources. (Mulaku et al 2001).

Nairobi municipality covers an area of 696 km². It has a population of 2,143,254, which comes to 3,079 persons per km². It is projected that with a growth rate of 4.8% per annum, the population is likely to be 2,724,608 by 2004. These would translate to about 3,914 persons per km². There are 380 registered health facilities; these include 47 hospitals, 36 health centers and 276 dispensaries. There are several clinics which are NCC, MOH, government parastatals, mission, NGO and private entrepreneurs. It has 105 government run health facilities and 208 non-governmental organizations (NGO). This represents 8.3% of the total health facilities in the country (CBS 2001). Nairobi's major industries include small-scale consumer goods (plastics, furniture, batteries, textiles, soap, cigarettes and flour), agricultural processing, and oil refining and cement production.

2.1 Climatic Conditions

Nairobi is situated close to the equator its altitude of about 1500 meters above the sea level results in a relatively cool tropical climate with temperatures neither uncomfortably low at night nor very high during the day(Kenya Meteorological Department-KMD 2005).

The main climatic conditions are the existence of definite wet and dry seasons, and the closeness of any large seasonal change in temperature. The year can be divided into four seasons; From mid December to mid March is warm, sunny and dry. From mid March to May is mainly rainy season. From June to mid October is cool and cloudy at times (especially July and August). Finally from mid October to mid December is characterized by short secondary rainy seasons. August is a hot, dry period. Midday temperatures rise to nearly 32°C relative humidity may fall to 10% and average temperature throughout 24 hours vary from 17°C during July and August to 20°C in March (KMD 2005).

2.2 Temperatures

Although the average temperature throughout 24 hours varies from only about 17°C during July and August to 20° C in March, the daily range of temperature is quite large, averaging about 10°C in May and 15° C in February. Many of the residential areas in Nairobi are situated some 100m higher than the city center and temperatures are accordingly 1° to 2°c lower. During the months of June to September, the southeast winds prevail in the coastal regions; a cloud cap frequently forms over the high ground of Kenya immediately east of the Greater Rift Valley, and sometimes persists for several days without a break (KMD 2005).

When this occurs, day temperatures remain low and occasionally the maximum value does not exceed 18°C. Low temperature also occurs during the night and early morning at this time of the year, ranging from as low as 8°C or even 6°C on the ground sometime being recorded. Very cold nights sometimes occur also during January and February when the sky is clear. The highest and lowest

temperatures recorded during the last 25 years in the city are 32.8°C and 3.9°C (KMD 2005).

2.3 Humidity

Since Nairobi is 500km from the sea, it does not experience the rather unpleasant humid heat, which is so characteristic of the tropical coastal forms, although there is a very marked range of daily relative humidity. In the early morning the air is frequently at or very close to saturation, but in the afternoon, humidity is usually about 50% and may fall as low as 10% on clear sunny days in February and March (KMD 2005).

2.4 Rainfall

The average annual rainfall in Nairobi is about 900mm, but the actual amount in any one-year may vary from less than 500mm to more than 1500mm. There are two rainy seasons, from mid-March to end of May ("long rains") and from mid-October to mid-December (short rains). The onset of these rainy seasons varies from year to year; in fact the beginning and the end of a wet season is seldom, if ever, well defined. These seasons coincide approximately with the time of change over of the monsoon currents, which affect Eastern Africa, the southeast monsoon becoming established in April, and northeastern monsoon in November (KMD 2005).

2.5 Sunshine

Although the early mornings are often cloudy in Nairobi the sun nearly always breaks through the mid morning and through out the year there is an average of nearly 7 hours of bright sunshine per day; 30% more sunshine occur in the afternoons than in the mornings, so the Westerly exposures receive more isolation than those facing East. There is also considerable more sunshine during the six months that the sun is in the Southern hemisphere, than when it is in the North, only occasionally during the rainy seasons, or in the months of June, July and August, do days occur with no sunshine at all. Even in the cloudiest month in August, there is an average of four hours sunshine per day. Not only is the amount of sunshine considerable, but also the quantity of ultra-violet radiation has been shown to be very high (KMD 2005).

2.6 Winds

The wind near the ground is predominantly easterly throughout the year, generally between northeast and east from May-September. The strongest winds occur during the dry season just prior to the "Long Rains" when speeds of 20-25 m.p.h are not uncommon from mid morning to early afternoon; at other times of the year wind speeds are usually 10-15 m.p.h. During the night the wind is usually light. In the squalls sometimes associated with thunderstorms, short lived wind speed of up to 70 m.p.h have been known to occur (KMD 2005). Table 3 gives a summary of the weather conditions in Nairobi.

Table 3: Average weather conditions in Nairobi

Weather	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Rainfall in mm	48	48	115	195	137	42	15	21	24	52	114	77	858
Sun shine in hrs	8.9	9.5	8.7	7.0	5.7	5.8	4.4	4.2	5.9	7.0	7.0	7.9	82
Relative humidity % average	62	55.5	62.5	69.5	70	72	68	69	66	63.5	46.5	83.5	67.8
Mean temp	20.0	20.5	20.5	20.5	19.5	18.0	17.0	20.5	19.0	20.0	19.5	19.0	19.5

Source: KMD 2005

2.7 Air Pollution Profile

Information on air pollution in Nairobi city is scanty, and data assessment and availability is limited. In comparison to the guidelines, it is observed that, concentration of suspended particulates exceeded WHO guidelines as early as 1977 and has been on an increasing trend since then (Table 4). Besides measurement of ambient suspended particulates a recent study by Wafula (1999) reported sulphur dioxide levels ranging from 18.85-245ug/m³ in industrial area. The study observed that, some levels recorded in industrial area were higher than 98th percentile value (142ug/m³). This level is higher than that recorded by 1978 in the same area (UNEP/WHO 1991).

In essence therefore, the increasing levels of particulates and sulphur dioxide suggest that air quality in industrial area is rapidly deteriorating. Summary of study findings on pollutants is shown in Table 4.

**Table 4: Concentrations of Studied Pollutants in the City of Nairobi
City 1977-1999**

No	Name of Study	Level of pollutant concentration	Reference
1	Urban air pollution, UNEP/GEMS Environment	TSP; 35-128ug/m ³ (city center and industrial area)	United Nations Environmental Programme (UNEP). Library report No 4 (UNEP. Nairobi 1991) pp6
2	Total suspended particulate matter, condensation nuclei and their size distribution in Nairobi	SPM; 252ug/m ³ (Industrial area)	Ngugi G.K. Msc Thesis, University of Nairobi, 1983.
3	Measured components in total suspended particulate matter in a Kenyan urban area	TSP; 397.7ug/m ³ (Industrial area)	Karue J.M. A.M. Kinyua and A.H.S. El Busaidy, Atmospheric Environment, 26B pp505
4	Total suspended particulate matter in air of some urban areas in Kenya	PM10; 30-80ug/m ³ (sub-urban)	Gatebe G.K. and A.M. Kinyua. A Review, International Journal of Biochemphysics, 1994.
5	Determination of the levels of heavy metals in suspended particulate matter (SPM) in Kibera	SPM; 77.6-159.1ug/m ³ (sub-urban slum)	Gitari W.M. MA Thesis, University of Nairobi, 1999.
6	The measurements of some of air pollutants in selected areas of Nairobi and environs, and in other selected industrial sites	Sulphur dioxide; 18.85-245ug/m ³ (industrial area)	Wafula G.A., M.Sc Thesis, University of Nairobi, 1999.

Nairobi does not have any regular air quality management system yet, and any measurements of air pollution have been done on ad hoc basis. Of particular interest for this study was the spatial distribution of TSP done in Nairobi in 2001. TSP concentrations were classified as having low (<90ug/m³ annual mean), medium (90-180 ug/m³) and high (>180ug/m³). Low meant that TSP levels were below the WHO recommended value of mean value 90ug/m³ ; medium meant that the WHO recommendation up to a factor of 2, while high meant the WHO guideline was exceeded by more than a factor of 2.

The final map, though based on a very simple dispersion model and relatively few sampling points, clearly shows that TSP in most of the city are above WHO recommended levels, and that most of the city's eastern residential areas and

the city center are within the "hot zone" with the highest concentration of TSP, which is consistent with their proximity to the city's industrial area. These ought to be sufficient indicators to enable basic decision making on intervention measures (Mulaku 2001). It is with this background that the study areas were chosen. TSP distribution is shown in Figure 1.

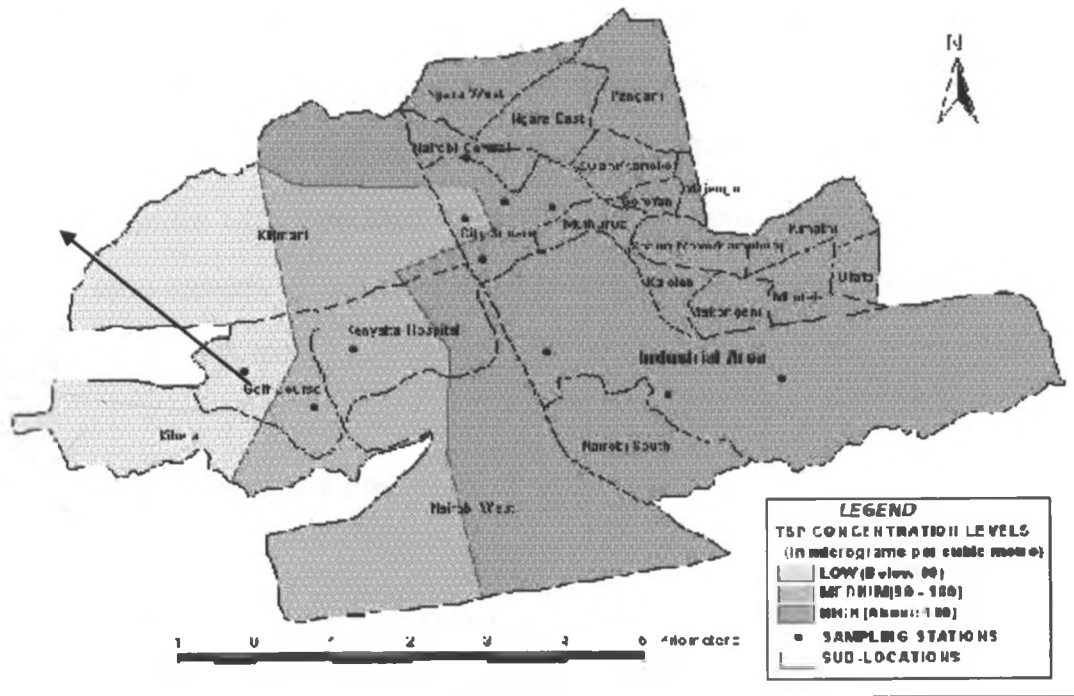


Figure 1: Average TSP distribution in Nairobi

CHAPTER THREE

3.0 LITERATURE REVIEW

Socio-economic Factors

Various studies have found a positive correlation between respiratory symptoms, lung function, and lung growth with exposure to outdoor air pollution. However, socioeconomic factors, household fuels used for cooking and smoking may be confounding factors. Therefore, when conducting an epidemiological study on the health effects of air pollution, socio-economy may act as a confounding factor. One study confirmed that socioeconomic status and the levels of NO_2 in the area of residence were associated in some cities. It means, therefore, that adjusting for socio-economy is important when investigating the health effects of air pollution (Emilie et al 2005).

