IMPACT OF USE OF BIOFUELS ON RESPIRATORY HEALTH AMONG WORKERS IN FOOD ESTABLISHMENTS IN NAIROBI

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A Research Thesis Submitted in Partial Fulfilment for the Award of the Degree of Master of Public Health in the School of Health Sciences of Kenyatta University

SEPTEMBER 2007

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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SUPERVISORS' APPROVAL

We confirm that the candidate under our supervision carried out the work reported in this thesis.

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DEDICATION

This work is dedicated to my mother, Hilda and my lovely daughter, Megan.

ACKNOWLEDGEMENTS

This thesis could never have been achieved were it not for the guidance and support of the following persons:

Foremost, a lot of gratitude to my supervisors Dr. Margaret Keraka, Dr. Evans Kituyi and Dr. Lawrence Oteba for their guidance, encouragement and availability throughout the study period.

I also thank the Chairman, Department of Public Health for granting me enough time to conduct the study. Other members of staff in the Department as well for review of my work and valuable input they gave me.

The City Council of Nairobi for granting me permission to carry out the study in Food Catering Enterprises in Nairobi. My gratitude also extends to the staff at the Directorate of Occupational Health and Safety. Thanks a lot for your time and input.

Most of all, my heartfelt gratitude goes to all the workers in food catering enterprises who despite the hardships they face in conducting their business, and their busy schedule, made time for me during the study.

Last but not least, I thank the Department of Public Health, School of Health Sciences and Kenyatta University for giving me the opportunity to enrol in the Masters in Public Health degree programme.

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LIST OF ABBREVIATIONS

ALRI	Acute Lower Respiratory Infections
ARI	Acute Respiratory Infections
CBD	Central Business District
CBS	Central Bureau of Statistics
CDM	Cleaner Development Mechanism
CO	Carbonmonoxide
COPD	Chronic Obstructive Pulmonary Disease
DALYs	Daily Adjusted Life Years
EF	Emission Factor
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GoK	Government of Kenya
GWh	Gigawatt Hours
ITDG	Intermediate Technology Development Group
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
$\mu g/m^3$	Micrograms per cubic metres
MoE	Ministry of Energy
MWh	Megawatt hours
NCC	Nairobi City Council
PAHs	Poly Aromatic Hydrocarbons
PM	Particulate Matter

SPSS	Statistical Package for Social Sciences
SMEs	Small and Micro Enterprises
Tg	Teragram (10^{12} g)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
US	United States
USEPA	United States Environment Protection Agency
USAID	United States Agency for International Development
VOCs	Volatile Organic Compounds
WEC	World Energy Council
WHO	World Health Organisation
WRI	World Resources Institute

ABSTRACT

Indoor air pollution from biofuel use has been found to be responsible for more than 1.6 million annual deaths and 2.7% of the global burden of disease. This makes it the second biggest environmental contributor to ill health, after unsafe water and sanitation. Respiratory system is the most affected. However, nearly all studies have been conducted in households, leaving out occupational environments where the same fuels are used. The main objective of this study was therefore to investigate the impact of use of biofuels on respiratory health among workers in food catering enterprises in Nairobi. A cross-sectional design was employed, and data collected using structured questionnaires, observation checklist and interviews. Data was analysed using descriptive statistics and chi square tests. Of the 370 respondents in the 250 randomly selected enterprises, 56% were males and 44% females, mostly aged between 20 to 40 years. Majority (86%) had not gone beyond secondary school, and were mostly casual employees or own account workers. Most of the enterprises (71%) were unregistered, and 81% utilized biofuels because they were cheaper than processed fuels. The study found significantly higher prevalence of respiratory symptoms among workers in enterprises using biofuels compared to those using processed fuels. *p* values were significant for cough (χ^2=38.16; df=1; *P*=0.000), phlegm (χ^2=6.46; df=1; *P*=0.011), breathlessness (χ^2=8.29; df=1; *P*=0.004) and wheezing (χ^2=16.56; df=1; *P*=0.000). Within the biofuels, fuelwood users recorded higher prevalence of symptoms compared to charcoal users. Prevalence of respiratory health outcomes was also considerably higher in those who were aged 40 years and above and who spent longer hours indoors, similar to findings by Ezzati *et al* (2000) and Shrestha *et al* (2005) in household studies. Significantly higher prevalence was also recorded in respondents in unregistered enterprises (*p*=0.002), and those that were poorly ventilated (*p*=0.000). The study has demonstrated that biofuels are a major public health threat to workers in food establishments, and urgent intervention is required. It therefore recommends a switch from biofuels to processed fuels in order to protect the health of the workers. Other measures that can be employed include a switch from more polluting biofuels such as fuelwood to less polluting ones such as charcoal, ensuring adequate ventilation, spending less hours indoors and awareness creation. However, for such interventions to occur, the activities of the sector needs to be formalised, because this would encourage investments in the sector that would lead to adoption of cleaner fuels and healthy work environments. Targeted energy sector policies that would make processed fuels more affordable and financial support measures are also required.

CHAPTER ONE: INTRODUCTION

1.1 Background

Worldwide, approximately 50% of people, almost all in developing countries, rely on biofuels in the form of wood, dung and crop residues for domestic energy [United Nations Development Programme (UNDP), 2000; Reddy, *et al*, 1997]. In developing countries, biofuels are commonly burned in inefficient simple stoves and in poorly ventilated conditions. In such situations, biofuel use generates substantial emissions of many health-damaging pollutants, including respirable particulates and carbon monoxide (CO), and results in indoor air pollution exposures often far exceeding national standards and international guidelines (Ezzati and Kammen, 2001b). Where biofuels are used, the average daily exposure concentration of children under the age of 5 to PM_{10} (particulate matter smaller than 10 microns in diameter) is approximately 1500 $\mu g/m^3$ and that of adult women approximately 5000 $\mu g/m^3$. This is many times higher than the latest United States Environmental Protection Agency (US EPA) standards, which states that individuals should not to exceed PM_{10} levels of 150 $\mu g/m^3$ for a 24-hour period (USEPA, 1997).

Several studies firmly associate biofuel use with acute lower respiratory tract infections, chronic obstructive pulmonary disease and lung cancer. Each of these three health outcomes is a major disease category in most societies. According to the World Health Organisation (WHO), (2000), household biofuel use is likely to be a major cause of disease burden in communities where it is prevalent.

Globally, WHO attributes 2.7% of all ill health to indoor smoke from biofuels, nearly all in developing countries. Evidence is also emerging that exposure to indoor air pollution from biofuels may increase the risk of a number of other important conditions, including tuberculosis, low birth weight, and cataract (Bruce *et al.* 2000; Ezzati and Kammen, 2001a; Ezzati and Kammen, 2001b and Smith, *et al.* 2000). In developing countries, according to WHO (2000), around 4.9% of deaths and 4.4% of Disability-Adjusted Lost Life (DALYs) are attributed to indoor air pollution from solid biomass fuels.

In Kenya, studies conducted by International Technology Development Group (ITDG) between 1998 and 2001 showed that smoke levels in indoor environments were unacceptably high. The 24-hour average of respirable particulates (PM_{10}) was 5526μg/m^3 (ITDG, 2001). These daily rates are over one hundred times than the USEPA accepted value of 150 μg/m^3 (USEPA, 1997).

The above mentioned studies have indicated that those who are mostly at risk are women, because they are responsible for food preparation and cooking, and infants/young children who are usually with their mothers near the cooking area. However, few, if any study had previously been done to determine if other groups of people who spend a lot of time indoors during cooking using biofuels for instance workers in food catering enterprises are also vulnerable. This is the gap the study aimed to fill, focusing on respiratory health given that the pollutants are inhaled. Workers in food catering enterprises were particularly chosen since these enterprises are the largest biofuel energy consumer among all Small and Micro-Enterprises (SMEs) under the cottage and service sector category (Republic of Kenya, 2002).

1.2 Problem Statement and Justification

1.2.1 Problem Statement

Consistent evidence has shown that use of biofuels indoors leads to levels of indoor air pollution many times higher than international ambient air quality standards allow for, exposing those involved to a major public health hazard. Typical 24-hour mean levels of PM_{10} in indoor environments where biofuels are used range from 300 to >3000 μg/m^3, and during use of an open fire, the PM_{10} level can reach 20,000 μg/m^3 or more. By comparison, the US-EPA standard for daily (24-hour) average PM_{10} is 150 μg/m^3 (this concentration should be exceeded only in one per 100 days).

Most developed countries rarely exceed these standards, whereas in developing countries, they are exceeded on a daily basis by a factor of 10, 20, and sometimes more (Ezzati and Kammen, 2001b). Levels of carbon monoxide and other pollutants also often exceed the standards. This exposure increases the risk of many diseases and conditions, especially those affecting respiratory health, and is estimated to account for a substantial proportion of the global burden of disease in developing countries.

However, these findings have only been obtained from household studies, and there has been no evidence to show if there is any link between biofuel use in occupational environments such as food catering enterprises and respiratory health of the workers. It has therefore not been known what proportion of disease burden occupational exposure contributes to, or its public health impact.

1.2.2 Justification

The slow pace of development in many countries suggests that biomass fuels will continue to be used by the poor for many decades (UNDP&WEC, 2000). Therefore people will continue to be exposed to pollutants and suffer from the associated health consequences if no intervention is undertaken.

Interventions in the energy sector have however been limited by lack of sufficient evidence on the link between biofuel use and respiratory health, the magnitude of the problem, groups at risk and possible measures that can be adopted to make the fuels safer. While many studies have established the link between biofuels use and health, all of them have been done in households, leaving out occupational environments such as food catering enterprises where the same fuels are used. Yet determining the impact of solid fuel use at national or local levels is important for identifying and prioritising environmental and public health interventions.

1.3 Research Questions

The study sought to answer the following research questions:

1. What is the demographic profile of workers in food catering enterprises in Nairobi?
2. What major fuel types are used by food catering enterprises in Nairobi and what factors determine their choice?

3. What is the prevalence of respiratory health symptoms among the workers?
4. What is the influence of biofuel use on respiratory health of the workers?
5. How do the respondents' demographic profiles and enterprise characteristics relate to the prevalence of respiratory health symptoms exhibited?

1.4 The Null Hypotheses

The following hypotheses guided this study:

1. Use of biofuels has no impact on respiratory health of workers in food establishments in Nairobi.
2. Demographic characteristics of respondents and enterprise characteristics have no influence on prevalence of symptoms exhibited.

1.5 Study Objectives

1.5.1 General Objective

To determine the impact of use of biofuels on respiratory health among workers in food establishments in Nairobi.

1.5.2 Specific Objectives

1. To determine demographic profiles of the workers in food catering enterprises in Nairobi;
2. To determine the major fuel types used by food catering enterprises in Nairobi and factors determining their choice;
3. To establish prevalence of respiratory health symptoms exhibited by the workers;
4. To investigate the influence of biofuels use on respiratory health of the workers;

5. To determine the influence of respondents' demographic profiles and enterprise characteristics on prevalence of health outcomes.

1.6 Significance and Anticipated Output

1.6.1 Significance of the Study

The bulk of energy investment in African countries has been largely aimed at improving energy services for high-income urban households and established commercial and industrial concerns. Some international development aid is aimed at improved rural energy services. However, the energy services for the urban poor and especially those in the informal sector are often forgotten and appear to have fallen off the development agenda. As a result, current understanding of the most energy-intensive end-uses and possible resultant health consequences is still unclear. Nor is it clear what interventions are needed to facilitate the availability of affordable, modern and non-polluting energy services for the informal sector such as food catering enterprises.

Determining the impact of biofuel use is important for generating the evidence that is required for making sound policy recommendations. Aside from filling the existing knowledge gaps, the study aimed to identify specific measures that can be employed in food catering enterprises to protect the health of the workers from risks posed by use of biofuels.

1.6.2 Anticipated Output

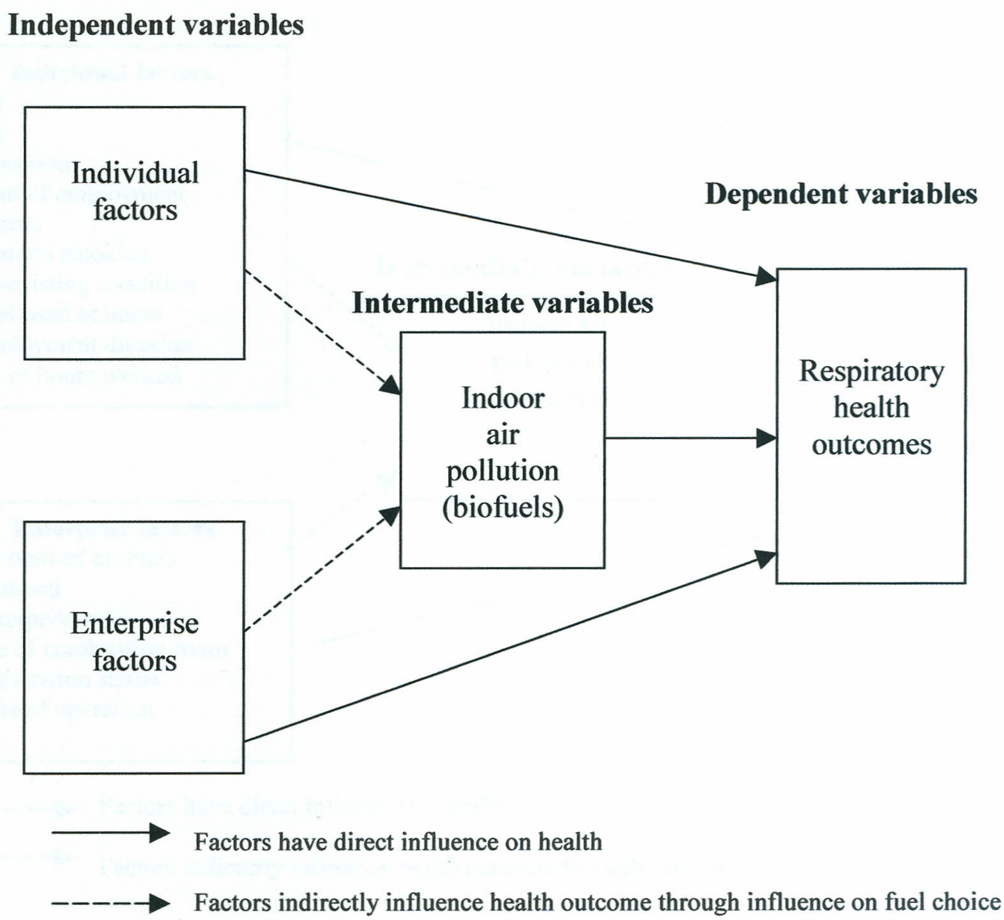
Establishing the impact of biofuels use on respiratory health of workers in food catering enterprises is important for identifying and prioritising public health interventions. It is therefore anticipated that the findings of this study will have important consequences for national and international public-health policies, energy and combustion research, and technology transfer efforts. This is because indoor air pollution is a major public health threat requiring greatly increased efforts in the areas of research and policy-making.