Respiratory Morbidity

Symptoms of outdoor air pollution are wide spread ranging from irritation of eyes, nose and throat, wheezing cough and breathing difficulties, tightening of the chest and worsening of existing lung and heart problems (Joachim et al 2000). Air pollution has been implicated in exacerbating conditions like asthma, pneumonia, acute respiratory infections, tuberculosis and aerial cancers (Nigel et al 2000). Lack of air quality control standards and uncontrolled unplanned residential areas are some of the problems that face the countries of the world.

Various studies have shown a positive relationship between outdoor air pollution and respiratory symptoms. A study conducted at the industrial area of

Puchuncavi Chile found that an increase of breathable particulate and sulphur dioxide resulted in increased incidences of cough and expectoration, wheezing, dyspnea, use of bronchodilators and a decrease in peak expiratory flow (Sanchez et al 1999).

Another study done on the relationship between out door air pollution and respiratory health in children aged between 8-10 years found that children living in polluted areas experienced more coughs, rhinitis, pneumonia and early respiratory infections than control subjects (Peter et al 1998). A similar study in Mexico City found that there were increased medical consultations due to respiratory infection as a result of increased ozone and carbon monoxide (Tellez-Rojo et al 1997). In addition, emergency visits for childhood asthma were noted to be higher in a more polluted area compared to a less polluted one (Romeo et al 1995). In China increased pollutants resulted in increased acute respiratory infections, exacerbation of asthma symptoms and chronic bronchitis (Ponka 1995). Furthermore, high mortality and morbidity was found in a slum area compared to middle class area attributing the differences to environmental pollution (Soman 1991 et al).

As regards to urban dwellers, Finnish children were compared for the frequency of upper respiratory infections in children residing in a polluted city with that in children from two less polluted cities. The researchers found a significant association between the occurrence of upper respiratory infections and living in an air polluted area (Natural Resources Council 2000).

Lung Function Tests and Body Mass Index

Increasing body mass index among children is documented to be a risk factor for asthma, which may in reality, be obesity related chest symptoms. Asthma, wheeze and inhaler use were noted to be common in obese children than in non obese children. Symptoms were more prevalent in obese boys (Bibi et al 2004). Other studies found an inverse relationship children's height and air pollution, and the magnitude depended on age. Children from a more polluted area were 1.2 (95%CI 0.5-1.8) cm shorter than children from a less polluted area (Bobak 2004 & Jedychowski 2002, Thomas 2005).

Air pollution affects the respiratory, circulatory and olfactory systems. The respiratory system is the principal route of entry for air pollutants some of which may alter the function of lungs. With respect to lung function tests, several studies have shown that increases in particulate pollution are associated with declines in Peak Expiratory Flow (PEF) [maximum rate at which air is exhaled from a maximum inhalation] and/ or lung growth rates in children with somewhat greater deficit in symptomatic children (Gold et al 2003 and Gilland et al 2003).

Industries

A large number of epidemiological studies focused on respiratory health effects due to short term exposures to air pollution in non-symptomatic children and children with asthma or chronic respiratory symptoms. Overall, there was an association between the level of air pollution and the prevalence of respiratory symptoms in both health and symptomatic children. Moreover, intervention studies have

provided strong circumstantial evidence of the health gains from clean air. One of the best examples is a labour dispute that shut down a large steel mill in Utah Valley. Respiratory hospital admissions in children substantially decreased during the strike and increased to pre-strike levels after the dispute ended (European Environment & Health Strategy 2003). A comparative study between a city with high air pollution levels and another city with low levels of air pollutants showered higher mortality rates (17-26%) respectively (Traudt 2005).

Data from Africa are scarce. However, an overview of African studies reveals evidence of increased prevalence of respiratory symptoms and reduced lung function in urban areas, where industries are located, compared to rural areas. Residents proximal to industrial estates were found to have more respiratory problems sequel to their exposure to air pollution from proximal industries (Tanimowo's 2000). Besides, the prevalence of ARI was found to be 10.2% in urban setup compared to 15% in the rural area (Chris et al 2003). Studies done in South Africa indicated an association between a variety of respiratory symptoms in urban industrial area and informal settlement areas. High prevalence rates for respiratory illness were found in residential suburbs within industrial area relative to a suburb further away (WHO 1999). In addition, air pollution data in Nairobi's industrial area was found to be deteriorating (Table 4).

Most of the locally available literature concentrated on adverse effects resulting from indoor pollution. It is therefore important to obtain data on the effects of outdoor air pollution. These data will be locally relevant to public health policy makers and public health officials to put up measures that can mitigate the menace of out door air pollution.

CHAPTER FOUR

4.0 JUSTIFICATIONS AND OBJECTIVES

4.1 Statement of the Problem

Urban outdoor air pollution is a worldwide problem and continues to get worse in developing countries. It is hardly noticed by many people and efforts to control it remains a challenge to both developing and developed countries. Kenya hoped to be industrialized by the year 2020 or currently has vision 2030. This implies that as industrial growth continues so is the environmental degradation and consequently negative health effects through industrial outdoor air pollution.

Urban air pollution has been known to afflict urban residents more especially those of low socioeconomic status. Kenyan industrial area was found to have high concentration of air pollutants and no studies have been done on health implications. This study therefore wished to establish whether there was any association in the episodes of respiratory symptoms and lung function tests among school going children near industrial sites as compared to their counterparts who were not industrially located.

4.2 Justification of the Study

A human being can survive for 6-8 days without food or water but only five minutes without air. It is for these reasons that clean air is of vital importance as it is an essential need rather than a want. Acute respiratory tract infections (ARIs) in developing countries have resulted in the occurrence of increased mortality

especially among children. Air pollution kills 2.7 million to 3.0 million people every year, about 6% of all deaths annually. About 9 in every 10 deaths due to air pollution take place in the developing countries where 80% of the total world population lives (Hinrichsen 2000). The World Health Organization (WHO) estimates about 700,000 deaths that occur annually could be prevented in developing countries if three major atmospheric pollutants carbon monoxide, suspended particulate matter and lead were reduced to safer levels (WHO 1989).

The economic costs of air pollution are enormous and a considerable amount of resources in terms of monetary, human resources and drugs are spent in the treatment of ARI. Outdoor air pollution affects more than 1.1 billion people mostly in cities annually. Global direct health cost was estimated in 1995 to be at US \$100 billion in a year and chronic bronchitis alone, accounted for US\$ 40 billion (WHO 1989). ARI is recognized to be the most important cause of morbidity and mortality among children in developing countries. Most children get about 4-6 episodes of ARI each year and children with respiratory infections account for a large proportion of patients seen by health workers in health care facilities (WHO 1989). Acute lower respiratory infections account for 19% of all deaths in children less than five years and 8.2% of all disability and premature mortality (Hinrichsen 2000).

In addition, there are considerable indirect losses to the economy that are hardly considered. Many hours are lost from work by ill adults or time taken to look after sick children who fail to go to school due to respiratory illnesses. Case management and use of immunization has reduced some episodes but, there still remain a huge number of children coming up with ARIs as it is still the leading cause of morbidity and mortality. In Kenya, the main cause of high incidence of diseases of the

upper respiratory tract infection is hardly suspected to be due to the presence of pollutants in the atmosphere.

Morbidity patterns in Kenya closely relate to causes of mortality. Over the years, malaria and acute respiratory infections (ARI) accounted for almost half of the reported visits to the outpatient facilities. In 1999, malaria accounted for 32% while diseases of the respiratory system were responsible for 25% of the overall morbidity in Kenya (WHO 1989). Similar patterns are also seen for inpatient morbidity. Malaria accounted for 26% of the total reported inpatients followed closely by ARI, which accounted for 22% of all the cases. Based on these statistics, it is apparent that quite a substantial amount of the country's medical expenditure goes to air pollution related diseases (WHO 1989).

In the city of Nairobi information on air pollution is limited. Nevertheless, the minimal data available indicates that there is significant air pollution in the city especially in the areas near Industrial Area. For instance, as early as 1977, suspended particulate concentrations were shown to exceed the WHO set standards/guidelines. Obviously the situation has deteriorated since then due to continued industrial growth.

To date, there is no evidence of studies that have looked at the effects of air pollution in Kenya and the city of Nairobi in particular. The highest percentage contributions of the diseases of the respiratory system are recorded in central and Nairobi provinces. In Nairobi the leading cause of out patient morbidity are diseases of the respiratory system responsible for 15.6% followed by malaria which accounted for 10% of total morbidity. This morbidity pattern might be an indication of

environmental contribution in terms of outdoor air pollution (CBS 2001). It appears that the next option will be to initiate environmental measures jointly with integrated management of childhood illnesses (IMCI) to control the problem of ARI and case management. That combined effort will be more effective in controlling the Impact of ARI.

4.3 Null Hypotheses

1. There are no differences in the episodes of respiratory symptoms, (reported and observed) among the school going children living in the city of Nairobi irrespective of their residential area relative to industrial area.
2. There are no differences in lung function test among the school going children living in the city of Nairobi irrespective of their residential area relative to industrial area.
3. There are no differences in growth rates among school going children irrespective of their residential areas.

4.4.0 Study Objectives

4.4.1 Broad Objective

The study's broad objective was to assess the influence of air pollution on the respiratory health among children in the city of Nairobi.

4.4.2 Specific Objectives

1. To determine the socio-demographic characteristics of study subjects;
2. To determine the prevalence of observed and reported respiratory symptoms in both pre-primary and primary level of schooling;
3. To identify the best predictors of outdoor air pollution in relation to respiratory symptoms;

4. To establish association (if any) between prevalence of respiratory symptoms with residence, age and sex;
5. To determine the influence (if any) of air pollution and growth rates among school going children.

CHAPTER FIVE

5.0 METHODOLOGY

5.1 Areas of Study

Selections of areas of study were based on concentration of pollutants as a primary interest factor. They were Ngummo and South C. The areas were chosen because they were both planned settlements and they had a fairly similar socio-economic status. South C was found to be the nearest to industrial area with an indicated population sample and therefore findings could be referred to a population base (CBS 2001). Finally according to the map provided (Figure 1) air monitoring showered higher concentration of TSP at industrial area (where South C lies) compared to Ngummo estate.

5.2 Study Design

The study was a comparative ecological study based on two areas, one proximal to industrial area and the other distal to it. The study assessed the upper respiratory symptoms experienced two weeks prior to data collection, lung function and stunting. The reported symptoms were obtained by self-administered questionnaire from the parents or guardians and they were delivered to and from the investigator by the children. Respiratory symptoms were observed at the time of data collection on kindergarten children. Lung function tests using a peak flow machine and body mass index (BMI) were determined at the point of data collection on children attending primary school.

5.3 Study Population

The study populations were children in kindergarten and primary schools. The first category targeted between 3-5 age group while the second category was between 6-12 years although the age went up to 16 years due to free primary education. Pre-tested samples of questions were sent out (using the children) to parents/guardians of all the children. Similarly, the procedure was applied in a different place with a view to establishing the trend in the other population that was less polluted.

5.4 Inclusion and Exclusion Criteria

The inclusion criteria were pupils in the chosen schools who had resided in the study areas for more than two years (two inclusive). The exclusion criteria were pupils who were non-residents in the two study areas and those that had lived for less than two years. Known or reported cases of asthma were also excluded from the study.

5.5. Variables

5.5.1 Independent

The following were independent variables; age, sex, residential location, medication use and missing school.

Age, Sex and Residential location relative to industrial site

Age was the completed years and months where necessary as reported by the parent or guardian .Sex (gender) of the subject and residence for the last two years prior to data collection were considered.

Use of medication in the preceding two weeks

This was relating to medication used in the preceding two weeks prior to data collection specifically due to respiratory symptoms.

Missing school due to respiratory symptoms in the preceding two weeks

This was absenteeism due to respiratory symptoms.

5.5.2 Dependent

The following were dependent variables; observed respiratory symptoms, reported respiratory symptoms, peak flow measurements, body mass index and stunting.

Observed respiratory symptoms

These were the symptoms observed at the point in time among the pre-primary children.

Reported respiratory symptoms

These were obtained via mailed questionnaires filled by parents or guardians. It covered both the pre-primary and primary school going children.

Peak flow measurement

These were obtained at the point in time for the primary school children.

Body mass index

The measurements were obtained at the point in time. This involved weight and height then the calculation of BMI by height in meter squared divided by weight in kilograms.

Stunting

This was a growth measurement done by using height for age.

5.5.3 Variable Definitions

Age- This was the number of completed years and months as stated by the mother or guardian.

Sex-This was the gender of the subject, categorized as male or female.

Residence-This was the place the respondent lived from the selected two, Ngummo and South C.

Number of Rooms-This was the physical count of rooms in a house.

Type of House-These were the materials the house was made of.

Cooking Fuel-This is what was used for cooking in the house hold.

Place of cooking-This referred to either inside or outside the house.

Employment Status of the Mother- These were categorized as employed, self employed or unemployed.

Level of Mother's Education-These were completed years of schooling from the mothers.

Parental Smoking-These were positive responses from mothers/guardian to smoking of either parent/guardian in the household.

Number of Persons-This was a total number of persons living in the house hold including Children.

Medication Use-This was a response obtained on the use of medication two weeks prior to data collection due to respiratory related symptoms.

Absenteeism-This was a response to those who missed school in two weeks prior to data collection due to respiratory symptoms.

Peak flow measurement-This was the best reading from the subject after maximum Inhalation.

BMI-This was height in meter square divided by weight in kilograms.

5.6 Sampling Procedure

Two areas were purposely selected for the study. One area (South C) was proximal to industrial area, which is highly air polluted, while the other was approximately ten kilometers away from industrial area (Ngummo). Schools in the two areas were randomly selected from the list of available schools. Two primary schools were selected at Ngummo from a total of five schools. In kindergarten selection, two schools were chosen from six schools. In South C, one school was chosen from primary school out of three schools while two were chosen in kindergarten out of six schools. One school declined the procedure due to administrative protocols and the nearest school was substituted. It was considered to have a similar population and from the same locality. Pupils were stratified by gender. Simple random selection was used to select candidates that met inclusion criteria. After obtaining a written consent, the investigator checked from children in kindergarten for the symptoms of inflamed throat, running nose, sneezing, wheezing, and difficult in breathing and chest in drawing. Failure to consent was regarded as non response.

Sampling Unit

The sampling units were the children and the households.

Sampling Frame

The sampling frame comprised the registers of students in primary and pre-primary schools that met selection criteria.

5.7 Sample Size Determination

The minimum sample size that was calculated was in regard to establishing significant differences between two population proportions with a 95% confidence interval at a 5% level of significance and an allowable difference of 5.4%. It was calculated as follows;

$$n = \frac{Z_{1-\alpha/2}^2 [p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)^2}$$

$$Z_{1-\alpha/2} = 1.96$$

n = minimum sample size

P1 = 15.6% Prevalence of respiratory infections

P2 = 10.2% prevalence of expected ARI

$$n = \frac{(1.96)^2 [1 - 0.156)(0.844) + ((1 - 0.102)(0.898)]}{(0.054)^2}$$

$$= 294$$

Adjusted by 2.5% for non-responses.

Final sample size was 301 in each place (WHO 1991).

5.8 Materials, Supplies and Personnel

The materials used were otoscopes, torches, tongue depressors, bathroom weighing scale and a tape measure disinfectant, cotton and wastebasket for cleaning and discarding waste. Writing materials and other stationeries that go with any study were also required. The study was carried out with the help of one research assistant.

5.9 Field Quality Control and Data Collection

Having selected the pupils, those under five years were examined by the chief investigator for inflamed throat, running nose, sneezing, difficulty in breathing, fast breathing, chest in drawing and coughing. Children between 6-12 years had their weight and height taken, thereafter peak expiratory flow rate (PEFR) was measured against their age and sex using a peak flow machine. In an upright position, a pupil inhaled maximally then blew into the peak flow machine as hard as possible. Three readings were done and the best was taken as the peak flow reading of a subject.

5.10 Data Collection Instruments

Anthropometric measurements of height and weight and spirometric assessment were done on children between 6-12 years. Using a peak flow machine, a selected child in a standing position did three forceful exhalations after maximum inhalation. The best value was taken as the subject's peak flow reading. Any spirometric volume less than 80% of the expected normal (PEFR) was recoded as abnormal. Spirometric measurements were done using OMRON peak flow meter, mode IPFM10. It was graduated from 0-720 liters per minute. A spirometric chart from Boehringer Ingelheim was used to determine the normal values at 80% PEFR (Mac Carthy2006). In addition, a pre-tested questionnaire accompanied by a covering letter was sent to the parents/guardians from the head teacher to assess the episodes of respiratory symptoms in the preceding two weeks. Information on use medication and absenteeism due to respiratory symptoms were given through the mailed questionnaire. The questionnaire was in English and a Kiswahili version was available for those who could not read English. Non-responses were assumed to

mean no consent. It was logistically difficult to follow up non-responses.

Data collection was done at different times in the two selected areas due to financial and logistical constraints in 2004. It took approximately ten months to complete the exercise owing to the fact that schools were breaking for holidays and other delays related to granting of permission. Clinical examination of the symptoms of ARI was observed on the children in pre-primary.

Information that was obtained as part of the socio-demographic data through the questionnaires included; age and sex of the child, number of rooms per household, type of house, cooking fuel, place of cooking, employment status of the mother, level of mothers education, parental smoking and number of persons in the household. Data collection commenced on January 2004, however due to logistical difficulties, it was not possible to collect data simultaneously between the two areas. Data collection exercise ended in October 2004.

5.11 Minimization of Bias

Pupils were randomly selected to avoid selection bias. Intra and inter interviewer bias was minimized by the researcher doing the work herself giving uniformity in coding of responses. Being a sole interviewer minimized interview bias. To minimize interviewee recall bias, the recall period was fixed at two weeks.

5.12 Pilot Testing

The questionnaire was pre-tested to ascertain the appropriateness of the data collection tool. This was a good tool in modification and correction of the way

questions were asked. The correct responses were very useful in subsequent data analysis.

5.13 Ethical Considerations

The study sought ethical approval from the University of Nairobi Department of Community Health and the ethical committee based at Kenyatta National Hospital before commencement of data collection. A written consent was obtained from the parents of the children to be examined. Those who were found to be ill at the time of the survey were referred with an accompanying letter to the nearest public health facility. A written permit was obtained from City Council primary education section before commencement of data collection at the schools. Permission was sought from head teachers before data collection.

5.14 Data Management

Daily cleaning of the data was done and responses were coded and entered into a computer by use of Statistical Package for Social Sciences (SPSS10.0) programme. Data validation was ensured by limiting entries on numeric values and names where necessary. Descriptive statistics and proportions were used. A suitable statistical method was employed to analyze whether there was any significant difference in symptoms of ARI and lung function tests between the two groups. To test for association between factors, chi square test of significance was used. The other tests employed were t-test, bivariate and multivariate analysis where appropriate.

5.15 Data Presentation

Data and results were presented in tables, graphs and pie charts, as appropriate. To test for association between factors, chi square test of significance was used. To control for confounders multiple logistic regression analysis was used. Data were presented in simple proportions.

5.16 Study Limitations and Constraints

The study could have been stronger if air sampling was done together with the symptoms of acute respiratory infections (ARI). Secondly, a better comparison could have been attained if an urban setting was compared with a rural one as the chosen areas might not be substantially different meteorologically and in terms of exposure.

In addition, there was no local data showing prevalence of ARI in specific areas of residence in Nairobi. The figure used was borrowed from Zambia, a setting that might have geographical, socio-economic and emission differences. Some of the parents may have misunderstood the questions therefore giving inappropriate responses. Mailed questionnaire has inherent weakness since the respondents do not feel obliged to respond honestly. This could be avoided by conducting a face-to-face interview. Data collection exercise was intended to be done simultaneously in the two areas but due to economic and logistic difficulties, it was not possible. This delay may have resulted in slight climatic changes whose impact is yet to be evaluated although it is known that Nairobi winds are easterly throughout the year.

There were selection constraints as the selected schools, especially kindergarten, could reject the procedure and the investigator was forced to move to a

different school. Some selected pupils refused to be examined despite having the consent from their parents. This prompted the investigator to look for more willing cases which may have led to biased findings. School calendar did interfere with data collection. Pupils could break for mid term or holidays before returning the filled questionnaires.

Respiratory health indicators have multiple etiologies and therefore it very hard to pin point air pollution as the only cause of respiratory morbidity.