The findings of this study could further be used to raise the option of energy used in SMEs as part of Clean Development Mechanism (CDM) projects, as it should be possible to obtain reduction in greenhouse gas emissions and health protection from energy improvements at a combined cost.

1.7 Conceptual Framework

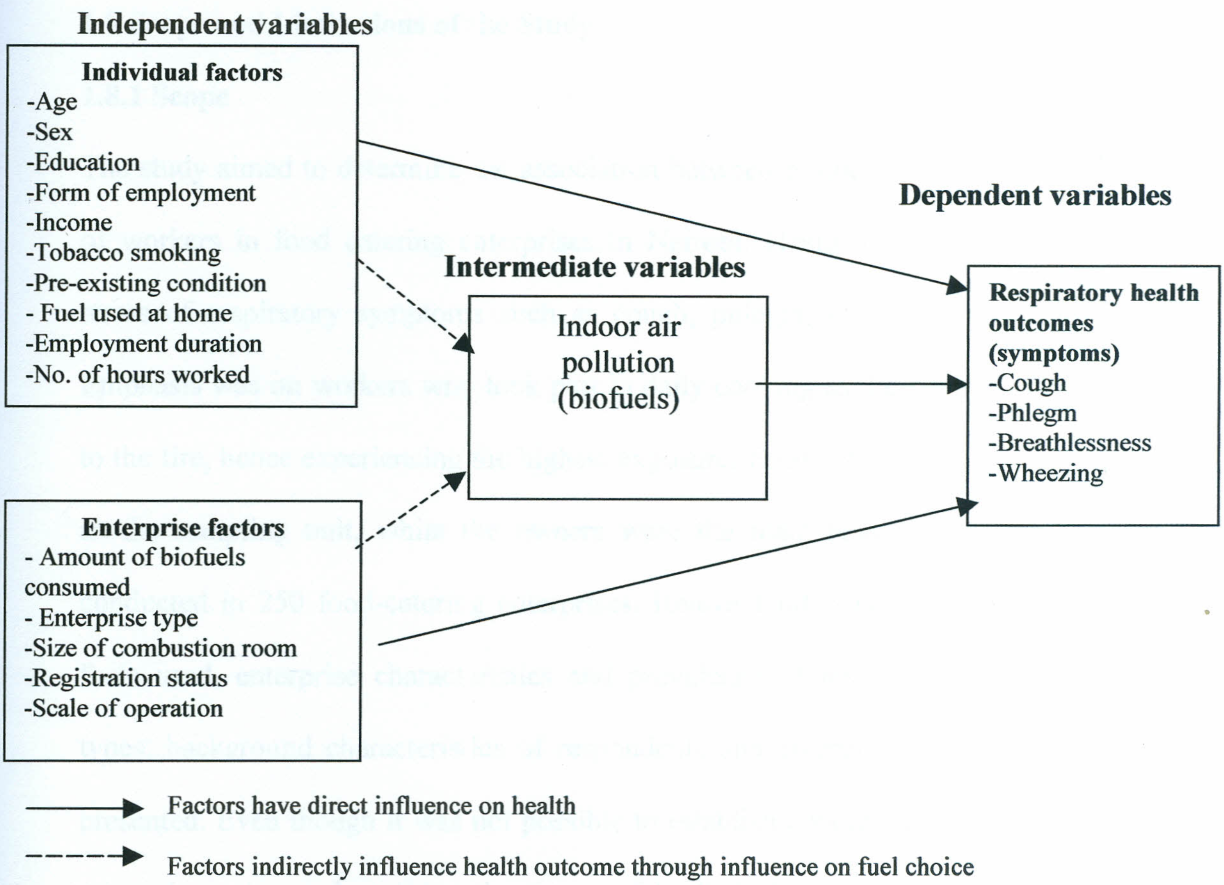
The study utilised the conceptual and operational frameworks shown in Figure 1.1 and 1.2 respectively.

The framework depicts the multiple links between exposure to indoor air pollutants from biofuels and health effects. It is expected that use of biofuels in food catering enterprises would lead to generation of pollutants indoors, which when inhaled could lead to respiratory health problems. Individual factors and enterprise factors are also likely to influence health outcomes either directly; or indirectly by determining whether the enterprises use biofuels or processed fuels.



Source: Researcher

Figure 1.1: Conceptual Framework



Source: Researcher

Figure 1.2: Operational Framework

1.8 Scope and Limitations of the Study

1.8.1 Scope

The study aimed to determine the association between biofuel use and respiratory health of workers in food catering enterprises in Nairobi. Health outcomes are expressed in terms of respiratory symptoms such as cough, phlegm, breathlessness and wheezing. Emphasis was on workers who took part in daily cooking as they spend more time close to the fire, hence experiencing the highest exposure. Food catering enterprises were taken as the sampling unit, while the owners were the main respondents. Interviews were conducted in 250 food-catering enterprises. Relevant information about major types of fuels used, enterprise characteristics and prevalence of respiratory symptoms by fuel types, background characteristics of respondents and enterprise characteristics are also presented. Even though it was not possible to establish concentration of pollutants in the enterprises, the study estimated amount of biofuels burned and related this to health outcomes.

1.8.2 Limitations

Due to various limitations, few studies conducted of indoor air pollution and its health effects in developing countries have actually measured pollutant concentrations directly for exposure assessment (Bruce, *et al,* 2000). In this study, the limitations of cost did not make it possible for the pollutant concentrations to be quantitified. The study however was able to relate quantities of fuel consumed with symptoms exhibited, given that amount of fuel burned has an influence on concentration of pollutants.

The second limitation was on assessing respiratory health outcomes. Due to limitation of cost, time and ethical barriers, it was not possible to take respondents to do a medical diagnosis of respiratory diseases. Instead the Medical Research Council (MRC) respiratory health questionnaire that has been used in similar studies was employed, and the study relied on self-reported symptoms.

The third limitation arose from the nature of respondents. Given the informal nature of their employment and constant transition from one form of employment to the next, the study employed a cross-sectional design. A longitudinal study could have been more useful as it would have enabled follow-up.

1.9 Definition of Operational Terms

Biofuels (Biomass fuels) Unprocessed fuels including charcoal, fuelwood, and organic matter (crop residues, dung).

Food catering enterprise/ Food establishment Any establishment involved in food preparation, and that employs people to prepare the food. This includes food kiosks (informal, makeshift type) and restaurants (formal).

Casual employee An employee who is paid on a daily basis.

Chronic obstructive pulmonary disease (COPD) Progressive and incompletely reversible airflow obstruction.

Emission factors Factors applied to biofuels to convert them to CO2-equivalent.

Energy All forms of fuels used to perform various tasks. Include biofuels, LPG, electricity.

Environmental health Ecological balance that must exist between man and his environment to ensure his well -being (physical, mental and social health).

Exposure The concentration of pollution in the immediate breathing environment during a specified period of time.

Fuel types Various fuels used by food catering enterprises such as charcoal, fuelwood, kerosene.

Forms of fuel Binary classification of fuels used into biofuels and processed fuels

Global warming	The rise in temperature caused by rising greenhouse gas concentrations in the atmosphere.
Greenhouse gases	Gases that trap some of the heat that the earth radiates back into space. They carbon dioxide (CO^2), methane (CH_4) and nitrous oxide (N_2O).
Health outcome	Symptom or illness that result from exposure to a pollutant.
Informal Sector	Range of small-scale economic units that are not registered by registrar of companies.
Indoor air pollution	Presence in local in-house environments of pollutants such as particulate matter (PM), poly-aromatic hydrocarbons (PAH) and carbonmonoxide (CO) which can be inhaled resulting to adverse health outcomes.
Occupational hazards	Substances present in occupational environment that can cause harm, injury or death.
Perinatal mortality	Still births and deaths in the first week of life.
PM_{10}	Small particles of diameter less than 10 microns.
Prevalence	Proportion of the population with a given health condition at a given point in time.
Processed Fuels	Electricity and mineral fuels such as LPG and Kerosene. Also referred to as clean fuels.
Respiratory health symptoms	Cough, phlegm, breathlessness and wheezing.

Small and Micro-Enterprises

Small-scale enterprises that employ between 1 and 20 people. Referred to as micro-enterprise when it has 1-5 employees; and small enterprise when it has 6-20 employees.

Woodfuel Collective term for charcoal and fuelwood.

CHAPTER TWO: LITERATURE REVIEW

2.1 Consumption Trends of Biofuels

Globally, almost 3 billion people rely on biofuels as their primary source of domestic energy (UNDP, 2000). Biofuels account for more than half of domestic energy use in many developing countries and for as much as 95% in some lower- income nations (UNDP, 2000). According to the World Resources Institute (1999), although the fraction of global energy from biofuels has fallen from 50 per cent in 1900 to around 13 per cent currently, biofuel use has increased in developing countries.

Reddy, *et al,* (2000) observes that as the urbanization of Africa gathers pace, the demand for modern energy is likely to increase substantially. Sub-Saharan Africa's energy sector will begin to acquire the characteristics prevalent in Northern Africa. This implies major increases in demand for modern energy services. This would, however, be subject to rising real incomes for the majority of inhabitants of sub-Saharan Africa. Otherwise, the increase will be met by unprocessed and environmentally unsound biofuels.

While most of Africa is still essentially rural, the continent's towns and cities are growing rapidly. Karakezi (1999) estimates that for most African countries, Kenya included, the urban growth rate is on average double the national population growth rate. As urbanization accelerates, energy use in urban areas is expected to increase rapidly. Typical activities of the average urban resident are usually more modern energy-intensive than the activities of a rural resident. Consequently, the ongoing and accelerating rural-urban demographic shift is expected to result in a much faster increase in urban energy consumption.

Current trends indicate that most of the increase in urban energy consumption will be in the form of traditional biofuels. Between 1970 and 1990, Africa's population increased by about 150 million but over this period the number of persons with access to electricity increased by only about 50 million. Of the estimated one-third of Africa's population who live in urban areas only about 25% have access to electricity (Reddy, *et al*, 2000). Urban household electrification levels are generally below 30%, and according to Karakezi (1999), this is the equivalent of having the whole of Nigeria, the most populous country in Africa, not being electrified.

With the exception of South Africa, biofuels dominate national energy supplies in sub-Saharan Africa. Goldemberg, *et al*, (2000) observes that even in countries with significant fossil fuel resources like Gabon, Nigeria, and Angola, biomass constitutes the majority of national energy consumption. Apart from the low electrification rates, electricity tends to be the most expensive option for cooking, so that even in countries where household access exceeds the regional average, biomass fuels still dominate energy supply (Reddy, *et al*, 1997).

Biofuels are typically used in different forms in sub Saharan Africa. The most common forms of biomass are unprocessed fuelwood and charcoal, with limited use of crop residues and dung. Regionally, roughly 20 percent of the wood energy harvest is processed into charcoal before final consumption (World Energy Council, 1999).

In Kenya, the major form of energy is biofuels in form of fuelwood and charcoal. In 1995, Kenya had fewer than 50,000 household Liquefied Petroleum Gas (LPG) cylinders in use, almost entirely in the four largest urban areas. Kenya's consumption of LPG at 1.1kg/capita compares dismally to other countries such as Egypt (36.2kg/capita), Senegal (10.3 kg/capita) and Cote de voire (2.7kg/capita) and it is far below the African average consumption of 8.3kg/capita (Energy Alternatives Africa (EAA), 2003). According to a survey done by the Ministry of Energy in 2000 (Republic of Kenya, 2002), 89% of rural and 7% of urban households reported regular use of firewood, giving a national average of 67% of all households. Use of charcoal was 47% at national level, with 82% of households in urban areas and 34% in rural areas. The other forms of biofuels including farm residues and food wastes were only used by 0.5% of urban households, and none by food catering enterprises. The current concern is that charcoal demand in Kenya will continue to grow since alternative cleaner commercial energy options for cooking still remain inaccessible to majority of the potential market.

The above survey also found out that rural and urban households often consume a mixture of both traditional and conventional energy types depending on household income, with the poor using greater quantities of traditional fuels while higher income households relying more on modern energy resources. Cottage industries such as food catering enterprises were found to be obtaining their energy where most households source theirs, and sharing similar patterns of use.

2.2 Consumption of Biofuels in the Informal Sector

According to Karakezi (1999), an important aspect of the urbanization, particularly in Africa, is the growth of the informal sector. The informal sector is one of the largest employers in most African cities, and their activities are essentially dominated by the urban poor. While most of the informal sector enterprises are characterized by low to medium energy intensity use, studies have shown that provision of clean, efficient and affordable energy leads to improved performance in the informal sector and would reduce associated negative health and environmental impacts (Karakezi, 1999).

Current trends indicate that most of the increase in urban energy consumption in Africa will be in the form of traditional biofuels. The trends also indicate a shift in energy uses from household to commercial use with the growth of informal sector, an important aspect of urbanization, particularly in Africa. With the growing rate of urban poverty and limited development of energy infrastructure in low-income areas, the cost of energy services is increasingly becoming prohibitive for low-income households and informal sector enterprises, the largest source of employment for low-income urban residents.

Typically, commercial energy applications found in low-income urban areas include use of electricity, kerosene and charcoal for cooking and lighting in small restaurants, food kiosks, small shops, bars, beer halls and informal video kiosks. Currently, most informal sector enterprises extensively use unprocessed biofuels and residual oil products.

According to Karakezi (1999), these constitute an occupational health and environmental health hazard as well as compounding existing urban energy related environmental problems, which include ambient and indoor air pollution. These mainly arise from the use of biofuels which emit smoke leading to respiratory ailments. He observes this to be particularly problematic in sub-Saharan Africa where unprocessed wood is used for cooking in urban areas. Conditions in parts of southern Africa such as South Africa, Zimbabwe and Botswana where coal is used in urban households are particularly more acute.

The transition to clean modern energy in urban areas is heavily reliant on increased incomes - a trend that is found in only a few African cities. Consequently, the increased demand for energy in urban Africa will continually be met by environmentally unsound biofuels. Unfortunately, current understanding of the most energy-intensive end-uses is still unclear. Nor is it clear what interventions are needed to facilitate the availability of affordable, modern and non-polluting energy services for the low-income urban areas of Africa.

In Kenya, there has been high but unplanned growth in the SME sector, mainly in food catering. Past decades has realised the government creation of numerous districts and provincial administration centres. Catering enterprises have hence emerged to cater for growing populations around these centres. The high immigration from rural areas has further seen the growth in unplanned settlements and kiosks to serve these urban-poor populations who are mainly job seekers or casual labourers in cities.