CHAPTER SIX: RESULTS

6.1 Introduction

The main objective of the study was to assess the impact of outdoor air pollution on respiratory health and stunting on school children in the city of Nairobi. Given the difficulties in clearly defining symptom complexes for respiratory diseases, analyses were primarily performed on individual symptoms. Two sets of cases were selected from two different places namely; Ngummo and South C estates. Pupils with history of asthma and those that had lived in the selected areas for less than two years were excluded from the study. A two-week recall period was intended to minimize recall bias as recommended in the previous studies (Sanchez 1999). The total numbers of cases studied were 602 and the response rate was 85%. In Ngummo estate a total of 303 pupils met the selection criteria. Among those selected 155 were females while 148 were males. The ratio of male to female was 1.05:1. South C estate was selected to be a highly polluted resident because of its close proximity to industrial area compared to Ngummo estate, which is approximately 10km away from industrial area. In South C, the number that met the selection criteria was 299. Out of the total selected from South C, 151 were males while 148 were females

representing 50.5% and 49.5% (n=299) respectively. The results were presented first descriptively and then analytically.

6.2 Socio-demographic Characteristics

The socio-demographic characteristics investigated included age, gender, cooking fuel, number of rooms in the household, type of house, cooking place, parental smoking, and employment status of the mother as well as education years. The health end points (indicators) investigated included, observed respiratory symptoms, reported respiratory symptoms, peak flow measurements, Body Mass Index and stunting. Absenteeism (failure to attend school) and medication use were ascertained as measures of respiratory morbidity.

The two areas studied were grossly similar although there were a few significant differences like number of rooms, type of house and cooking fuel used that might have altered the outcome. The socio-demographic variables were used mainly for the purpose of comparability. The variables that were significantly different meant that the areas could not be compared along that particular variable. Table 5 gives reported socio-demographic characteristics in the two study areas.

Table 5: Socio-demographic Variables in all Study Subjects (n=602)

Variable	Mean/No	Percent	X ² - statistic	p-value
Age	7.7		50.403	0.035
Sex	M-299 F-303	49.7 50.3	0.165	0.684
Rooms	2	38 > 61.8%	46.530	0.000
House type	Stone wall & tile roof	55.6%	29.487	0.000
Charcoal	Always-84	14%	0.440	0.803
Cooking gas	Always-265	44%	36.249	0.000
Electricity	Always-25	4.2%	0.431	0.806
Firewood	Always-3	0.5%	0.337	0.845
Kerosene	Always-184	30.6%	57.995	0.000
Cooking place	Inside the house-554	92.0%	6.029	0.014
Smoking	Yes-104	17.3%	0.621	0.431
Employment	Employed-294	48.8%	11.254	0.004
Education years	14years & >= 212	35.2%	0.881	0.830
Persons	4 & >= 533	88.5%	2.503	0.475
Total	-	-	17.608	0.352

6.2.1 Age Distribution

Majority of the cases were from 4.1-6.0 age group representing 43.4% of all the cases. The mean age was 7.7 years, mode 6.0 years and the median age was 6.5 years. The age range was 12.8 years with a standard deviation of 2.8 years. In Ngummo estate there were 303 cases. The mean age was 7.5 years, with a median of 6.0 years while the mode was 6.0 years. In South C estate the cases were 299. The mean age was 7.8 years while median was 7.0 and the mode was 6.0 years. Comparison in terms of age groups across the two areas using chi square test was not significant ($\chi^2=2.376$, $df=4$, $p=0.667$). Similarly comparison of age

groups in the two areas using t test for equality of means revealed no significant differences ($t=-0.778$, $df=600$, $p=0.437$).

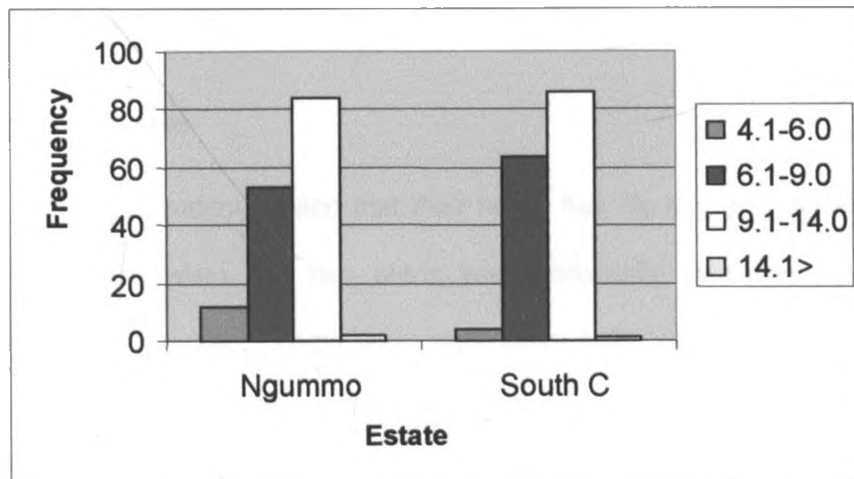


Figure 2: Number of cases combined showing age groups in the two areas

6.2.2 Sex Distribution

From the cases selected, males were 299 (49.7%) while females were 303 (50.3%). In Ngummo estate 148 (48.8%) were males and females were 155 (51.2%). In South C estate 151 (50.5%) were males while 148 (49.5%) were females. The sex ratio in the two study areas was not statistically significant using Fisher's exact test ($p=0.744$).

6.2.3 Number of Rooms per Residence

Majority of respondents reported living in a house of three and more rooms (61.8%). Those who reported living in a single room represented 22.4% while two rooms were 15.8%. In Ngummo estate ninety nine (99) reported that they lived in a single room, while fifty seven (57) said they lived in two rooms. For three rooms and above, the respondents were one hundred and forty seven (147). In South C estate, 36 respondents stated occupying one room, while on the other hand 38 were occupying two rooms and 225 occupied three or more rooms. The number of rooms reported was statistically significantly different with Ngummo reporting more

residents with single rooms a factor that potentially confounds the out come ($\chi^2=49.530,df=2,p <0.001$).

6.2.4 Type of House

Majority of the respondents stated that their house had tile roof and stonewall. The type of house between the two areas was statistically significantly different. ($\chi^2=29.487,df=4,p<0.001$). There were more cases from Ngummo in the category of others perhaps making the difference significant. This group included houses made of canvas, carton, and manila among others.

6.2.5 Medication Use

Medication use was obtained as a measure of morbidity within two weeks prior to data collection. A total number of 171(28.4%) took medication due to respiratory symptoms two weeks prior to data collection exercise. In Ngummo estate those who took medication for respiratory symptoms in the same period were 77 representing 25.4% while in South C estate they were 94 representing 31.4%. Use of medication in the two areas was not significantly different ($\chi^2=2.687, df=1,p=0.101$).

6.2.6 Absenteeism

Being absent from school as a morbidity indicator due to respiratory symptoms was ascertained from hand delivered questionnaires. Out of 602 cases those who missed school during the study period were 82 (13.6%). In Ngummo estate 33 (10.9%) reported missing school while 49 (16.4%) did so at South C estate (Figure 3). Missing school was statistically different in the two areas ($\chi^2=3.865, df=1,p=0.049$).

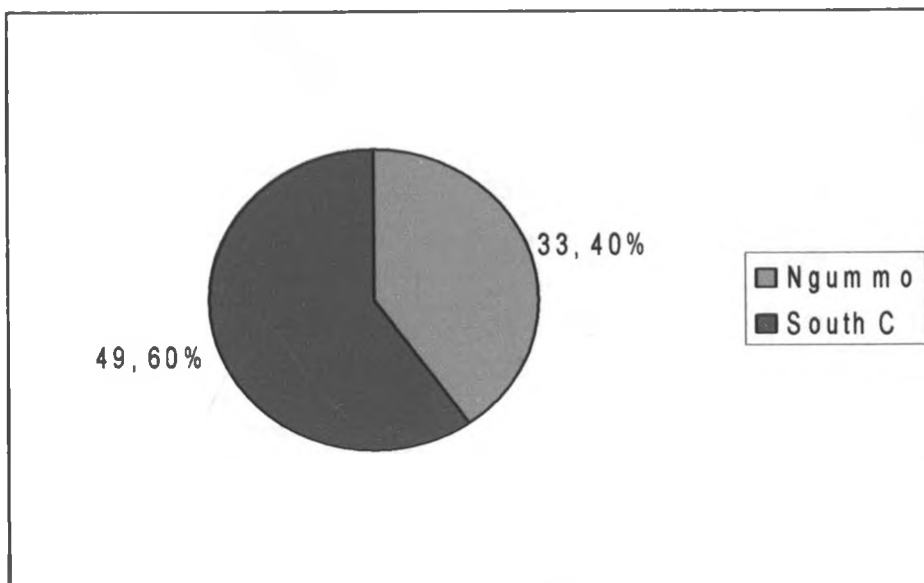


Figure 3: Percentage absentees in the two study estates (n=602)

6.2.7 Cooking Fuel

Previous studies have shown that cooking fuel used at home has a direct influence on the prevalence of respiratory symptoms especially on children as well as a small but statistically significant reduction in lung function test (WHO 1998). The study established the use of cooking fuel as a potential confounder to be controlled for in the outcome. Cooking gas was the most popular type of fuel used while electricity and firewood were the least popular fuel type (Table 6). Comparison of cooking fuel use in the two areas showed significant differences in the use of cooking gas and Kerosene ($\chi^2=36.249$, $df=2$, $p<0.001$ and $\chi^2=57.995$, $df=2$, $p<0.001$) respectively. There were more respondents from Ngummo that reported using kerosene while South C had a higher number of respondents using cooking gas.

**Table 6: Type of cooking fuel and frequency of use by estates
(n=602)**

Cooking Fuel	Ngummo			South C			P value
	1	2	3	1	2	3	
Charcoal	45	230	28	39	233	27	0.803
Gas	99	57	147	166	52	81	<0.001
Electricity	14	52	237	11	49	239	0.806
Firewood	2	22	279	1	21	279	0.0845
Kerosene	133	96	74	51	107	141	<0.001

Foot note: 1=Always
2=Sometimes
3=Never

Note: There were multiple responses on one item.

6.2.8 Cooking Place

Approximately 92% of the respondents were cooking inside the house while the rest cooked outside the house. In Ngummo estate, a total number of 287 respondents reported cooking taking place inside the house while 267 reported the same activity in South C estate. A small number of respondents in South C reported cooking taking place outside the house while in Ngummo there was hardly any respondent with outside cooking making the difference statistically significant ($\chi^2=6.029, df=1$ $p=0.014$).

6.2.9 Parental Smoking

Parental smoking was ascertained as a potential confounder to the outcome as it is known to aggravate respiratory problems. In the study, the total parental smokers were 104 (17.3%). Separately, 56(18.5%) reported being smokers at

Ngummo estate while 48(16.1%) were smokers in South C estate (Figure 4). There was no statistical difference in the number of parental smokers in the two study areas ($\chi^2=6.210,df=1,p=0.431$).

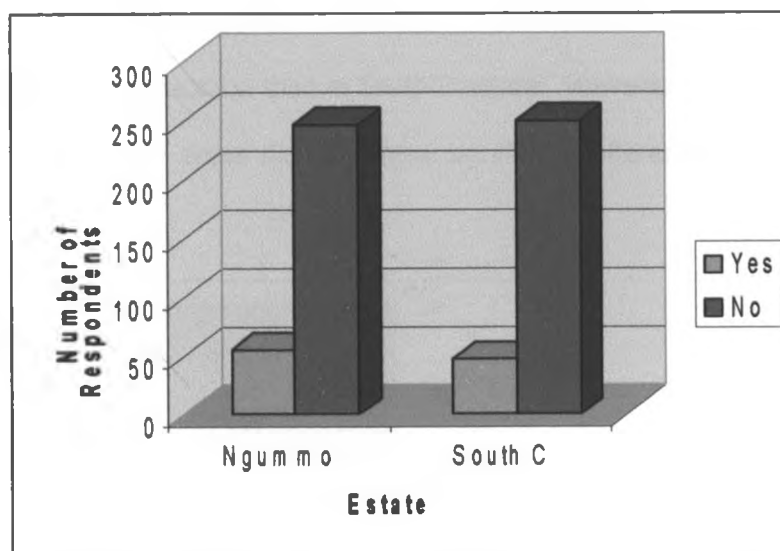


Figure 4: Parental smokers and non smokers in the two areas (n=602)

6.2.10 Employment of the Mother

Based on respondents, overall employed were 294, self employed were 223 and unemployed were 85. The level of unemployment in South C was approximately twice as much as Ngummo estate. Ngummo estate reported majority as employed almost twice as much as the self and unemployed combined at South C estate. This resulted in highly significant differences in the two areas, ($\chi^2=11.257, df=2 p<0.001$){Table 7}.

Table 7: Employment Status in the Two Areas (n=602)

Estate	Employment status			OR Unemployment
	Employed	Self Employed	Unemployed	
Ngummo	161	113	29	5.6
South C	133	110	56	2.4
Overall	294	223	85	3.5

$\chi^2=11.26$ $p=0.004$, (OR=1.93 unemployment, {0.03-0.74} 95%CI)

6.2.11 Mother's Level of Education

This was categorized into 0-8 years of education, 9-12 years, 12-14 years and 14 years and above. Majority of the study subjects came from the category of 12-14 years of education. The study subjects in Ngummo estate reported a high proportion of more than 14 years of education than in South C estate. However, comparison of education years in the two areas did not show significant differences ($\chi^2=0.881$, $df=3, p=0.83$).

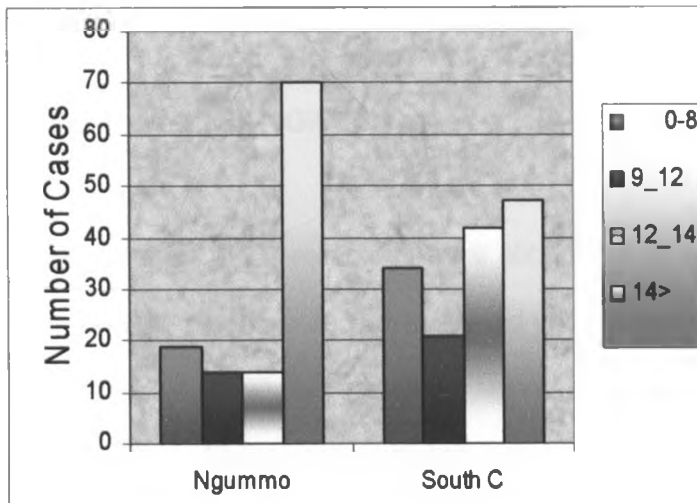


Figure 5: Maternal education (years) of respondents

6.2.12 Number of Persons in Households

The number of persons in the household was one of the factors that could show overcrowding index. Majority of households in the study reported having four and more persons in the family. The mean number of persons in the household was 3.8 persons. Number of persons reported was not significantly different for the two areas ($\chi^2=2.503$, $df=3$, $p=0.475$).

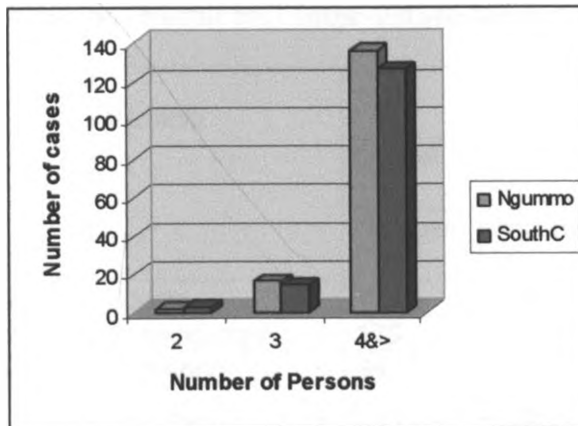


Figure 6: Number of Persons in the household

6.3 RESPIRATORY MORBIDITY

A total number of 602 responses were obtained from this study. The percentages shown are the respondents who answered yes to the required symptom. Among the cases studied 303 (50.3%) were from Ngummo estate while 299 (49.7%) were from South C estate. All the cases reported respiratory symptoms in two weeks preceding data collection exercise. At the pre-primary school level, respiratory symptoms were observed at the point in time while in primary school level peak flow measurements and body mass index were obtained besides reported respiratory symptoms. Table 8 gives the overall morbidity pattern among the study subjects. The highest symptom morbidity (39.5%) was from reported cough while the least reported was high temperature (6%). At pre-primary level, the most frequent observed respiratory symptom was inflamed throat (52.7%) followed by blocked nose and running nose that recorded 45.3% respectively. The least observed health condition representing (0.7%) was observed sneezing.

Table 8: Overall and Inter-Estate Morbidity Pattern (n=602)

State	Variable	Morbidity			
		Overall		Estate	
		Number	Percent	Ngummo n-303	South C n-299
Reported symptoms n=602	Cough	238	(39.5)	47(15.5)	53(17.7)
	Running nose	175	(29.1)	41(13.3)	45(15.1)
	Wheezing	54	(9)	18(5.9)	14(4.7)
	Reported sore throat	103	(17.1)	30(9.9)	22(7.4)
	Itchy eyes	65	(10.8)	24((7.9)	18(6.0)
	High temperature	36	(6)	13(4.3)	11(3.7)
Observed symptoms n=296 (Ngummo= 152 South C n=144)	Blocked nose	134	(45.3)	55(18.6)	79(26.8)
	Running nose	134	(45.3)	63(21.3)	71(24.0)
	Inflamed throat	156	(52.7)	67(22.6)	89(30.1)
	Coughing	8	(2.7)	4(1.4)	4(1.4)
	Sneezing	2	(0.7)	0	2(0.7)

Figures in parenthesis are percentages

Among primary school pupils, approximately 78.8% recorded abnormal peak flow measurement while normal body mass index was obtained in 45.0% of all the cases. Moderate to severe stunting accounted for 8.3% of all the cases (Table 9).

Table 9: Observed Lung Function, BMI & Stunting in the study areas (n=306)

Variable		Overall		Estate		P-value
Observed Variable (n=306)		No.	%	Ngummo (n= 151)	South C (n= 155)	
Peak flow-Abnormal		241	(78.8)	116(76.8)	125(80.6)	0.414
BMI	Normal	272	(45.0)	133(43.9)	137(51.2)	0.248
	Under weight	28	(4.6)	17(5.6)	11(3.7)	
	At risk of overwgt	1	(0.2)	-	1(0.3)	
	Overwgt	5	(0.8)	1(0.3)	4(1.3)	
Stunting	Normal	166	(27.5)	74(24.4)	91(30.4)	0.309
	Mild	90	(14.9)	49(16.2)	40(13.4)	
	Moderate	38	(6.3)	22(7.3)	16(5.4)	
	Severe	12	(2.0)	6(2.0)	6(2.0)	

Figures in parenthesis are in percentage

6.3.0 Univariate Analysis

6.3.1 Observed Respiratory Symptoms among Pre-primary School Children

A total number of 296 subjects were from pre-primary school children. From the total subjects studied 134 (45.3%) had blocked nose and same number had running nose. Those with inflamed throat were 156 (52.7%), coughing were 8 (2.7%) and sneezing were 2 (0.7%). Out of these 296 children, 152 (51.3%) were from Ngummo estate while 144 (48.6%) were from South C estate. In Ngummo 55 subjects (36.2%) had blocked nose, 63 (41.1%) had running nose, 67 (44.1%) had inflamed throat and 4(2.6%) were observed coughing. In South C, 79 (54.9%) had blocked nose, 71 (49.3%) running nose, 89 (61.8%) inflamed throat, 4 (2.8%) coughing and 2 (1.4%) sneezing. Inter estate comparisons in observed symptoms showed significant differences in observed blocked nose and observed inflamed throat respectively (Table10).

Table 10: Observed respiratory symptoms (Pre-primary) estates and significance (n=296)

Observed Symptom	Ngummo estate n=152 %		South C estate N=144 %		OR	95%CI	p-value
	Yes	No	Yes	No			
Blocked nose	Yes	55(36.2)	Yes	79(54.9)	1.4	0.293-0.743	0.001
	No	97(63.8)	No	65(45.1)			
Running nose	Yes	63(41.4)	Yes	71(49.3)	1.3	0.460-1.152	0.175
	No	84(58.6)	No	71(50.7)			
Inflamed throat	Yes	67(44.1)	Yes	89(61.8)	1.3	0.306-0.775	0.002
	No	85(55.9)	No	55(38.2)			
Coughing	Yes	4(2.6)	Yes	4(2.8)	1.0	0.232-3.855	0.938
	No	148(97.4)	No	140(97.2)			
Sneezing	None		Yes	2(1.4)	-	0.995-1.034	0.145
			No	142(98.6)			

6.3.2 Lung Function Test

Peak flow readings were done to establish the state of lung performance, a factor that might show impairment due to repeated and chronic airway infections. Majority of the cases recorded abnormal peak flow measurements. Abnormal in this study meant lower than the expected readings. Table 11 shows that the cases that recorded normal peak flow reading in Ngummo estate were 35 while abnormal readings were 116 representing 23.2% and 76.8% respectively. In South C estate those that recorded normal peak flow measurements were 42 while abnormal were 113 representing 27.1% and 72.9% respectively. Inter estate analysis on normal peak flow measurement did not show significant differences ($\chi^2=0.669, df=1, p=0.414$). Further analysis on abnormal peak flow measurement revealed statistically significant differences ($\chi^2=43.506, df=2, p=0.031$).

Table 11: Lung Function Test (Peak flow reading) by estate (n=306)

Peak Flow Reading	Ngummo No (%)	South C No (%)	Total No (%)	OR	95%CI
Normal	35(23.2)	42(27.1)	77(25.2)	1.20	0.487-1.948
Abnormal	116(76.8)	113(72.9)	229(74.8)	0.97	0.901-1.120
Total	151(100)	155(100)	306	-	-

6.3.3 Body Mass Index (BMI) and Stunting

Body mass index is weight in kilograms divided by height (in meters squared) (kg/m^2). It is an objective tool for clinical assessment of nutritional status. A CDC pediatric age and sex for BMI was used for calculation using Epi info program. Height for age was used in stunting. Categorization was done as follows; underweight ≤ 5 percentile, at risk of overweight =85-95 percentile, over weight >95 percentile and normal ranges were from 4.9-84.9 percentile.