The SMEs in Kenya, which include food catering enterprises have been found to rely mainly on fuelwood and charcoal for their operations, with electricity and fossil fuels such as LPG, kerosene and diesel playing a smaller, substitutive role—owing largely to their higher costs. For instance, over 95% of all rural restaurants and kiosks depend on fuelwood for all their cooking (Kituyi, *et al,* 2000).

Small and micro enterprises (SMEs) in Kenya are mainly of the cottage (e.g. brick making, tobacco curing, fish smoking, bakeries etc) and service (e.g. restaurants) type. These are known to waste as much as 70% of woodfuel energy (Kituyi, *et al,* 2001). The wasted energy contribute to high levels of indoor air pollution which would negatively affect the health of the workers. The high energy loses have been attributed largely to continued use of obsolete fuel conversion technologies (mainly open fires) as well as poor fireplace management techniques. This is made worse by the general characteristic of SMEs, for instance the unplanned, congested, mainly unregulated structures that house many of them. Such conditions could compound the levels of indoor air pollution, and its effects on health of the enterprises employees.

According to the Ministry of Energy survey on energy uses by SMEs conducted in 2000 (Republic of Kenya, 2002), food catering enterprises emerged as the highest consumer of energy among all SMEs under the cottage and service sector category (Table 2.1). Continued unsustainable consumption of woodfuels by SMEs is contributing to the already heavy burden placed on the environment by household fuel demand whose share in sub-Saharan African countries' primary energy consumption is estimated at 60% -

86% (WEC, 2001). It is further contributing to the high disease burden attributed to indoor air pollution from biofuels.

According to a study by Kituyi, *et al,* (2001), about 87,500 formal and informal (kiosks) restaurants existed in Kenya in 2000. A mean guest size of 188 per day, and fuelwood consumption rate of 0.33 kg per guest were reported in the study. Overall, restaurants in Kenya consume 1.2 million tons of fuelwood and 0.4 million tons of charcoal annually. Their annual demand in the year 2000 for electricity and LPG stood at 715 GWh and 0.1 million tons, respectively (Republic of Kenya, 2002). Yet the impact of this on the health of the workers had previously not been documented.

Table 2.1: Annual energy consumption by the cottage and service sector in Kenya

SME type	*Fuelwood (tons)*	*Charcoal (tons)*	*Electricity (MWh)*	*LPG (tons)*	*Kerosene (litres)*	*Diesel (litres)*
Brick making	56,000					
Tobacco curing	78,000					
Milk Processing			3000			72,030
Fishing					1,600	1,600
Fish smoking	17,960					
Jaggery	178,750					
Posho Mill			75			144,000,000
Bakeries	73,500	210	27			
Food catering enterprises	1,208,000	437,000	715,000	116,400		
Tea Processing	155,000					

Source: Republic of Kenya, 2002

Ironically, the SMEs in general and restaurants in particular continue to operate on this unsustainable path at a time when improved-efficiency technological innovations abound on the market. Improved woodfuel stoves have been designed to save on fuel and cut down on pollutant emissions. Their dissemination in households and more recently, communal institutions in Kenya has yielded significant albeit localized positive impacts.

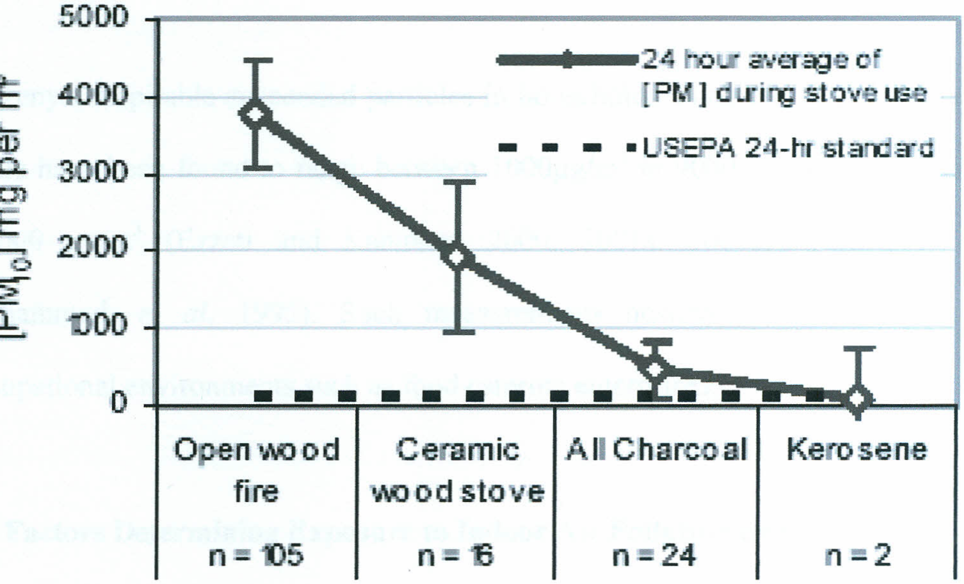
However, little effort has targeted technology development and transfer to the cottage and service sector—a sector whose annual demand is 3.3 million tons of woodfuel—approximately 10% of the total annual woodfuel demand (Republic of Kenya, 2004).

2.3 Indoor Air Pollutants Associated with Biofuels

Air pollution has been consistently linked with ill health in both developed and developing countries. Historically, however, public health attention focused mainly on the risks from outdoor air pollution. Yet a rule of thumb states that a pollutant released indoors is 1000 times more likely to reach people's lungs than a pollutant released outdoors (Desai, *et al,* 2004). The problems are worsened in areas where people spend most of their time indoors.

Although wood and other biomass consist mainly of carbon, hydrogen and oxygen, hundreds of dangerous chemicals are produced as a result of incomplete combustion in typical household stoves. This includes small particles, carbon monoxide, formaldehyde, acrolein, benzene, 1,3-butadiene, toluene, styrene, and polyaromatic hydrocarbons, according to De Koning, *et al.* (1985). These products are pollutants that, at varying concentration levels, pose substantial risks to human health. The products are inhaled, greatly compromising the respiratory system.

The latest National Ambient Air Quality Standards of the US EPA and WHO limit daily average concentrations of PM_{10} to 150 $\mu g/m^3$, while the annual average should not exceed 50,000 $\mu g/m^3$ (USEPA, 1997; WHO, 2000). Monitoring of pollution and personal exposures in biomass-burning households in Kenya has however shown concentrations of pollutants many times higher than the set standards (Ezzati and Kammen, 2000) as shown in Figure 2.1.



The dashed line shows the USEPA's standard for exposure (24 hour average concentrations of PM10 should not exceed 150 µg/m3).
Source: Ezzati and Kammen, 2000).

Figure 2.1: Mean concentration of PM_{10} in rural Kenyan homes using different cooking technologies

Studies from Kenya and other developing countries (von Schirnding, *et al*, 2001) have shown that indoor air pollution levels from combustion of biofuels are extremely high - often many times the standards in industrialized countries. Whereas cities in industrialised countries infrequently exceed the US-EPA 24-hour standard for PM_{10}, in rural homes in Kenya, the standard may be exceeded on a regular basis by a factor of 10, 20, and sometimes up to 50 (Figure 2.1), exceeding even the high levels found outdoors in coal-burning Cities in northern China (Ezzati and Kammen, 2000). Studies in other developing countries by Bruce, *et al* (2000) have yielded similar results. While indoor air pollution levels of particulates in households using bio-fuelled cookstoves have been found to be as high as 10,000 μg/m3, in comparison, typical levels found in a home in the developed world where at least two packets of cigarettes are smoked per day are about 40 $\mu g/m^3$ (Bruce, *et al*, 2000).

In Kenya, respirable suspended particles in households using biofuels measured over 24 hours have been found to range between $1000 \mu g/m^3$ to $9000 \mu g/m^3$ with peaks reaching 21,000 $\mu g/m^3$ (Ezzati and Kammen, 2000, 2001a, 2001c; Wafula, *et al*, 2000; Mohammed, *et al*, 1995). Such measurements however have not been done in occupational environments such as food catering enterprises.

2.4 Factors Determining Exposure to Indoor Air Pollution from Biofuels

Research on exposure to indoor smoke and its impacts on respiratory illnesses in developing countries began in the 1960s and 1970s in India, Nigeria, and Papua New Guinea (De Koning, *et al.*1985). The initial emphasis of research on household energy in developing countries was on the environmental impacts of biomass use, such as deforestation and desertification, with increased efficiency as the goal. The public health benefits from reducing exposure to indoor smoke became the subject of attention soon after, with the promise of double dividend - improving public health while reducing adverse environmental impacts.

People's exposure to indoor air pollution from biofuels and the resultant health outcomes are determined by various factors. Studies conducted by Ezzati & Kammen (2001c) and

Ezzati, *et al*, (2000) in rural Kenyan households have shown that these include individual factors such as age and sex, concentrations of pollutants in the indoor environment, and most importantly, by the time that individuals spend in polluted environments. Concentration levels measured depended on amount of biofuels burned, and where and when monitoring took place. For example, they recorded concentrations of 50,000 $\mu g/m^3$ in the immediate vicinity of the fire, with concentration levels falling significantly with increasing distance from the fire. Other factors determining concentration of pollutants include fuel type, stove type and housing characteristics including ventilation, according to studies by Boy, *et al,* (2002) and Smith, *et al*, (2000).

Time-activity budget is another crucial parameter to consider when assessing exposure and health impacts of indoor air pollution from biofuels. Recent work on exposure to indoor smoke under actual conditions of use by Ezzati *et al.* (2000) in Mpala ranch in Kenya has shown that stove emissions are highly episodic and that peaks in emissions concentrations commonly occur when fuel is added or moved, the stove is lit, the cooking pot is placed on or removed from the fire, or food is stirred. Hence those closest to the fire during such episodes would be more affected than those who may be outside at the time.

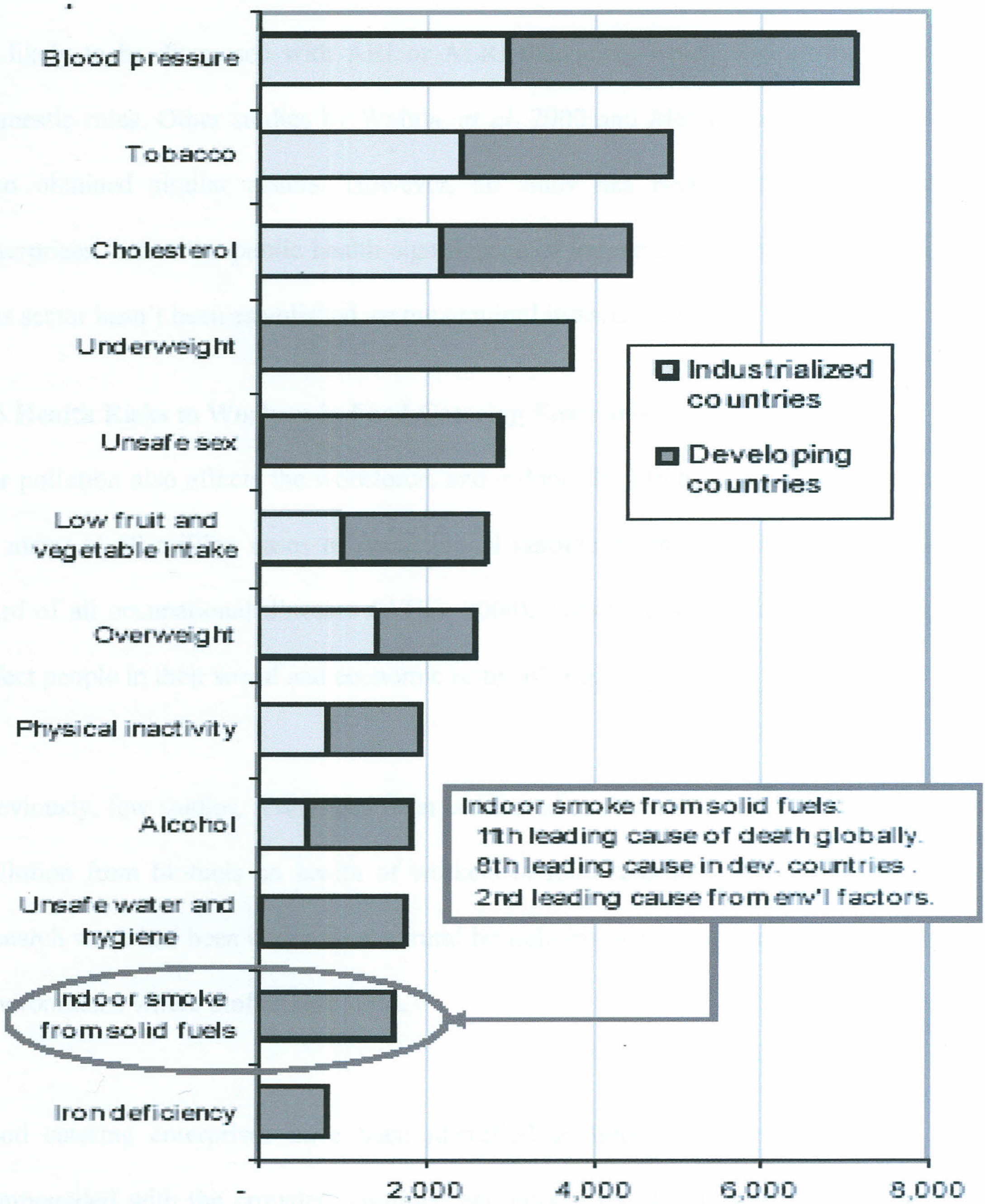
The health effects of indoor air pollution further depend on levels of exposure and susceptibility of the exposed population. Studies by Smith and Metha (2000) and Ezzati and Kammen (2001a) have shown that people suffering from respiratory conditions such as asthma, both the very young and old, smokers, and people living in poverty, are particularly at risk. All these parameters therefore need to be investigated when determining the link between exposure to pollutants from biofuels and health outcomes.

2.5 Respiratory Health Risks

Exposure to indoor air pollution from combustion of solid fuels has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries, including acute respiratory infections (ARI), otitis media (middle ear infection), chronic obstructive pulmonary disease (COPD), lung cancer (from coal smoke), asthma, nasopharyngeal cancer and laryngeal cancer (Ezzati and Kammen, 2001b; Ezzati and Kammen, 2001a; Bruce, *et al.* 2000 and Smith *et al.* 2000).

Most current studies on the health impacts of exposure to indoor air pollution in developing countries have focused on ARI, otitis media and COPD. Conservative estimates of global mortality due to indoor air pollution from biofuels using only these three diseases show that in 2000, between 1.5 million and 2 million deaths were attributed to this risk factor (Smith and Metha, 2000 and von Schirnding, *et al.*, 2001). This accounts for approximately 3% to 4% of total mortality worldwide. Approximately 1 million of the deaths were due to acute lower respiratory infections (ALRI) among children; the remainder were due to COPD, lung cancer among adult women, and other causes, according to Smith and Metha (2000).

In recent years, new evidence has emerged which suggests that indoor air pollution in developing countries may also increase the risk of other important child and adult health problems. These include prenatal conditions and low birth weight, and diseases of the



Source: Desai, et al, (2004).

Figure 2.2: Number of global deaths (x 1000) for 12 leading risk factors in 2000

rate of increase of exposure-response was highest for exposures below 1000-2000 μg/m3 (Ezzati & Kammen, 2001a). The results of the study also showed that women were twice as likely to be diagnosed with ARI or ALRI than men, which was attributed to their domestic roles. Other studies by Wafula, *et al*, 2000 and Mohammed, *et al*, 1995 have also obtained similar results. However, no study has been done in food catering enterprises, hence the public health significance of indoor air pollution from biofuels in this sector hasn't been established, or the required interventions.

2.6 Health Risks to Workers in Food Catering Enterprises

Air pollution also affects the workforce, and indoor air pollution is the primary cause in as many as 50 million cases of occupational chronic respiratory disease each year - a third of all occupational illnesses (WHO, 2000). These are widespread, debilitating and affect people in their social and economic prime of life.

Previously, few studies, if any, had been conducted to determine the impact of indoor air pollution from biofuels on health of workers in food catering enterprises. The bulk of research work had been undertaken in rural households, leaving out urban areas and work environments where biofuels are used.

Food catering enterprises have been identified as large consumers of energy. This, compounded with the crowded, confined and poorly ventilated work environments that characterize most SMEs could aggravate the negative consequences of indoor air pollution.

2.7 Impact on Environment

The damage to the environment resulting from use of biofuels can impact on health in a wide variety of ways, from increasing pressure on food production and water shortages in the local setting, to the potentially widespread and major impacts that global warming may have - particularly on the countries of sub-Saharan Africa. The burning of biomass, like all combustion of carbon fuels, produces carbon dioxide and other gases which contribute to global warming, which is expected to increase the risk of vector borne disease, food and water shortage and population dislocation (Reddy, *et al*, 1997). Furthermore, the stoves used in developing countries have a low efficiency of around 15%, with nearly 10% of the energy of wood being lost as products of incomplete combustion (Karekezi, 1999). These products include methane, which has a greenhouse effect many times greater than carbondioxide

Biomass burning has recently emerged as a key source of important atmospheric trace gases. Of the 8700 Teragrams (Tg) of biomass burned globally each year, 16% is attributed to biofuel burning in developing countries, mainly as firewood and charcoal (production and consumption). Combustion of wood fuel emits a variety of trace gases that have implications for global warming, tropospheric chemistry and human health. Carbondioxide and methane are greenhouse gases while nitrous oxide and volatile organic compounds which are precursors in tropospheric ozone formation (Liefmann, 1991).

Although the link between use of biomass as a cooking fuel and deforestation is no longer as clear as it was originally assumed, enough studies have shown that in peri-urban and urban areas, the use of wood requires transport over longer distances, thus increasing the demand for charcoal which is leading to forest depletion in rural areas in order to provide fuel to cities. Charcoal is an important fuel for many poor peri-urban and urban populations in sub-Saharan Africa (Goldemberg *et al*, 2000).

The production and consumption of biofuels in Kenya has serious though not well document implications for the atmospheric environment, and consequently, human health (Kituyi, 2000). This is attributable to particulates and trace gases emitted from the largely inefficient conversion technologies employed in charcoal production and domestic charcoal use. The current concern is that biofuel demand in Kenya will continue to grow since alternative cleaner commercial energy options for cooking still remain inaccessible to majority of the potential market. An upward trend in emissions of greenhouse gases is thus implied.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Research Design

The study employed a cross-sectional design. The design was suitable for this study given that most of the enterprises are built in illegal land and are constantly demolished. Employment in the sector is also temporary, with workers constantly shifting from one form of activity to another. This is a general characteristic of the informal sector.

3.2 Study Area

The study was carried out in the city of Nairobi (Figure 3.1). Nairobi was purposively chosen for the study because it has the largest number of SMEs including food catering enterprises (Republic of Kenya, 2005); the highest proportion of people working in the informal enterprises and is the leading province in Kenya in energy consumption (Republic of Kenya, 2002).

Nairobi extends between $36^0 4'$ and $37^0 10'$ in the North and between $1^0 9'$ and $1^0 28'$ to the South (Republic of Kenya, 2003). It covers an area of 696.1 Km^2. It lies at an altitude of 1,670m; the longitude is $36^0 50'$ East, and latitude $1^0 17'$ South, just 140 Km South of the Equator. It shares common borders with Kiambu District to the North, Machakos District to the East and Kajiado District to the South.

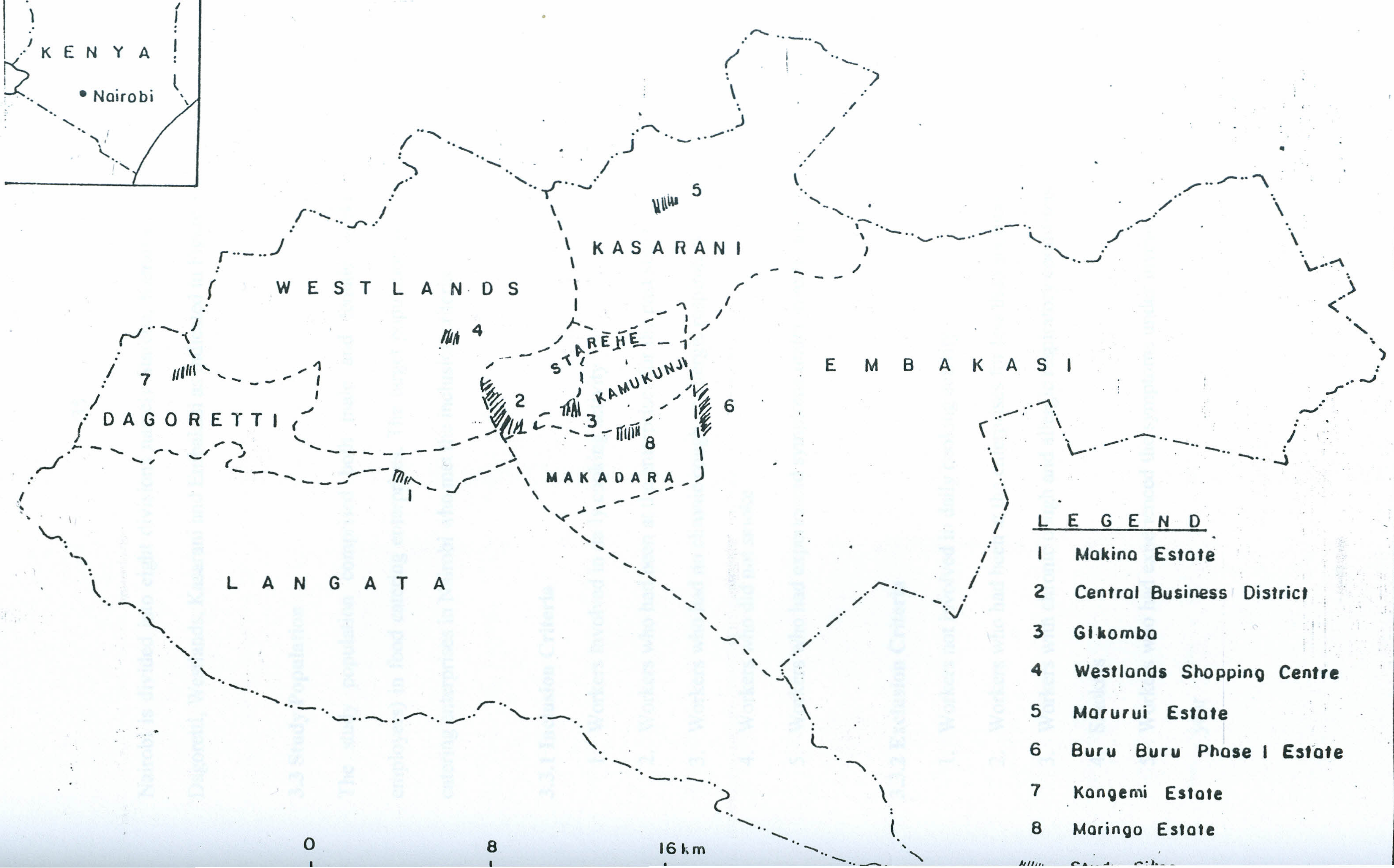
According to the population and housing census of 1999, Nairobi's population was 2,137, 000 with 828, 000 males and 1,325, 000 females (Republic of Kenya, 2003). The growth rate was projected at 2.7%; hence the current population is about 2,540,893. The number of males working for pay was estimated at 454, 456 and females 209, 514. According to

Economic Survey of 2005, unemployment figures were 95, 535 and 73, 128 for males and females respectively (Republic of Kenya, 2005). A large proportion of the unemployed engage in informal sector activities as a source of income. In 2004, Nairobi province accounted for 24.2% and the highest informal sector employment of 1,343 thousand persons.

A lot of biofuels are consumed in Nairobi. Current estimates indicate that households in Nairobi consume 2,009,534 tones of biofuels per year (Republic of Kenya, 2002). The cottage sector where food catering enterprises fall consume 243,124 tonnes per year, giving a total biofuel demand of 2,252,658 tonnes per annum. Per capita consumption of charcoal in Nairobi stands at 133 Kg per person per year. Nairobi is however the second least province in terms of biofuel energy demand in the country, even though it ranks highest in processed fuels demand. Biomass used in Nairobi is obtained from other provinces.

Administratively, Nairobi is both a province and a district, with the highest number of SMEs including food catering enterprises, and a high population of people employed and served by them. The high immigration from rural areas has seen the growth in unplanned settlements and kiosks to serve these urban-poor populations who are mainly job-seekers or casual labourers in cities. Given that most of those in formal employment are in the low-wage categories, many of them also depend on food catering enterprises, contributing to their large numbers.

Figure 3.1: Map of Nairobi Showing Study Locations



Nairobi is divided into eight divisions namely Starehe, Kamukunji, Makadara, Langata, Dagoretti, Westlands, Kasarani and Embakasi as indicated in Figure 3.1.

3.3 Study Population

The study population comprised both male and female workers (employees and employers) in food catering enterprises. The target population were the workers in food catering enterprises in Nairobi who met the inclusion criteria.

3.3.1 Inclusion Criteria

1. Workers involved in daily cooking activity
2. Workers who had been at the enterprises for the past six months.
3. Workers who had no chronic cough or allergic respiratory conditions
4. Workers who did not smoke
5. Workers who had experienced symptoms under investigation for one year or more

3.3.2 Exclusion Criteria

1. Workers not involved in daily cooking activity
2. Workers who had been at the enterprises for less than six months
3. Workers with chronic cough and allergic respiratory conditions
4. Smokers
5. Workers who had experienced the symptoms under investigation for less than one year

3.4 Sampling Design and Sample Size

3.4.1 Sampling Design

In this study, workers at the enterprises were the main respondents, while the food catering enterprises were taken as the sampling unit. A combination of cluster sampling and simple random sampling were used. Cluster sampling is suitable where no sampling frame covering the study area exists, and where it is difficult and expensive or impossible for the researcher to develop one (Lutz, 2000). Most food catering enterprises are informal hence no up-to-date records exist on them. Preliminary visits to the relevant government registration and licensing institutions found out that updated records for food kiosks were not available. Nairobi City council also lacked the records.

A pre-survey revealed that food catering enterprises shared similar characteristics under investigation whatever their location. The enterprises were therefore selected randomly. To select the enterprises, a list of all the estates (clusters) in each of the eight divisions of Nairobi was made. One Estate was then picked at random from each Division. From the selected estates, food catering enterprises were conveniently chosen for the study. Equal number of enterprises were selected from each estate.

For respondents, purposive sampling was employed. Purposive sampling was necessary because not all employees in the enterprises met the inclusion criteria. Only those who met the inclusion criteria were studied, with preference being given to owners or managers involved in daily cooking activity.

3.4.2 Sample size

The sample size was arrived at using the formula as used by Fisher and others (Fisher, *et al,* 1998 in Lutz, 2000) as shown below:

$$N = \frac{Z^2pqD}{d^2}$$

Where,

N = the sample size

Z = the standard normal deviate (1.96), which corresponds to 95% confidence interval

p = the proportion of the target population estimated to have a particular characteristic

q = 1 - p

d = the degree of accuracy = 0.05

D (the design effect) = 1

Since no current records exist on food catering enterprises in Nairobi, the study employed findings from a survey by Kituyi, *et al.* (2001), which found that there were 87,500 food catering enterprises in Kenya. Nairobi accounted for 19% of the enterprises; hence the *p* value of 0.19 was employed in determining the number of enterprises to be included in the sample.

$$\text{Thus, } N = \frac{(1.96)^2 \text{ X } 0.19 \text{ X } 0.81}{0.05^2} = 236.39$$

Due to unreliability of the data, the sample size was increased to 250 enterprises to cater for possible changes that may have occurred over time.

In determining the sample size of workers, the study employed the Government of Kenya's categorization of informal enterprises in determining *p* value for sample size estimation, given that there are no records of workers in food catering enterprises. The informal sector in Kenya is classified in five broad categories as shown in Appendix Vi. Food catering enterprises belong in the wholesale & retail, hotels & restaurants category. This category comprised 3,256, 000 employees out of the total 5, 545, 000 employees in the informal sector in 2004 (Republic of Kenya, 2005). This forms 60% of employees in the sector.

Thus, $N = \frac{(1.96)^2 \times 0.6 \times 0.4}{0.05^2} = 368.6 = 367$ respondents.

3.5 Research Instruments

3.5.1 Questionnaire

The study employed a questionnaire shown in Appendix I. Prior to commencement of the study, a field assistant was hired and trained on the basic theory and rigors of the tasks. The questionnaire was pre-tested in 25 enterprises (10% of the sample) in Githurai Estate, Nairobi, which was not a study site. Necessary modifications were then made.

The questionnaire was divided into two major sections. The first section was used to obtain information on demographic profiles of the respondents, enterprise characteristics, types of fuels used and factors governing their choice. A weighing balance was used in measuring fuel quantities. This was tested for validity and reliability during the pre-survey.

The second section was used to obtain information on health outcomes, expressed in terms of respiratory symptoms such as cough, phlegm, breathlessness and wheezing as defined in the Medical Research Council questionnaire for respiratory symptoms, chronic respiratory illnesses such as COPD, asthma, and ALRI which has been used in similar studies. The MRC questionnaire was modified to suit local conditions.

The questionnaires were self-administered by the researcher and her assistant. The owners or managers answered questions relating to fuel types, while the workers engaged in cooking answered the rest of the questions. At some enterprises, the owners also took part in daily cooking activity and therefore responded to all the questions in the questionnaire.