Most cases fell within acceptable ranges of BMI for age (Figure 7). A total number of 272 cases had normal BMI, 28 were underweight, one case was at risk of overweight while 5 cases were overweight. Assessment of height for age, which gives stunting revealed that 3.9% of the cases were severely stunted, 12.9% with moderate stunting and 2.9% had mild stunting. Inter-estate age for BMI comparisons did show statistical significant differences ($\chi^2=4.132$, $\text{df}=3$, $p=0.248$). Stunting analysis from the study areas showed that 49 cases had mild stunting from Ngummo while South C had 40 cases. Moderate stunting from Ngummo were 22 while South C had 16 cases.

Finally, the two areas had 6 cases each with severe stunting. Analysis on stunting did not reveal any statistical significant difference between the two study areas ($\chi^2=3.596$, $df= 3$, $p=0.309$).

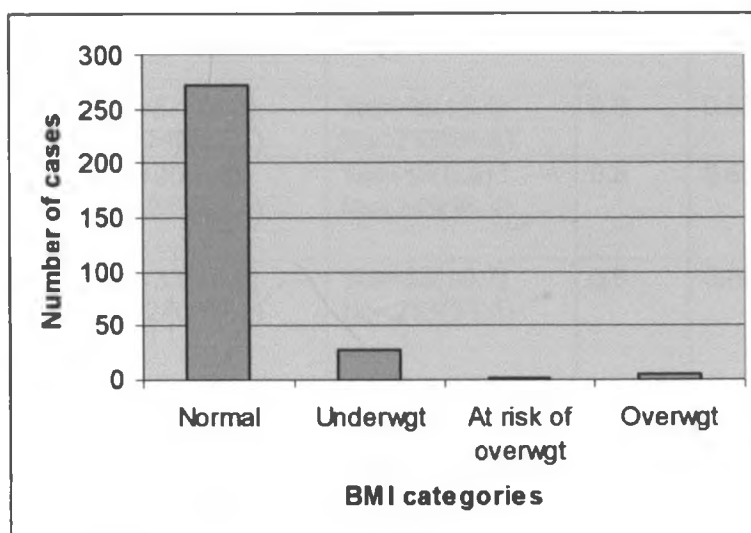


Figure 7: Age and sex for BMI in the two areas

6.3.4 Reported Respiratory Symptoms among the Study Subjects

The information on reported symptoms was obtained via mailed questionnaires that were filled by parents or guardians of all the study subjects. The reported symptoms were; cough, running nose, wheezing, sore throat, itchy eyes and high temperature(s) that could have occurred in two weeks preceding data collection exercise. Table 12 shows the proportion of symptoms reported in the two studied areas. Overall, the most reported symptom was cough and the least reported was high temperature. When stratified by estate, cough still remained the most symptom reported by the subjects in the two study areas. Inter estate comparisons did not reveal any significant difference in reported symptoms.

Table 12: Reported respiratory symptoms in the two estates areas (n=602)

Reported Symptom	Ngummo estate N=303 %	South C estate N=299 %	Odds ratio	95%CI	p-value
Cough	Yes= 112(37.0) No=191 (63.0)	Yes=126(42.1) No=173(57.9)	1.1	0.580-1.117	0.194
Running nose	Yes=81(26.7) No=222(73.3)	Yes=94(31.4) No=205(68.6)	1.2	0.796-1.132	0.204
Wheezing	Yes=27(8.9) No=276(91.1)	Yes=27(9.0) No=272(91.0)	1.0	0.563-1.724	0.959
Sore throat	Yes=57(18.8) No=246(81.2)	Yes=46(15.4) No=253(84.6)	0.8	0.832-1.952	0.264
High temperature	Yes=20(6.6) No=283(93.4)	Yes=16(6.6) No=283(93.4)	0.8	0.635-2.462	0.518
Itchy eyes	Yes=33(10.9) No=270(89.1)	Yes=32(10.7) No=283(93.4)	0.9	0.609-1.707	0.941

6.3.5 Relationships between Selected Independent Variables and Respiratory Symptoms

a) Observed Respiratory Symptoms in Kindergarten Children

Analysis was done on few selected socio-demographic variables. These were age, sex and residence. School absenteeism and medication use as an indicator of morbidity was also evaluated in relation to respiratory symptoms. According to this study age was significantly associated with observed coughing ($\chi^2=42.485$, $df=26$, $p=0.022$). The younger the child, the more likely such a child was observed to be coughing. When individual estates were analyzed separately, age was noted to be significantly related to observed coughing and sneezing at South C, ($\chi^2=35.818$, $df=19$, $p=0.011$) and Ngummo ($\chi^2=30.423$, $df=19$, $p=0.047$) respectively. In Ngummo estate age was not associated with any of the observed respiratory symptoms. Age did not have significant association with BMI values in the study areas.

Sex as a variable was significantly associated with observed coughing ($\chi^2=5.717,df=1,p=0.017$). There were more girls that were observed coughing compared to boys. Analysis on individual estates showed sex being significantly related to observed coughing and running nose ($\chi^2=4.001, \chi^2=4.016,df=1,p=0.045$) in Ngummo estate. There was no significant association between sex and observed symptoms in South C estate. Additionally, sex was not positively associated with BMI.

The place of residence was significantly associated with observed blocked nose ($\chi^2=10.411,df=1,p=0.001$) and inflamed throat ($\chi^2=9.322,df=1,p=0.002$). There were more cases with the above observed symptoms in South C estate and the significant difference could be attributed to outdoor air pollution. On the other hand, residence was not positively associated with BMI.

Analysis on use of medication and symptoms showed significant relationship to observed blocked nose, running nose and inflamed throat ($\chi^2=11.347,df=1,p=0.001$; $\chi^2=6.944,df=1,p=0.008$; $\chi^2=29.019,df=1,p<0.001$). From the estates there was significant medication use in Ngummo due to observed blocked nose ($\chi^2=9.424,df=1,p=0.002$) and running nose ($\chi^2=15.357,df=1,p<0.001$). In South C, medication use was significantly related to observed running nose ($\chi^2=13.609,df=1,p<0.001$) and inflamed throat ($\chi^2=4.197,df=1,p=0.040$).

School absenteeism was significantly related to both observed blocked nose, running nose ($\chi^2=9.514,df=1,p=0.002$) and inflamed throat ($\chi^2=5.052,df=1,p=0.025$). In Ngummo, absenteeism was significantly related to observed blocked nose ($\chi^2=6.981,df=1,p=0.008$) and running nose ($\chi^2=9.025,df=1,p=0.003$).

b) Reported Respiratory Symptoms

Reported symptoms were obtained from all the pupils via hand delivered questionnaires. Similar analysis was done as in observed symptoms to determine associations between selected independent variables and reported respiratory symptoms in the study subjects. Age was not significantly related to any of the reported symptoms collectively and from individual estates. Similarly sex was not significantly related to any of the reported symptoms. Individual estate analysis gave a similar picture of no relationship.

A place of residence did not show any significant relationship to reported symptoms. On the other hand, use of medication had a very strong significant relationship to all the reported symptoms ($p < 0.001$). On individual estates, all reported symptoms were related to use of medication ($p < 0.001$) except reported itchy eyes in Ngummo estate. In South C, all the reported symptoms were highly significantly related to medication use ($p < 0.001$). The fact that south C estate had significant medication use on itchy eyes compared to Ngummo could be attributed to more exposure from outdoor air pollution.

School absenteeism was significantly related to all reported symptoms except itchy eyes ($p < 0.001$). In Ngummo, all reported symptoms were significantly associated with absenteeism except high temperature and wheezing. In south C, reported symptoms were associated with all reported symptoms except reported wheezing ($p < 0.001$).

6.3.6 Multivariate Analysis

a) Observed Respiratory Symptoms

Multiple logistic regression analysis was done in order to assess the best predictors of the out come variable, that is, observed respiratory symptoms. Fuels used for cooking and parental smoking were controlled for during the analysis. From Table 13, residence, use of medication and number of persons were the most common predictors of observed symptoms implying that the place of residence in relation to industrial set up, the main focus of this study was a risk factor to respiratory symptoms in children.

Table 13: Multiple Regression analysis on observed symptoms pre-primary (n=296)

Dependent variable	Predictor(s)	Exp(B)	Wald's statistic	P value
Blocked nose	Residence	0.489	4.147	0.042
	Employment	0.196	7.535	0.006
	Persons	60.929	21.043	<0.001
Running nose	Medication	5.497	19.271	<0.001
	Persons	18.007	163.435	<0.001
Inflammed throat	Residence	0.354	9.270	0.002
	Medication	2.128	3.861	0.049
	Persons	38.426	100.670	<0.001
Coughing	Nil	None	None	none
Sneezing	Nil	None	None	none

b) Lung Function Test, Body Mass Index and Stunting

These parameters were obtained from primary school going children only. From the variables studied it was only absenteeism that significantly predicted peak flow measurement (Wald's =4.437, Exp (B) =2.899, p=0.038). Age was a significant predictor of stunting (p<0.001). That might give an indication of malnutrition in under five populations.

c) Reported Respiratory Symptoms

Data in Table 14 indicates that medication use emerged as the most common predictor of reported respiratory symptoms as it appeared on almost all the reported symptoms. The other significant predictors were residence, age, number of persons per house and rooms among others.

Table 14: Multiple regression analysis on reported symptoms (n=602)

Dependent variable	Predictor(s)	Exp(B)	Wald's statistic	P value
Cough	Medication	9.587	73.981	<0.001
	Employment	0.359	8.740	0.003
	Persons	16.548	56.246	<0.001
Running nose	Medication	5.092	44.268	<0.001
	Persons	47.349	76.288	<0.001
Wheezing	Rooms	0.260	4.548	0.033
	Medication	10.820	36.240	<0.001
	Persons	28.851	45.891	<0.001
Sore throat	Residence	1.882	4.205	0.040
	Medication	2.789	12.339	<0.001
	Persons	57.402	70.281	<0.001
Itchy eyes	Education years	0.331	4.626	0.031
	Persons	16.037	45.373	<0.001
High temperature	Age	14.771	3.843	0.050
	Medication	9.277	32.960	<0.001
	Absenteeism	2.941	6.966	0.008
	Education yrs	0.375	4.249	0.039

CHAPTER SEVEN

7.0 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 Discussions: Socio-demographic Characteristics

From a total of 602 subjects studied, minimum age was 2.2 while maximum was 15.0 years. The mean age was 7.7 years with a standard deviation of 2.8 years. Majority of subjects were six years old. Comparison of age across the two areas using the t-test for equality of means was not significantly different. Previous studies have noted that the younger the child, the smaller their airways and subsequently the more responsive their reactions to air pollutants (Lewis et al 1998). Analysis of gender in the two areas revealed that males were 299 (49.7%) while females were 303 (50.3%). There was no statistically significant difference in the two areas ($p=0.684$).