3.5.2 Observation Checklist

This was used to collect background information on characteristics of the enterprises such as construction material and forms of ventilation. A tape measure was used for parameters that required measurements of length for instance size of cooking area, windows and doors. The checklist is presented in Appendix ii.

3.5.3 Interview Schedules

Enterprise owners and managers were interviewed to get in-depth information on issues such as energy technologies used, opinion on fuels used and health problems experienced, challenges faced and potential areas of intervention. Other stakeholders such as the Nairobi City Council and officials in the ministries of labour and health were also interviewed to gauge their opinion on possible interventions in the sector.

3.6 Data Analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) programme version 11.0. Since the collected information was mainly qualitative in nature, it could only allow for a few quantitative analyses. The study therefore mainly employed descriptive statistics such as percentages and Chi-square statistic. Descriptive statistics was applied for independent and intermediate variables. These included background characteristics of respondents, enterprise characteristics, fuel types and prevalence of respiratory health symptoms. Chi-square statistic was used to judge the association between respiratory symptoms such as cough, phlegm, wheezing and breathlessness (dependent variables) and the independent variables. It was also utilised in establishing statistical association between respondents and enterprises characteristics with the health outcomes. The confidence level was set at 5%. Confounding variable such as fuel used at home was treated as independent factor in a separate analysis.

3.7 Challenges Encountered

A few problems were encountered during data collection. Firstly, the respondents were very busy especially during lunch hours when most customers would visit the enterprises. To overcome this, most of the questionnaires were administered either early in the morning or early evening when most of the customers had left and the workers were free to respond to the questions. Secondly, some workers feared admitting that they were experiencing health problems related to fuels used in front of their employers. For instance some were visibly coughing but denied experiencing cough. Own account workers also did not want to admit to health problems relating to their business. The challenge was overcome by interviewing the workers away from their employers, and reassuring enterprise owners that they would not be victimised by the responses they gave. The third challenge was suspicion that the researcher could be from Nairobi City Council and may have them arrested for operating illegally or for failure to adhere to public health standards. Respondents were reassured that the research was for academic purpose by showing them the research permit and letter from Graduate School, Kenyatta University.

3.8 Ethical Considerations

Clearance for conducting the study was obtained from Kenyatta University and Ministry of Education (Appendix Vii). At the enterprises, permission was sought from the owners or managers. Informed consent was obtained from all the study subjects and participation in the study was voluntary. To ensure confidentiality, respondents were not asked to give their names during the study.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Demographic Profile of Respondents

The demographic profiles of respondents assessed in the study included age, sex, level of education, income, fuel used at home and number of hours spent indoors.

4.1.1 Age

Findings from the respondent's background characteristics indicated that the mean age of respondents was 28.6 and the standard deviation was 7.1. The 21-30 years age stratum had the largest proportion (58.5%) of respondents. This could be explained by the fact that the SME sector offers an automatic entry to the young people disregarding issues of education and work experience as Mitullah (1999) also found. The informal sector has also been found to be responsible for absorbing the larger proportion of new entrants into the job market, most of who are usually the youth.

Age Categories	*Number of respondents*	*Percentage*
20 years and below	28	7.6
21- 30 years	216	58.4
31- 40 years	107	28.9
41 and above	19	5.1
Total	370	100.0

n=370

Table 4.1: Age Strata of the Respondents

Even though household studies have related age to duration of exposure, this was not the case in this study as some respondents had been in totally different forms of employment where biofuels were not used. The exception was the 41 and above age group where majority had worked in food catering enterprises for long periods of time. They however formed only 5% of the respondents.

4.1.2 Sex of Respondents

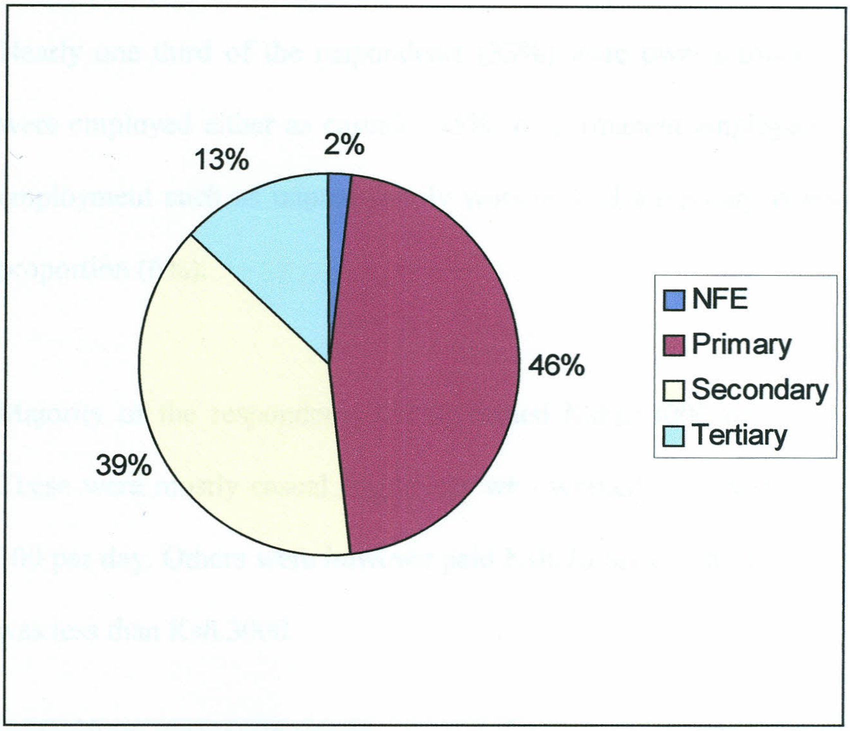
Both sexes were well represented in the sample. There were however more males (56%) than females (44%). This could be attributed to the nature of the business, which entails long working hours which may not be preferred by many women.

Forms of employment could have also contributed to the observed differences. A study by Mitulla (1999) for instance found informal enterprises to be slightly more owned by men (54%) than women (46%).

Unlike households where cooking is mainly done by women, these findings suggest that the same does not apply to food catering enterprises, where both sexes take part in the cooking activity. Therefore both males and females would be equally vulnerable to health problems associated with indoor air pollution from biofuels.

4.1.3 Level of Education

Most (98%) of the respondents had formal education. Those with primary level of education formed the largest proportion (46%), followed by those who had attained secondary level education, who accounted for 39% of the respondents. A few respondents (13%) had tertiary level education (Figure 4.1).



n = 370

Figure 4.1: Highest levels of education attained by respondents

Aside from reflecting what currently exists in the country, the results support findings by Mitullah (1999) who noted the automatic entry of school leavers into the informal sector. In Kenya, it has been observed that the expansion of informal sector is as a result of employment creation not being able to match ever-increasing demand of those seeking employment, most of whom tend to lack tertiary level education (Republic of Kenya, 2005). It has also been noted that the largest number of youth from each level of the educational system will not find a place in the next higher level and will not find a job in the formal sector. In addition, no specialized training is required in food catering enterprises, which could explain the low education levels reported.

4.1.4 Level of Income

Nearly one third of the respondents (33%) were own account workers. The remaining were employed either as casuals (35%) or permanent employees (26%). Other forms of employment such as unpaid family workers and temporary employees formed the least proportion (6%).

Majority of the respondents (67%) earned Kshs. 3000 or less per month (Table 4.2). These were mostly casual employees who worked for seven days a week, earning Ksh. 100 per day. Others were however paid Ksh.70 per day hence their total monthly earning was less than Ksh.3000.

Monthly Earnings (Kshs)	*Number of Respondents*	*Percentage*
Ksh.3000 or less	248	67.0
Ksh.3001-6000	83	22.4
>Ksh.6000	39	10.6
Total	370	100.0

n=370

Table 4.2: Respondents' stratified monthly income

The Ksh. 3001-6000 income stratum comprised of respondents mainly in well established enterprises, either employed as casuals earning between Ksh.150 to Ksh. 200 per day, or permanent employees earning up to Ksh.6000 per month. A few respondents with tertiary education especially in food industry and working in restaurants earned greater than

Ksh.6000 per month. They were however few, accounting for only 10.6% of the respondents.

Household studies have established that income influences fuel choice, whereby as income increases, people tend to consume energy higher up in the energy ladder, which comprises of cleaner processed fuels (Reddy *et al*, 1999). It was not possible to establish this in the current study given that no data were collected on income of the enterprises. However, the income of employees would determine the fuel they use in households, which could impact on their health.

4.1.5 Main Fuel Used at Home

Results in Table 4.3 indicate that kerosene was the main form of fuel used at home by a large proportion (62.4%) of the respondents. This was followed by charcoal, the only biofuel used at home, accounting for 20.3% of the respondents. With the exception of kerosene, only a small proportion (10%) of the respondents used processed fuels. Some respondents (7.3%) used a mixture of fuels in varying quantities hence could not classify any as the main fuel type.

In a study carried out by Keraka and Wamicha (2003) among low-income settlements in Nairobi, kerosene was found to be the major fuel type used, and was associated with high prevalence of respiratory ailments. A survey by the Ministry of Energy (Republic of Kenya, 2002) however found that charcoal was the most preferred fuel for cooking by urban households, with kerosene used mainly in lighting but not cooking. The survey found out that 82% of urban households regularly used charcoal. This inconsistency could be explained by the fact that this study focused on a special group, most of whom worked for 12 hours a day hence would be home for only short periods of time and may prefer a fuel type that is

Main fuel type used at home	*Number of Respondents*	*Percentage*
Kerosene	231	62.4
Charcoal	75	20.3
LPG	32	8.6
Mixture	27	7.3
Electricity	5	1.4
Total	370	100.0

n = 370

Table 4.3: Main fuel types used at home by respondents

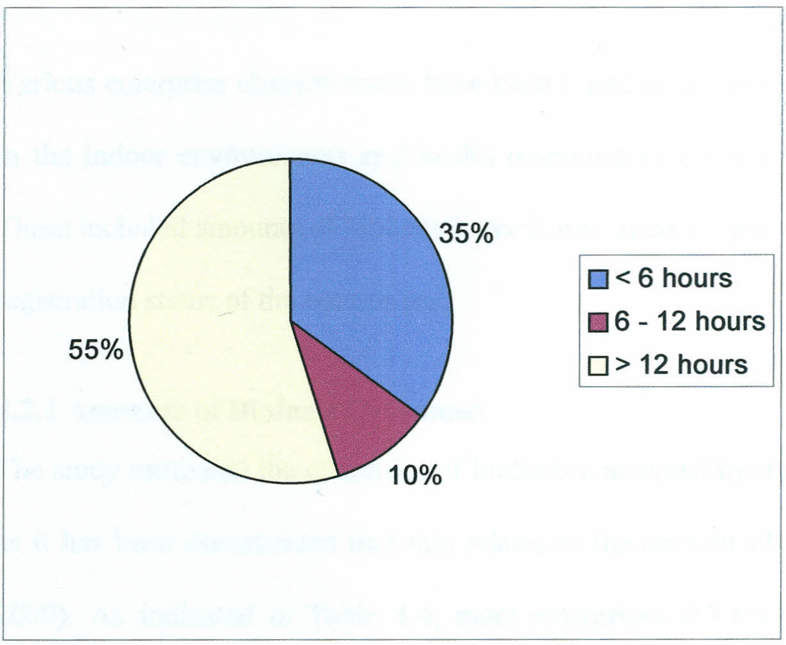
easy to light. This could explain why kerosene was highly preferred, given that it is the cheapest among processed fuels. Some respondents also reported that they carried food home that only required warming hence preferred using kerosene stoves which are easier to light.

Fuelwood was not used for home cooking by any of the respondents. This finding is consistent with previously documented fuel consumption patterns in the country, which indicate that fuelwood is not commonly used by urban households due to the confined living spaces and its smokiness. Nationally, it is used by only 7% of urban households (Republic of Kenya, 2002).

Unlike charcoal, which has undergone some form of processing, fuelwood releases high quantities of PM_{10} when burned, which affects respiratory health (Ezzati, *et al*, 2001a). Given that none of the respondents used fuelwood at home, recorded exposures and health outcomes in this study could therefore be more accounted for in the occupational rather than home environment, thereby reducing the bias of exposure to PM_{10} in the home environment.

Most of the respondents were low-income earners, judging by their education status and form of employment. Casual employees were paid a meagre Ksh.100 per day in 90% of the enterprises. This would explain why only a few respondents used LPG and electricity, which are costly and very high on the energy ladder.

4.1.6 Number of Hours Spent in Cooking Area



(n = 370)
Figure 4.2: Number of hours spent in cooking area

Over half (55%) of the respondents spent less than six hours a day in the cooking area (Figure 4.2). Those who spent 6-12 hours (35%) came second, followed by 10% who spent more than 12 hours per day in the kitchen. The mean was 6.3 hours, with a standard deviation of 3.2.

The study indicates that 45% of workers in food catering enterprises spend 6 hours or more in the kitchens for six days in a week. This is much more compared to those who cook in households, who were found to spend between 3 to 4 hours per day while cooking is underway (Shrestha, *et al*, 2005). Given that the number of hours spent in the kitchen has been found to influence respiratory health outcomes in households, the longer hours spent in the kitchen by workers in food catering enterprises could translate into higher prevalence of respiratory health outcomes among them.

4.2 Enterprise Characteristics

Various enterprise characteristics have been found to relate to concentration of pollutants in the indoor environments and health outcomes hence were investigated in the study. These included amounts of biofuels burned, size of cooking area, forms of ventilation and registration status of the enterprises.

4.2.1 Amounts of Biofuels Consumed

The study estimated the quantities of biofuels consumed by the food catering enterprises, as it has been documented that this relates to the amount of pollutants emitted (Kituyi, 2000). As indicated in Table 4.4, most enterprises (63.8%) used less than 300Kg of charcoal per month. This was followed by 24.8% who used between 300 and 600Kg per month. Only 11.4% of the enterprises were using above 600Kg of charcoal per month, which ranged up to 2000 Kg in some enterprises. The mean consumption of charcoal was 338.2 Kg per month.

Amount of Charcoal Used Per Month	*Number of respondents*	*Percentage*
1 - 300Kg	139	63.8
301 - 600Kg	54	24.8
>600Kg	25	11.4
Total	218	100.0

n = 218

Table 4.4 Distribution of Respondents by Amount of Charcoal Consumed

Fuel wood was mainly consumed in the range of 400-800Kg per month by 39.7% of the respondents as shown in Table 4.5. This was followed by the 400Kg and below category, which accounted for 26.5%. The rest consumed 801-1200Kg per month (17.6%) and above 1200Kg (16.2%). The mean consumption of fuelwood was 592.7 Kg per month, with a standard deviation of 404.8. The amounts of sawdust consumed were however not estimated, as only 14 respondents (3.5%) reported using it as a main fuel type.