Majority of respondents had three and more rooms in the household. Analysis of the rooms in the two areas showed significant differences in the number of rooms ($X^2=49.3$, $df=2$, $p=0.001$). This was mainly due to construction of extensions from the main households. It meant that the two areas were not comparable along that variable.

The other category studied was the type of house respondents live in. Those who reported mabati both wall and roof were 81 (43.5%), timber wall and roof were 18 (3.0%), stone wall and iron sheet roof were 134 (22.8%), stone wall and tile roof were 335 (55.6%) and others who included houses of canvas and such like were 34 (5.6%). The type of house individual lived in was significantly different ($X^2=29.49$, $df=4$, $p<0.001$). This could have been due to the mix up of formal and

informal settlements as well as uncontrolled constructions/extensions.

Those who reported always using charcoal were 84 (14.0%) and the difference was not significant, $p=0.80$. Cooking gas they were 265 (44.0%) and the difference was significant ($X^2=36.49$, $df=2$, $p<0.001$). There were more responses from South C who reported to always using gas as a cooking fuel. Those who reported always using electricity were 25 (4.2%) and the difference was not significant. Very few individual reported using firewood and the difference was not significant. Lastly in cooking fuel was kerosene. Those who always used it for cooking were 184 (30.6%). There were more respondents from Ngummo who reported always using kerosene and the difference was significant ($X^2=58.0$, $df=2$, $p<0.001$).

Approximately 92.0% of respondents reported cooking taking place inside the house. However, there were fewer responses from South C who reported cooking outside the house and the difference was significant ($x^2=6.029$, $df=1$ $p=0.014$). In addition, 17.3% of respondents were smokers but the difference was not statistically significant.

There were more responses from Ngummo with formal employment (mothers) and the difference was statistically significant $p=0.004$. Besides, the mothers who had zero to eight years of education were 21.4%, between 9-12 years were 16.4%, 12-14 years were 26.9% and 14> years were 35.2%. There were no significant differences in terms of education years of the mother between the two estates.

Finally the number of persons in the household was ascertained. Those who reported two persons were 4%, three were 7.5% and four and more

persons were 88.6%. There was no statistical difference between the numbers of persons reported in the household.

7.1.2 Respiratory Morbidity

Total suspended Particulate matter studies done in Nairobi found the levels to be above $180\mu\text{g}/\text{m}^3$ in industrial area described as high concentration. Medium concentration was between $90\text{-}180\mu\text{g}/\text{m}^3$ and low concentration was below $90\mu\text{g}/\text{m}^3$ (Figure 1). In China's city of Wuhan (urban) the levels were $448\mu\text{g}/\text{m}^3$ and $191\mu\text{g}/\text{m}^3$ in suburban. According to WHO, epidemiological studies on large populations, no threshold concentration below which ambient particulate matter has no effect on health has been identified. It is likely that within any large human population there is such a wide range in susceptibility that some subjects are at risk even at the lowest end of concentration range (WHO 2003). In China the prevalence of cough was 56.4%, phlegm 22.2% and wheeze was 16.9% (Junfeng et al 1999) while this study found the overall prevalence of reported cough to be 39.5% (observed 2.7%), running nose 29.1% (observed 45.3%), wheezing 9% (observed 0.7%) sore throat 17%, itchy eyes 10% and high temperature 6%.

Although reported cough was the leading symptom in both places, these results do not compare well due to high pollution levels in China, higher population density and perhaps better techniques in pollution detection and symptom evaluation (the prevalence given for this study was on reported symptoms). There is also a possibility of differences in geographical and personal exposures in the two areas.

In Africa, a prevalence study carried out in South Africa found cough, wheeze, asthma and chest illnesses being more frequently reported from polluted areas compared with non polluted areas, taking into account parental smoking and home cooking fuel but lung function test was not significant as assessed using spirometry tests. No pollution levels were given in the study (Zwi et al 1990). This study compares well with the current study where more respiratory symptoms were recorded in a more air polluted area although not all were statistically significant probably due to differences in topographical, geographical and pollution sources.

Respiratory symptom outcome comparison was done based on outlined air sampling of total suspended particulate that was done earlier. Total suspended particulate was found to be high in the industrial areas, South C estate inclusive. It is the presence of particulates in the atmosphere that has shown the clearest link to an increase and exacerbation of respiratory symptoms in a two-year period of residence (Collen 2005).

The study observed respiratory symptoms on pupils attending kindergarten as well as relying on parental reporting on respiratory symptoms in two weeks preceding data collection. The following symptoms were assessed among pupils in pre-primary; blocked nostrils, running nose, inflamed throat, coughing, sneezing, difficulty in breathing and fast breathing. The last two were not obtained as they normally indicate a severe form of illness and any child experiencing them is likely to be in a hospital or at home being monitored closely. At the same time, the investigator did not observe any sneezing at Ngummo although two subjects were observed at South C. The overall picture in pre-primary showed 134 (45%) cases with blocked nose and the same number with running nose, 156 (52.7%) had inflamed throat, 8 (2.7%) had coughing and 2 (0.7%) were observed with sneezing.

In Ngummo estate 55(36.2%) were observed with blocked nose, 63 (41.1%) observed with running nose, 67 (44.1%) observed with inflamed throat and 4 (2.6%) observed coughing (n=140). In South C estate, 79 (54.9%) were observed with blocked nose, 71 (49.3%) observed having running nose, 89 (61.8%) were observed having inflamed throat, 4 (2.8%) were coughing and 2 (1.4%) was observed sneezing (n=144). There were significant differences in observed blocked nose ($p=0.001$) and observed inflamed throat ($p=0.002$). These scenarios implied that a child living at South C, close to industrial area, was twice as likely to experience blocked nose and inflamed throat compared with their counterpart at Ngummo estate (OR 2.2,95% CI,0.510-0.854 \$ OR=2.1,95%CI,0.572-0.889) respectively. The excess morbidity could be attributed to out door air pollution.

Reported symptoms were done on all the subjects both in primary and pre-primary. In Ngummo estate, reported cough was 112 (37.0%), running nose 81 (26.7), wheezing was 27 (8.9%), sore throat was 57 (18.8%), high temperature 20 (6.6%) and itchy eyes were 33(10.9%) n=303. In South C estate reported cough was 126 (42.1%), running nose 49 (31.4%), wheezing 27 (9.0%), sore throat 46 (15.4%), high temperature 32 (10.7%) and itchy eyes was 65 (10.5%) n=296. Comparison across the two areas did not show significant differences. No differences were obtained even when subjects were stratified to primary and pre-primary. These could have been due to either inaccurate reported information or a balanced effect since such children can relocate when they are already exposed. However more cases were reported from South C in terms of percentage and the difference was likely to be clinically significant. That difference could be attributed to outdoor air pollution.

Lung function testing obtained by peak flow measurements were done on children in primary school because they could take instructions on the procedure involved. After doing the anthropometric measurements of weight and height, three readings of forceful exhalations were recorded after maximum inhalations. The best reading was taken as the subject's peak flow reading. The readings were compared with the chart provided by Boehringer Ingelheim Company that used sex and height in meters of the child for the readings. Using 80% of PEFr the reading were coded either normal or abnormal (abnormal was a reading below expected). Majority of the subjects recorded abnormal peak reading. In Ngummo only 47 (31.1%) recorded normal peak reading. In South C 42, cases out of 155 recorded normal peak flow measurements. The possible explanation for this is that the technique could have been poor and probably the table used was done on American children who are taller and consequently with higher lung volume than our black children. There is need to have an African based set normal peak flow reading through which we can compare the deviations. Therefore, it means that the interpretation of these results should be done with a lot of caution. In terms of sex, 26 (33.3%) were females who had normal peak while males were 21 (28.8%) from the same place but there was no statistical differences noted.

Further analysis done on abnormal peak flow reading revealed significant differences in the two areas ($\chi^2 = 43.506, df=28$ and $p=0.031$). The result suggested that there were more subjects with abnormal peak flow reading from South C compared to Ngummo and the difference was significant implying that more outdoor exposure at the proximal end of industrial area had a detrimental effect on lung compliance. This was in agreement with previous findings that besides aggravation of

wheezing, coughing and reduction in lung function, over the long term, particulate air pollution could stunt lung function growth in children (National Ambient Air Quality standards 1997).

Regarding body mass index studies, most of the subjects recorded normal BMI from the expected readings. The overall prevalence rate for under weight was 4.6%, at risk of overweight was 0.2% and over weight was 0.8%. Moderate to severe stunting accounted for 8.3% of the cases studied. Previous studies found an inverse relationship between children's height and air pollution (Bobak 2004 & Jedychowski 2002) but that was not established in this study. The probable reason would be the presence of coarse particulates (PM_{10} average of $300\mu g/m^3$ 1999) in Kenya compared to more fine particulates found in developed countries $PM_{2.5}$. Fine particles or particulate matter of less than 2.5 microns diameter cause health effects at low levels (National Ambient Air Quality standards 1997). Alternatively, a longitudinal study could have been ideal to verify or dispute previous findings regarding relationship between air pollution and stunting.

Finally on respiratory morbidity a chi square test of significance was carried to establish whether there were any differences in observed symptoms in the two studied areas. This study found significant differences in observed blocked nose ($\chi^2=10.41, df=1, p= 0.001$). In addition, observed inflamed throat was statistically significant across the two areas ($\chi^2=9.32, df=1, p=0.002$). These showed that there was excess blocked nose and inflamed throat cases observed at a more polluted area. This can be an indication of frequency of respiratory infections in a more polluted area compared to a less polluted area, a factor that can be

attributed to outdoor air pollution. This compares well with the study done at Sao Paulo in Brazil where two communities were compared, one with high concentration of pollutants while the other had less. Symptoms were higher by a factor or two in the community with highest air pollutant concentration (Lewis et al 1998). Similarly, a study in Latin America found increased frequency in coughing, phlegm production and wheeze occurrence in children close to industrial establishment (Gouveia et al 2000).

7.1.3 Relationships Between Selected Independent and Dependent Variables

Overall observation from this study revealed age and sex as significantly related to observed coughing ($p=0.022$ & $p=0.017$) respectively. There were more girls observed coughing probably due to indoor air pollution. Residence was highly associated with observed blocked nose ($p=0.001$), and inflamed throat ($p=0.002$). This was an indication of more frequent respiratory symptoms observed from a more air polluted air compared to their counter parts in a less polluted area. From the socio-demographic parameters entered at Ngummo, age did not show any association with observed respiratory symptoms. Sex was marginally significantly associated with both observed running nose and observed coughing ($\chi^2 =4$, $p=0.045$, $n=152$). It meant that the proportion of girls who experienced running nose and coughing was higher than boys. The plausible explanation was that time spent indoors for girls is more and therefore, they are likely to suffer more from indoor air pollutants.

In South C, age was noted to be associated with observed sneezing, ($\chi^2=30$, $p=0.047$, $n=144$). It meant that the younger children are more likely to

experience sneezing and coughing. This is line with narrow nostrils from birth and eventual expansion as they grow up.

Age was also significant in abnormal peak flow reading ($\chi^2 = 28.526$, $df=11$, $p=0.003$) perhaps due to poor technique in handling the peak flow machine. Sex was not statistically significant in abnormal peak flow readings.

Within the estate sex comparisons in observed symptoms showed significant differences at Ngummo in running nose and coughing both ($p = 0.045$). South C did not record any significant differences in observed symptoms across gender. Comparisons of sex and reported symptoms between the estates did not yield any significant differences. Analysis on the association between age, sex, residence and BMI failed to show positive association. Subsequently, using the same variables in the analysis on stunting did not give statistical significant differences.

7.1.4 Multivariate Analysis

The common predictors of respiratory morbidity that were singled out in this study were use of medication, school absenteeism, and place of residence in relation to industrial set up. The study analyzed those who took medication and missed school in the preceding two weeks due to respiratory problems. In total 171 out of 602 (28.4%) took medication. Approximately (25.4% $n=306$) respondents reported taking medication due to respiratory related problems at Ngummo. In South C approximately (31.4% $n=299$), took medication in the same period. This was fairly a large number considering the rising cost of living and the malignant growth in

poverty levels. The study findings agree with previous studies done in California where medication use, as an expression of morbidity, was noted to be high in children (Defino et al 1997). Medication use in the two areas was not statistically significant probably due to inaccurate reported information.

The results showed that medication use was highly associated with observed blocked nose and observed running nose ($\chi^2=9$, $p= 0.002$, $\chi^2=15$ and $p<0.001$) respectively at Ngummo. This is probably the most visible sign of infection and majority of people are likely to act by either giving medication or visiting a health care institution that would prescribe medication.

Medication use was highly associated with most of the studied reported respiratory symptoms. All the variables studied except itchy eyes had p-values less than 0.001 and all the chi values were more than 20 at Ngummo estate. Overall, medication use emerged as a significant predictor in all reported symptoms except itchy eyes and observed running nose and inflamed throat.

In South C estate, medication use was significantly associated with all the observed symptoms when analyzed collectively. It showed how widely medication was being used in the respiratory symptoms in children despite the already efforts of I.M.C.I., immunizations and case management. Therefore, there is a need to include environmental preventive measures in the fight against childhood diseases. In addition, all reported symptoms were positively association with medication use from South C estate.

Additionally, the study wanted to find the number of pupils that missed school due to respiratory problems. A total of 82 cases out of 602 (13.6%) were found to have missed school in the study period. In Ngummo, 33 pupils out of 303 (10.9%) missed school in the preceding two weeks due to respiratory problems. From the responses obtained at South C, 49(16.4%) were reported to have missed school. This is the proportion of pupils who might miss the opportunity to realize their academic potentials due to respiratory illnesses. This was precious time lost both on the child and a parent or caretaker. The child loses schooling time while the parent loses productive time taking care of the sick child. Similarly, there was probably money spent on medication for such a sick child. Previous studies have shown increase school absenteeism and exacerbation of asthma symptoms in children exposed to outdoor pollutants (Romeo et al 1992). Missing school in the two areas was statistically significant ($p=0.049$) with more children missing school coming from a more polluted environment South C estate.

Collectively, school absenteeism was associated with observed blocked nose $p=0.008$ and observed running nose $p=0.003$. As mentioned earlier, it is the obvious physical sign of being ill and probably the reason of not attending school in case the illness gets worse. In South C, missing school was not associated with any of the observed symptoms.

Being absent from school was also associated with most of the reported symptoms except wheezing and high temperature at Ngummo. This is the response of people to respiratory infection and consequently valuable man-hours are lost.

Similarly, in South C missing school was associated with all except reported wheezing. This shows that a lot of money is used to treat the children suffering from respiratory symptoms.

Residence in relation to industrial set up was analyzed as a potential risk factor. Multiple regression analysis done on observed respiratory symptoms found significant association between residence and observed blocked nose ($p=0.042$) and inflamed throat ($p=0.002$). This was an indication that proximity to industrial set up can be detrimental to children's health. In addition, a chi square test performed on the reported symptoms in the two areas found residence to be positively associated with reported sore throat ($p=0.038$) as well as being independently associated with the same ($p=0.040$) in multiple regression analysis.

7.2 Conclusions

1. The most common reported symptom was cough and the observed symptom was inflamed throat. The industrially placed estate recorded high episodes in terms of numbers both reported and observed. On observation, inflamed throat and running nose were statistically significantly different.
2. In peak flow measurement, majority of the cases had abnormal peak reading. The results of the study will only apply to areas selected and a more elaborate study will be required to be applied countrywide. BMI findings were not contributory.

3. Medication use and missing school emerged as the best predictors of respiratory morbidity. Residence was a significant predictor of observed blocked nose, inflamed throat and reported sore throat. Therefore residential location in relation to industrial set up should not be wished away.

7.3 Recommendations

The National Environmental Management Authority (NEMA) set up a task force in 2002 to do environmental impact assessment on environmental pollution and water management, environmental information system among others and give recommendation that will help mitigate environmental pollution. The report said that Kenya's data on atmosphere and global change was not being systemically observed, collected and assessed. This study can go along way in filling the gap where a lot needs to be done on environmental issues. From this study, the general trendy did indicate more episodes experienced in a more industrially placed estate, although most were not significant, compared to far placed estate. The following were the recommendations forwarded;

1. Pollution levels should be included in weather forecasts and public announcements to sensitive the population on outdoor pollution.
2. The government in collaboration with the ministry of planning, ministry of environment and natural resources should establish and maintain zoning of residential, commercial and industrial set up.
3. Industries should be monitored and regulated to ensure they do not exceed local and internationally agreed levels of pollution as there is no threshold of SPM at which one is safe.

4. There is need for extensive longitudinal studies on air pollution health effects that can provide elaborate basis for planning and prevention of air pollution and consequently reduce respiratory morbidity and mortality.
5. There is need for a local applicable table on peak flow measurements relevant to Kenyan children.
6. Traffic air pollution study will go along way supplementing the current study as it might be a major contributor to outdoor air pollution.

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APPENDIX 1 CONSENT FORM

A study will be done in Nairobi whose purpose will be to assess the impact of outdoor air pollution on the respiratory health of the children. It will be carried out by Gladys Motende a student at the University of Nairobi Department of Public Health. The results, if positive, will help in locating of the residential areas away from industrial setting whose deleterious effects would have been established. I'm therefore appealing to you to volunteer your child for the purpose the study.

The study will involve examination of children's ears, throat and nose. As a parent or guardian I will require you to answer for me the questions in the paper the child will deliver to you. Children between 6-12 years will be required to blow into a designated instrument and the reading on the machine will be recorded. They will blow thrice. I too will take their weight and height.

CONSENT

This is to confirm that I agree to have my child examined by the investigator for the purpose that I have read and understood. This involves examination of the nose, ears and the throat (for under fives) or weight and height and blowing into an instrument (for between 6-12 years).

While results remain a confidential property of the investigator, significant findings that may require any intervention on my child may be made available to me.

I understand that I'm free to withdraw my child from the study without forfeiting any medical benefit due to him/her.

Child's name-----

Parent's name-----

Signature (Parent) -----

Date-----

1.3 Has your child had some of the following symptoms in the last two weeks (Y/N)?

Y-1N-2

- i) Cough.....
- ii) Running nose.....
- iii) Wheezing.....
- iv) Sore throat (painful throat).....
- v) Itching and tearing of the eyes.....
- vi) High temperature.....

1.4 Has the child used any medication in the last two weeks?.....Y-1N-2.

If yes, What was the reason?

1.5 Has your child missed school in the last two weeks? (Y/N)-----

Y-1N-2

If yes what was the reason for missing school (tick more than one as the case may be)

- a) Coughing
- b) Blocked nostrils
- c) Painful throat
- d) Difficult in breathing
- e) Others (specify)

1.6 How often do you use charcoal for cooking?

- a. Always
- b. Some time
- c. Never

1.7. How often do you use gas for cooking?

- a. Always

b. Some times

c. Never

1.8 How often do you use electricity for cooking?

a. Always

b. Sometimes

c. Never

1.9 How often do use firewood for cooking?

a. Always

b. Sometimes

c. Never

1.10 How often do you use kerosene for cooking?

a. Always

b. Sometimes

c. Never

1.11 Where does the cooking take place?

a. Inside the house most of the time

b. Outside the house most of the time

c. Never inside the house

1.12. Does anybody in the house smoke cigarettes?

a) Yes-1

b) No-2

1.13 What do you do for a living?

a. Self employed

b. Formal employment

c. Not employed

1.14. How many years of education do you have?

- a) .0-8 years---1
- b) 9-12 years---2
- c) 12-14years---3
- d) 14 years and above---4

1.15 How many people live in your house including children?

- a. Two
- b. Three
- c. Four
- d. Four and above

1.16. How long have you stayed in this estate?

- a. More than two years
- b. Less than two years

1.17. Is any of the following located close to where you stay? (Y/N) Y-1N-2

- a. Car garage
- b. Bakery
- c. Steel smelting
- d. Others

SECTION 2.1 AMONG PRE-PRIMARY 3-5 YRS

School Clinical Assessment of children with the following symptoms

Tick appropriately

Symptom	Present	Absent
Blocked nostrils		
Running nose		
Inflamed throat		
Fast breathing		
Difficulties in breathing		
Chest in drawing		
Coughing		
Sneezing		

Present (1) Absent (2)

SECTION 3 PEAK FLOW MEASUREMENTS AMONG PRIMARY SCHOOL PUPILS

Socio-demographic information

Subject number

Name of the school

Age

Sex

Residence

Weight (kgs)

Height (cm)

What is the Spiro meter reading?

First reading	Second reading	Third reading

APPENDIX 3 PEAK FLOW MESSUREMENT PROCEDURE

Peak Expiratory flow rate

The child takes as deep a breath as possible and then blows out as hard as possible.

The equipment used measures the highest naxw of air that is achieved during the blowing out phase

1. Move the indicator to the bottom of the numbered scale
2. Stand up or sit up straight
3. Take a deep breath from the air, filling your lungs completely.
4. Place the mouthpiece in your mouth and close your lips around it. Do not put your tongue inside the hole.
5. Blow out as hard and fast as you can in a single blow.
6. Repeat steps from 1-5 two more times and write down the highest (personal best) of the three blows.

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