Amount of fuelwood used per month	*Number of respondents*	*Percentage*
400 Kg and below	18	26.5
400 - 800 Kg	27	39.7
801 - 1200 Kg	12	17.6
Above 1200 Kg	11	16.2
Total	68	100.0

n = 68

Table 4.5: Distribution of Respondents by Amount of Fuelwood Consumed

These findings are consistent with previous studies that have been done on biofuel consumption in the informal sector. According to the Ministry of Energy survey on energy uses by SMEs conducted in 2000 (Republic of Kenya, 2002), food catering enterprises emerged as the highest consumer of energy among all SMEs under the cottage and service sector category. They were found to consume 1.2 million tons of fuelwood and 0.4 million tons of charcoal annually.

Various studies have been done to quantify the concentrations of pollutants in indoor environments where biofuels are used (Ezzati, *et al*, 2000; Shrestha, *et al*, 2005). Even though it was not possible to measure concentration levels of pollutants in this study, the large quantities of biofuels consumed by food catering enterprises could imply high levels of indoor air pollution, which could greatly compromise the health of workers in these enterprises.

4.2.2 Size of Cooking Area

Most of the kitchens were very small, with a mean size of $4.8m^2$ and a standard deviation of 2.3. About one third (31.6%) of the enterprises had kitchens with an area of $3m^2$ or less, and formed the majority. Only 14.4% of the enterprises had kitchens whose areas were greater than $7m^2$ as shown in Table 4.6.

This has health implications, as the small rooms could imply that pollutants are highly concentrated and not well dispersed, hence large quantities can be inhaled compared to if the room was larger providing better ventilation. The small kitchen size also imply workers are very close to the fire whenever they are in the kitchen. Proximity to the open fires has been associated with very high exposure levels (Ezzati, *et al*, 2000).

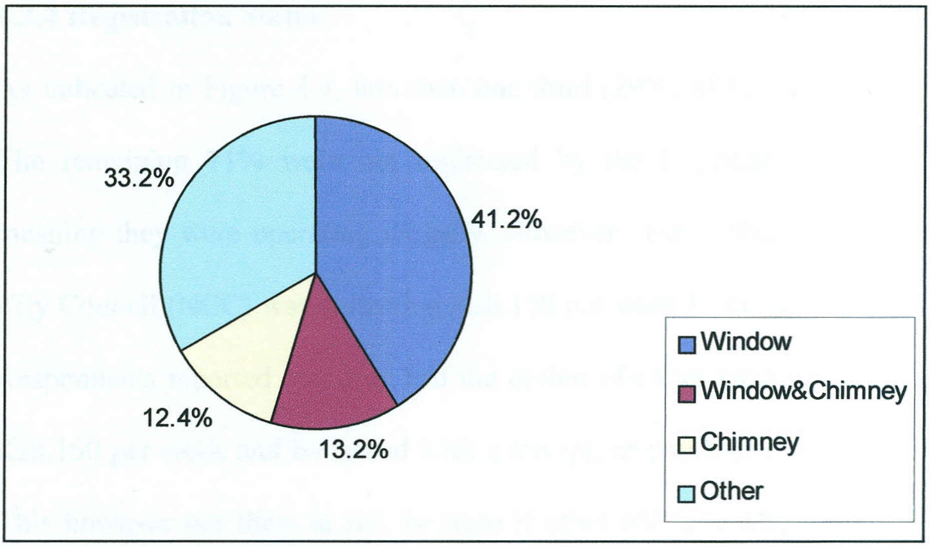
Size of Cooking Area (Metres^2)	*Number of Respondents*	*Percentage*
< 3M^2	79	31.6
3.1 - 4 M^2	41	16.4
4.1 - 5 M^2	24	9.6
5.1 - 6 M^2	40	16.0
6.1- 7 M^2	30	12.0
>7 M^2	36	14.4
Total	250	100.0

n = 250
Table 4.6: Size of cooking area

4.2.3 Forms of Ventilation

Most enterprises had windows or chimneys as forms of ventilation, accounting for about two thirds of the respondents. Enterprises that had windows as the main form of ventilation accounted for majority of the respondents (41.1%), while those with chimneys accounted for 12.4% as shown in Figure 4.3. Others had both chimneys and windows, accounting for 13.2% of the respondents.

Nearly one third of the respondents (33.2%) however worked in enterprises that had neither windows nor chimneys, but other forms of ventilation. These ranged from large open spaces on the roof or wall to very tiny holes on the upper part of the walls that would hardly let out smoke from the kitchens. Some enterprises consisted of space with wire-mesh surrounding the entire wall of the kiosk. These were however in areas where customers were served, not in the kitchens. The poor ventilation in these enterprises would therefore imply higher prevalence of health outcomes to due to high residence time of pollutants in the indoor environments, leading to high exposure levels. The enterprises were visibly smoky, with walls covered in soot. Respondents in these enterprises were coughing during the interviews, and complained of a range of respiratory health problems.



n = 250

Figure 4.3: Main forms of ventilation in food catering enterprises

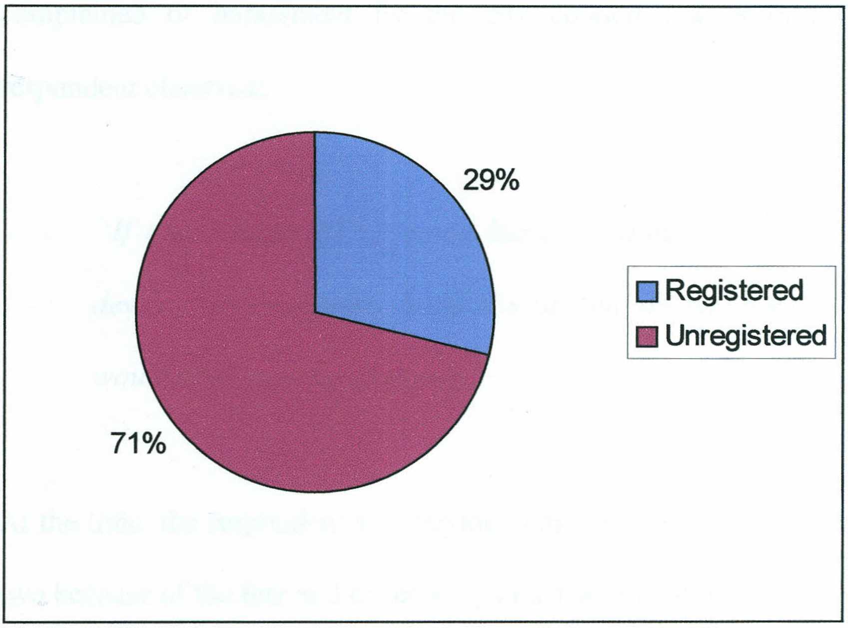
When asked why they did not have adequate ventilation, the kiosk owners explained they would not make much investments in their structures because they were temporary and could be demolished any time. Otherwise *jua kali* chimneys were easily available which the enterprises could fit in their structures were there no threats of eviction. Lack of registration however does not explain the small size of the windows or open spaces for letting out smoke. It could imply lack of awareness of the risks associated with biofuel use in poorly ventilated environments.

Chimneys are able to accumulate the fumes and release it outdoors, hence lowering the concentration of pollutants indoors. Some of the chimneys were fitted in with fans to further improve on ventilation.

4.2.4 Registration Status

As indicated in Figure 4.4, less than one third (29%) of the enterprises were registered. The remaining 71% were not registered by the Registrar of Companies of Kenya, meaning they were operating illegally. However despite their illegal status, the Nairobi City Council (NCC) was collecting Ksh.150 per week from the enterprises as license fee. Respondents reported that they had the option of either paying Ksh.75 twice a week, or Ksh.150 per week and be issued with a receipt, or pay Ksh.100 and no receipt is issued. This however put them at risk because if other officials who didn't receive the money came they would have to pay again.

There was also a cheaper option of paying Ksh.3000 biannually, or an annual license fee of Ksh.6000. However, it was the larger enterprises that would afford this, unlike the small ones who said they did not earn enough to pay the Ksh.3000 or Ksh.6000 in advance. This is a loss to the enterprises that needs to be addressed. Given that income is one of the factors determining fuel choices, any savings the enterprises make may translate to health benefits as it may enable them to purchase cleaner fuels or make other investments that would lead to improved health status.



n = 250
Figure 4.4: Registration status of food catering enterprises

Most of the respondents in the unregistered enterprises believed that their enterprises were officially allowed to operate; otherwise the NCC would not be collecting money from them. They were unable to distinguish between the operating license and registration, therefore failed to understand why the City Council law enforcement staff were constantly harassing them yet they were remitting the required fees.

The study also found out that the activities of the NCC were uncoordinated, and they would send public health officials as well as licensing officers to the enterprises who would arrest the owners and employees and confiscate their property. Enterprise owners interpreted this as harassment, because they could not distinguish between the public health officers and licensing officers, or what purpose they served. Unlike their counterparts in registered enterprises who reported that their major challenges were lack of customers and increased cost of food and fuel, owners of unregistered enterprises complained of harassment by the city council law enforcement officers. As one respondent observed:

> *"If only 'kanjo'(NCC) could leave us alone, life would be so good. I would develop my enterprise, build it well, buy all the material I need in bulk which would save me a lot of money."*

At the time, the respondent was buying items in small quantities that would last a day or two because of the fear and uncertainty under which he was operating.

Even though most of the informal enterprises may not afford to use processed fuel, they could use less polluting biofuels such as charcoal as opposed to fuelwood, which is very damaging to health. Charcoal is cheaper when bought in bulk. Registered enterprises for instance reported buying a bag of charcoal at between Ksh.350 and Ksh.450. Unregistered enterprises on the other hand would buy charcoal in tins, costing between Kshs 20 to Kshs 30 depending on the location and size of tin. This translates to about Kshs 800 to 1200 per bag, which is more than twice the amount spent by registered enterprises. Some therefore found charcoal to be unaffordable and resorted to fuelwood and sawdust. Others also reported that they could not invest in expensive appliances such as gas cylinders and cookers as these would be targeted by NCC officials.

Lack of registration has been observed to be a common feature of most informal enterprises (Karakezi, 1999). The main legal feature of the informal sector businesses in most African countries is that they are neither registered with the Registrar of Companies nor are they in most cases recorded in official or tax records. Their operators may or may not have licences from the relevant authorities. The level of organisation is generally low with little access to organised markets, formal credit, education and training. These features were confirmed during this study.

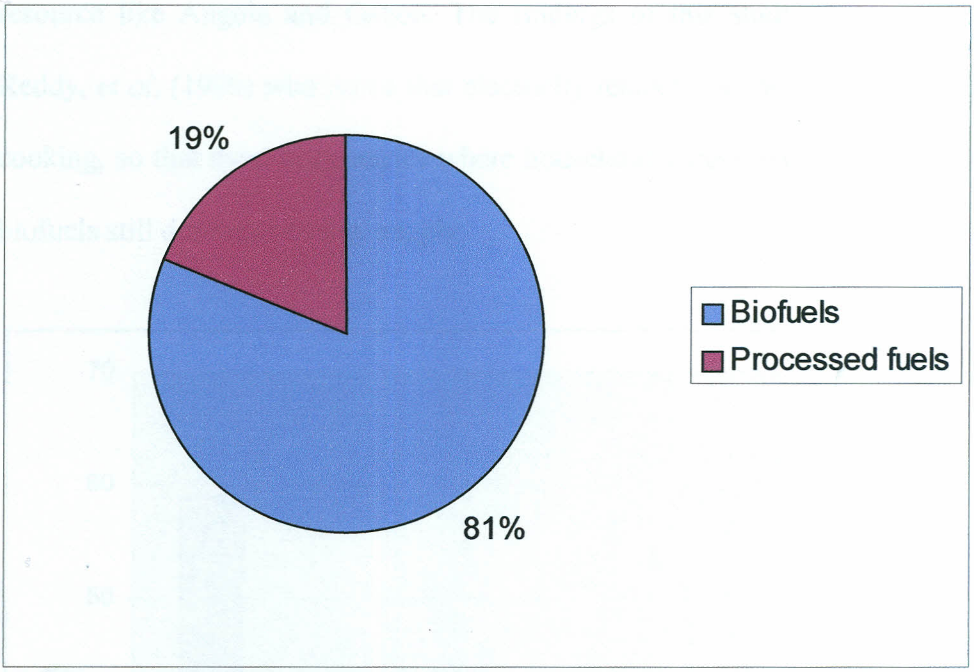
Registration status of enterprises has an influence on various exposure factors which determine respiratory health outcomes. According to the Government of Kenya (Republic of Kenya, 2005), majority of informal sector enterprises in Kenya rely on unprocessed biofuels and waste oils for energy, which can lead to a wide range of occupational and health hazards as well as compounding the existing urban energy related environmental problems such as ambient air pollution. Furthermore, before a certificate of registration is issued, premises are usually inspected to ensure they comply with the required health standards including ventilation, lighting and adequate space amongst others. These could be associated with positive health benefits to the workers.

4.3 Types of Fuels Used by Food Catering Enterprises

4.3.1 Fuel Types

When classified on the basis of binary fuel types, most enterprises (81%) reported using biofuels, whereas processed fuels accounted for only 19% (Figure 4.5). Other studies have found biofuels to be the most common energy source in Kenya, contributing 97% of total energy used at household and cottage industry level (Republic of Kenya, 2002;

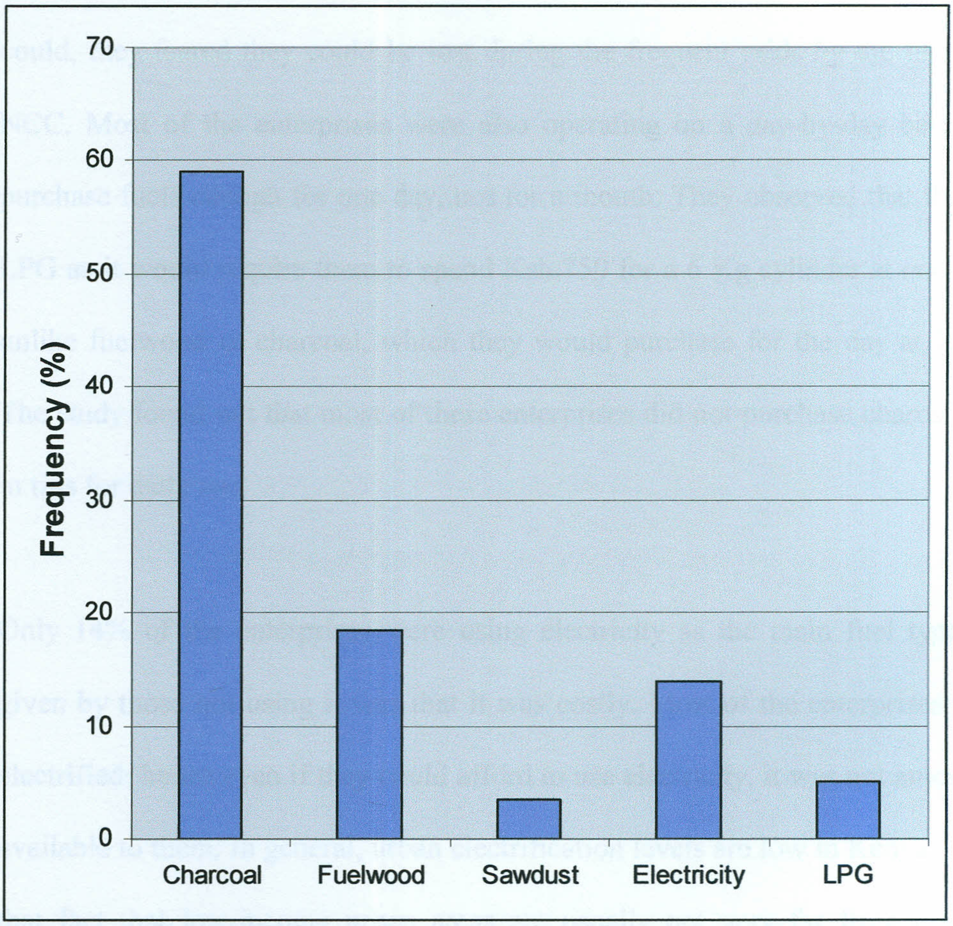
Kituyi, 2000). At the national level, biomass represents 83% of all energy types used in all sectors.



n = 250
Figure 4.5: Binary classification of fuels used by food catering enterprises

As shown in Figure 4.6 below, charcoal was the most utilised fuel type (58.9%), followed by fuelwood (18.6%) and electricity (14.1%). Liquefied Petroleum Gas came fourth, accounting for 4.9% of the respondents, followed by sawdust (3.5%). No enterprise reported using kerosene as a main fuel type. Charcoal was the most preferred biofuel. Even though many enterprises used fuelwood and sawdust, they were utilised as substitute fuels rather than main forms of fuel. Similarly, kerosene was used as a substitute fuel.

Apart from the studies done in Kenya, these findings reflect the situation in sub-Saharan Africa. For instance, Goldemberg, *et al*, (2000) observes that biofuels dominate national energy supplies in sub-Saharan Africa, even in countries with significant fossil fuel resource like Angola and Gabon. The findings of this study also support findings of Reddy, *et al*, (1999) who noted that electricity tends to be the most expensive option for cooking, so that even in countries where household access exceeds the regional average, biofuels still dominate energy supply.



n = 250

Figure 4.6 Fuel types mainly used by food catering enterprises

4.3.2 General Factors Governing Fuel Choice

According to Reddy, *et al*, (2000), the main factors that determine energy choices at the household level are accessibility, income, convenience and relative costs (including cost of appliances). The same factors were found to apply to food catering enterprises.

The major governing factor for fuel choice was found to be cost. Respondents who used biofuels reported that they were cheaper compared to processed fuels. Aside from the high cost, respondents observed that they would also require expensive appliances such as gas cylinders and cookers, which most of them could not afford, and even if they could, they feared they could be lost during the frequent raids by the officials from the NCC. Most of the enterprises were also operating on a day-by-day basis, thus would purchase fuels enough for one day, not for a month. They observed that they did not use LPG as it would require them to spend Ksh.750 for a 6 Kg cylinder at one point in time, unlike fuelwood or charcoal, which they would purchase for the day at Ksh.60 or less. The study found out that most of these enterprises did not purchase charcoal in sacks but in tins for daily use.

Only 14% of the enterprises were using electricity as the main fuel type. The reason given by those not using it was that it was costly. Most of the enterprises were also not electrified; hence even if they could afford to use electricity, it was not among the options available to them. In general, urban electrification levels are low in Kenya. This is despite that fact that low-income urban areas are usually not very far from major electricity transmission and switching stations. However, even with access to electricity, it tends to be the most expensive option for cooking, so that even in countries where household access exceeds the regional average, biomass fuels still dominate energy supply (Reddy, *et al*, 2000).

Enterprises that used processed fuels also complained of the high costs. Electricity, they observed, had high tariffs which were further loaded with levies they did not understand. There were also constant power interruptions, which would force them to switch to gas or biofuels. Of the two forms of processed fuels used, each side reported that the one they were using was cheaper. The governing factor for processed fuel use was cost and convenience. Majority of the processed fuel users (41%) said convenience was the decisive factor, 30% believed it was cheapest option while the remaining 29% reported that they had weighed both the issue of convenience and cost. Health benefit was considered as part of the convenience.

Among the biofuels users, those who used charcoal reported that it produced less smoke hence was more convenient to use indoors compared to other forms of biofuels. Fuelwood and sawdust users reported that cost was the determining factor. Otherwise 49.5% of fuelwood users observed that they would have preferred charcoal as their enterprises were smoky, which was inconveniencing their customers as well. Between fuelwood and sawdust, respondents were split on which was cheaper or less smoky.

The study found that there were inconsistencies when it came to ratings of fuel costs, with varied opinions on which fuel is cheaper. The confusion also exists in the wider energy sector, with contradictions among various sources. For instance, others have adopted the approach by the World Energy Council (2000) whereby energy costs have been computed by taking into account different energy uses as well as the appliances used. Based on the cost of useful energy per unit Mega Joule (MJ) delivered to the pot and the appliances used, crop residue has been found to be the cheapest, followed by fuelwood, charcoal, kerosene, LPG and electricity.

However, according to Reddy, et al, (1999), over time, the cost of using cleaner fuels is not necessarily higher, and it is poverty that prevents people from taking advantage of this fact. The reason is that poor families have very limited financial assets and generally find it difficult to invest money 'up-front' to obtain the appliances needed for burning kerosene cleanly (with pressurized stoves), for gas or electricity, or to buy the fuel in sufficient quantity to benefit from lower unit prices. High costs are incurred due to purchase of small quantities at a time due to the low income. The study found out that the same applied to food catering enterprises.

Other studies have associated biofuels with low energy content per unit of input. For example, according to Liefman (1991), 1Kg of charcoal would produce a lot less energy compared to the equivalent quantity of LPG. Among the biofuels, other authors have also reported that charcoal is cheaper than fuelwood as it has twice the calorific value per unit weight of wood (Karakezi, 1999). Given that cost is a major determinant of fuel choice, this poses difficulty when it comes to proposing interventions such as fuel switch in the sector, and this contradictions need to be ironed out.

The study also found out that there were misconceptions on health risks associated with various forms of fuels. When asked which fuel they thought would greatly affect health, respondents were almost equally distributed in attaching health risks to biofuels, with 28.5% reporting that charcoal was the most harmful as it produces poisonous gases, 30% attributing highest risk to fuelwood because its smoky, while 30.5% reported that sawdust posed the most risk. A few respondents (11%) reported kerosene to be the worst, with one respondent observing that *'fuelwood may be smoky, but it produces harmless smoke, unlike smoke from kerosene'*. All respondents felt that electricity and gas would not harm their health, though they reported fear of accidents such as electrocution and gas explosion.

Findings of this study suggest that there is lack of awareness on health impact associated with fuel use, and what one believes is safe, the other believes is harmful. There should be education therefore, so that as people weigh between issues of cost and convenience, health can also be paramount. Other studies have found charcoal to be less harmful, yet 28.5 % of the respondents would avoid it and use fuelwood or sawdust instead in the belief that they are protecting their health.

The findings also suggest that there are several factors that govern fuel choice for food catering enterprises, with cost being paramount. Awareness of the negative health consequences of biofuel use is therefore not enough to make people switch from biofuels to processed fuels. A shift from biofuels to processed fuels may therefore not be very easy unless measures are put in place that makes processed fuels and their appliances more affordable, and unless they can be sold in smaller units. The more immediate interventions should hence be targeted at making the biofuels safer, with less resultant health problems.

4.3.3 Relationship Between Respondents' Demographic Profiles and Fuel Choice

The demographic profiles of respondents (enterprise owners and managers) assessed included age, sex, level of education and type of fuel used at home. These would be important to consider when coming up with intervention.

Age and sex did not significantly influence fuel choice, as respondents of all age categories and both sexes were nearly equally distributed between the two forms of fuels. The findings suggest that age may not be a factor when coming up with interventions regarding choice of fuels and consequently health outcomes; hence similar measures can be applied to all age categories. The same argument may apply to sex which was also found not to influence fuel choice, as nearly equal proportions of both males and females were found in enterprises using biofuels and processed fuels.

Education level was however found to significantly influence fuel choice (χ^2= 23.6; df=3; p=0.000), whereby a high proportion of respondents with primary level education were found in enterprises using biofuels compared to respondents with tertiary level education. For instance, over half of the respondents with primary education (50.3%) worked in enterprises where biofuels are used. The corresponding figures for respondents with secondary and tertiary level education were 36.7% and 10.3% respectively as shown in Table 4.7. All respondents with non-formal education were also found in enterprises using biofuels. The findings could imply that enterprise owners who are well educated are aware of health consequences associated with biofuel use hence chose to use processed fuels unlike their counterparts with lower levels of education.

Highest Level of Education Attained	***Distribution of respondents by Fuel Type Mostly Used in Enterprise***		***Total***
	Biofuels	Processed fuels	
Primary	151 (50.3%)	19 (27.1%)	170 (45.9%)
Secondary	110 (36.7%)	34 (48.6%)	144 (38.9%)
Tertiary	31 (10.3%)	17 (24.3%)	48 (13.0%)
No formal education	8 (2.7%)	0	8 (2.2%)
Total	300 (100%)	70 (100%)	370 (100.0%)

n = 362

Table 4.7: Level of education and fuel types used in enterprises

Income was also found to significantly influence fuel choice (χ^2=15.5; df=3; p=0.001), with more high-income earners using processed fuels compared those earning lower incomes (Table 4.8). For instance, 59% of respondents earning Ksh.6000 and above per

Fuel Type	***Distribution of respondents by Monthly Earnings***			***Total***
	<Ksh.3000	Ksh.3000-6000	>Ksh.6000	
Biofuels	217(87.5%)	67(80.7%)	16(41.0%)	300(81%)
Processed fuels	31(12.5%)	16(19.3%)	23(59.0%)	70(19%)
Total	248(100.0%)	83(100.0%)	39(100.0%)	370(100.0%)

n = 370

Table 4.8: Level of income and fuel types used in enterprises

month were found to be working in enterprises using processed fuels. The corresponding figure for those earning less than Ksh.3000 per month was 12.5%. Even though income of respondents was not assessed, owners of enterprises tended to pay employees based on the overall earnings of the enterprise.

It has been hypothesized that with increasing income, there is generally a transition up the so-called 'energy-ladder' to fuels which are progressively more efficient, cleaner, convenient and expensive (Reddy, *et al*, 1999). This would explain why high income earners were found in enterprises using processed fuels.

The study also related fuel used in enterprises and fuel used at home by respondents as shown in Table 4.9.

Main Fuel Used at Home	***Distribution of respondents by Fuel Type Mostly Used in Enterprise***		***Total***
	Biofuels	Processed fuels	
Charcoal	71 (87.7%)	10 (12.3%)	75 (100.0%)
Electricity	3 (60.0%)	2 (40.0%)	5 (100.0%)
LPG	22 (62.9%)	13 (37.1%)	32 (100.0%)
Kerosene	188 (78.7%)	51 (21.3%)	231 (100.0%)
Mixture	7 (87.5%)	1 (12.5%)	27 (100.0%)
TOTAL	300 (81%)	70 (19%)	370 (100.0%)

n = 370

Table 4.9: Type of fuel used at home and at the enterprise

A high proportion of respondents who used charcoal (biofuel) at home were found to also work in enterprises using biofuels, while a large percentage of those using electricity and LPG at home were found to work in enterprises using processed fuels. For instance, 87.7% of respondents using charcoal at home worked in enterprises using biofuels. The corresponding figures for Electricity and LPG were 60% and 62.9% respectively. Similarly, while only 12.3% of respondents using charcoal at home worked in enterprises using processed fuels, the corresponding figures for electricity and LPG users were 40% and 37.1% respectively, which was found to be significant (χ^2= 0.032; df=5; p=0.000). Kerosene users were the exception, with majority (78.7%) working in enterprises using biofuels.

For respondents using biofuels at home and at the workplace, the risks of experiencing respiratory symptoms could be higher due to exposure at work and at home. On the other hand, those using processed fuels at home and in the workplace would be facing no threat of exposure to pollutants from biofuels, and are expected to have the least symptoms.

4.3.4 Relationship Between Enterprise Characteristics and Fuel Choice

Poorly ventilated enterprises were found to predominantly use biofuels compared to well ventilated enterprises which used mainly processed fuels. For instance, 37% of enterprises with other forms of ventilation were using biofuels, with only 17.1% using processed fuels. On the other hand, 27.1% of enterprises with chimney and windows were using processed fuels, and only 10% used biofuels (Table 4.10). It is documented that use of biofuels in poorly ventilated enterprises is a major health threat, implying greater vulnerability to workers in these enterprises.

Forms of Ventilation	*Distribution of Respondents by Fuel Type Mostly Used in Enterprise*		*Total*
	Biofuels	Processed fuels	
Chimney	26 (8.7%)	20 (28.6%)	46 (12.4%)
Window	133 (44.3%)	19 (27.1%)	152 (41.2%)
Chimney&Window	30 (10.0%)	19 (27.1%)	49 (13.2%)
Other	111 (37.0%)	12 (17.1%)	123 (33.2%)
Total	300 (100.0%)	70 (100.0%)	370 (100.0%)

n = 370

Table 4.10: Forms of ventilation and fuel types used in enterprises

Majority of unregistered enterprises (76.3%) were also found to use unprocessed fuels compared to only 23.7% of the registered enterprises (Table 4.11). Given that most of these enterprises were also small in size, poorly ventilated and did not adhere to public health standards, use of biofuels in them could translate into higher prevalence of symptoms to workers in these enterprises compared to those in registered enterprises.

Registration Status of Enterprise	*Distribution of Respondents by Fuel Type Mostly Used in Enterprise*		*Total*
	Biofuels	Processed fuels	
Registered	71(23.7%)	36(51.4%)	107(29.0%)
Unregistered	229(76.3%)	34(48.6%)	263(71.0%)
Total	300(100.0%)	70(100.0%)	370(100.0%)

n = 370

Table 4.11: Registration status and fuel types used in enterprises

4.4 Prevalence of Respiratory Health Symptoms

Nearly half (49%) of the respondents reported having one form of respiratory symptom or another. The remaining 51% reported that they did not experience any of the listed symptoms. Other respondents had more than one symptom (16.5%), while a few (4%) reported experiencing all the symptoms under investigation.

As shown in Table 4.12, the most experienced symptom was cough, which was reported by 42% of the study population, and 86% of respondents with symptoms. Cough tends to be the first indication of irritation of the respiratory tract. This would explain why it had the highest prevalence. The remaining symptoms were however reported by less than one fifth of respondents. The leading amongst them was breathlessness (18%) followed by wheezing (15%), with phlegm being the least experienced symptom (14.5%).

Respiratory Symptoms	***Number of responses (%*)***		***TOTAL***
	Yes	***No***	
Cough	155(42.0%)	215(58.0%)	370(100.0%)
Phlegm	54(14.5%)	316(85.5%)	370(100.0%)
Breathlessness	67(18.0%)	303(82.0%)	370(100.0%)
Wheezing	56(15.0%)	314(85.0%)	370(100.0%)
All symptoms	15(4.0%)	355(96.0%)	370(100.0%)

* Multiple responses allowed

n = 370

Table 4.12: Distribution of respondents by respiratory symptoms

Presence of these respiratory symptoms over a long period of time are indicative of respiratory health ailments, and in studies where it is not possible to ascertain the presence of respiratory diseases, they have been employed (Ezzati and Kammen, 2001). In this study, only respondents who had experienced respiratory health symptoms for one year and above were classified as symptomatic. The analysis however did not go into the difference in prevalence amongst the symptoms, but rather assessed all the symptoms in relation to dependent variables that could have influenced their outcomes.

4.5 Factors Influencing Respiratory Health Outcomes

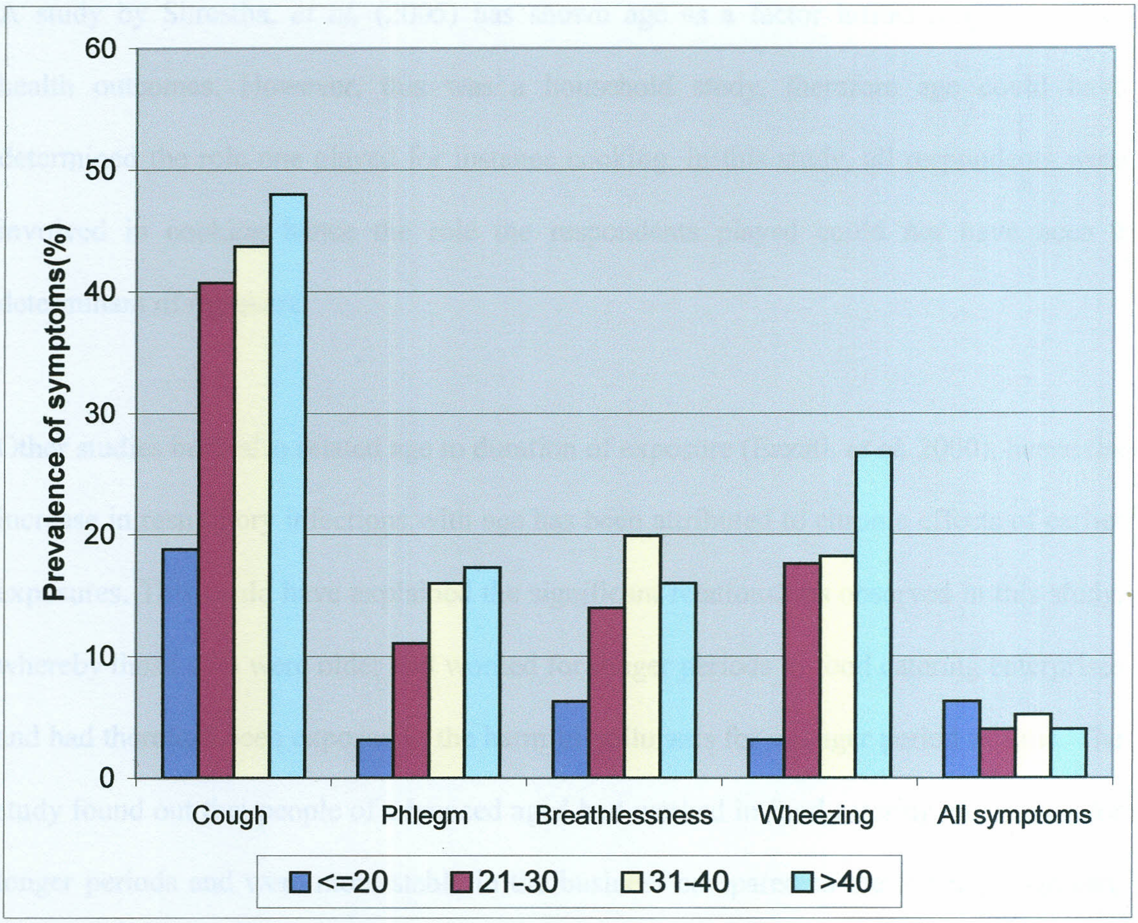
The study assessed the influence of demographic profiles of respondents, enterprise characteristics and fuel types on respiratory health outcomes.

4.5.1 Influence of Demographic Profiles of Respondents

The demographic profiles assessed included sex, age, education levels, income and fuel used at home.

4.5.1.1 Influence of Age

As shown in Figure 4.7, there was a higher prevalence of most respiratory health symptoms with increase in age. The only exception was breathlessness, which was highest in the 31-40 age category. The 20 years and below age strata had the highest proportion (6%) of respondents experiencing all symptoms even though the difference with the other age categories was negligible.



n = 370

Figure 4.7: Distribution of respondents by symptoms and age

Computation of chi-square statistic revealed statistical associations between two respiratory health outcomes and age, with the prevalence of symptoms being higher in respondents aged 40 years and above compared to respondents aged 20 years and below. The computed *p* values were significant at 5% for cough (χ^2=13.04; df=5; *p*=0.023) and wheezing (χ^2=6.16; df=1; *p*=0.047). For the remaining health outcomes however, no significant relationships were established.

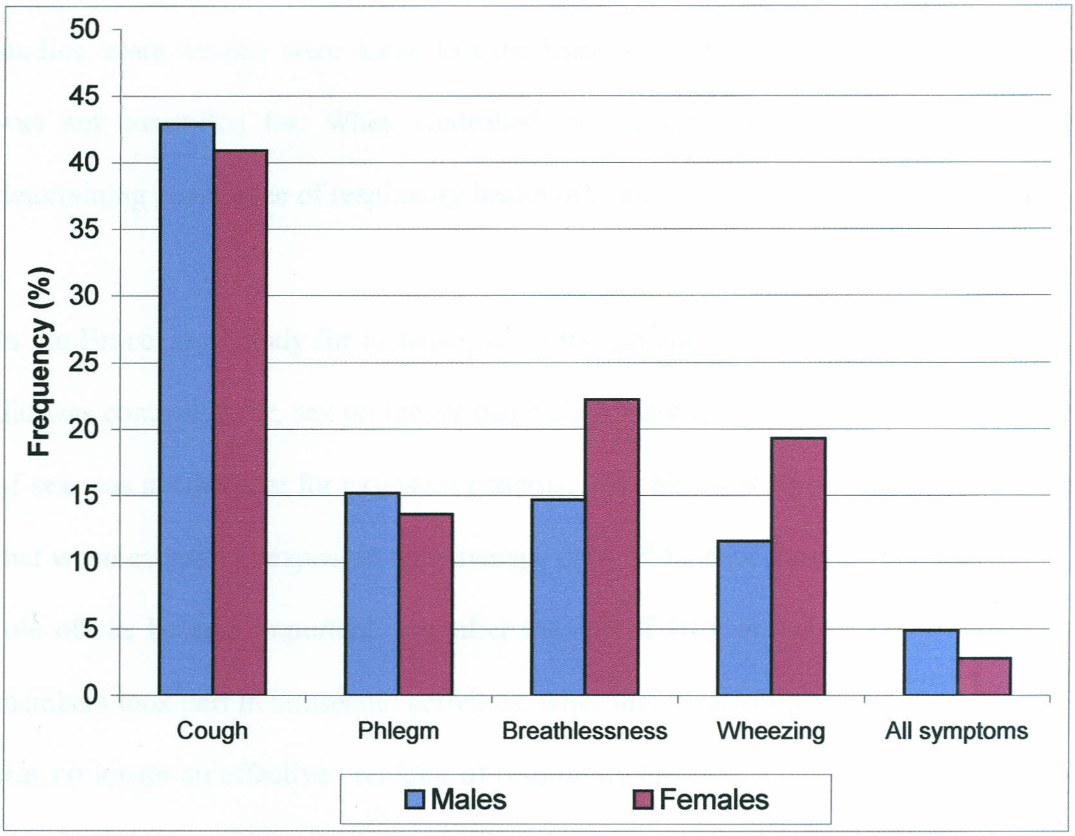
A study by Shrestha, *et al,* (2005) has shown age as a factor influencing respiratory health outcomes. However, this was a household study, therefore age could have determined the role one played for instance cooking. In this study, all respondents were involved in cooking hence the role the respondents played could not have been a determinant of exposure.

Other studies have also related age to duration of exposure (Ezzati, *et al,* 2000), hence the increase in respiratory infections with age has been attributed to chronic effects of earlier exposures. This could have explained the significant relationships observed in this study, whereby those who were older had worked for longer periods in food catering enterprises and had therefore been exposed to the harmful pollutants for a longer period of time. The study found out that people of advanced aged had worked in food catering enterprises for longer periods and were more stable in the business compared to the lower age-groups, majority of whom were new entrants in the sector hence had not experienced long term exposure.

4.5.1.2 Influence of Sex

Figure 4.8 shows the frequency distribution of respondents by respiratory symptoms and gender. More (19.3%) women reported wheezing compared to men (14.7%). The difference was found to be significant (χ^2=4; df=1; p=0.046). More women (22.2%) further reported having experienced breathlessness compared to men (11.6%).

However, for the remaining symptoms, there were higher prevalence in men than in women, with 42.9% of men reporting cough compared to 40.9% women, and 15.2% of men reporting phlegm compared to 13.6% women. Those who reported experiencing all symptoms also comprised of more men (4.9%) than women (4.2%). These differences were however negligible.



n = 370

Figure 4.8: Distribution of respondents by symptoms and gender

These findings are inconsistent with previous household studies. For instance, the results of a study by Ezzati and Kammen (2001a) in Central Kenya showed that women were twice as likely to be diagnosed with ARI or ALRI than men. Other studies by Wafula, *et al*. (2000), Mohammed, *et al,* (1995) and Bruce, *et al,* (2000) also obtained similar results.

This inconsistency could be explained by the fact that in this study, both men and women took part in the daily cooking activity, hence were equally exposed to pollutants arising from biofuel use. This is unlike the households where it is mostly women who take part in the daily cooking activity. This is supported by the fact that in the above mentioned studies, more women were found to experience the symptoms when time spent indoors was not controlled for. When controlled for, gender was found not to be a factor determining prevalence of respiratory health outcomes.

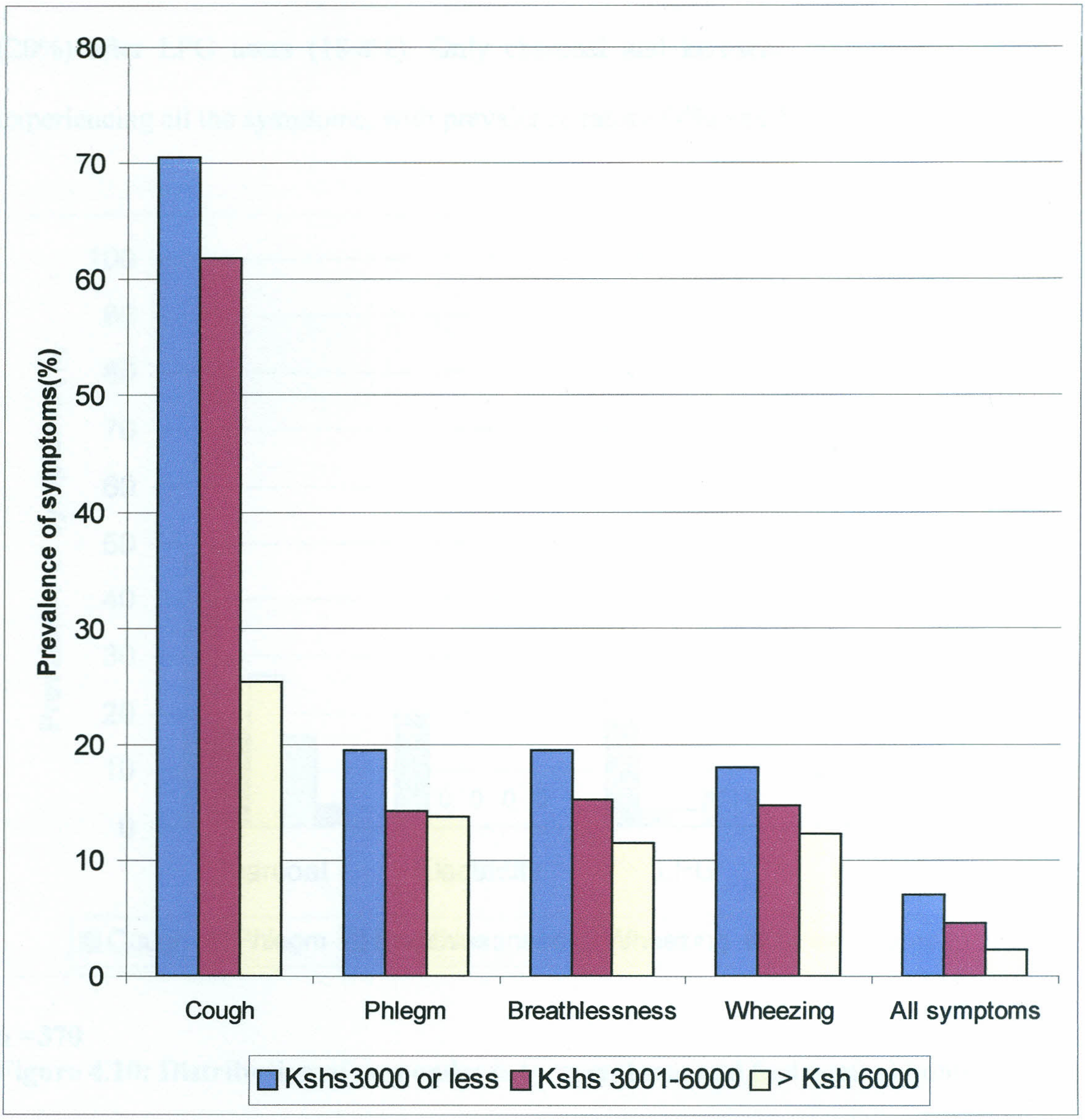
In the Bruce, *et al* study for instance, when the amount of cooking activity that a person did was controlled for, sex no longer had a significant influence, confirming that the role of sex was a substitute for exposure patterns. This bias was further confirmed by noting that when estimating exposure with average daily PM_{10} concentration and time alone, the role of sex became important only after the age of 10 years when many female family members took part in household activities. After inclusion of high-intensity exposure, sex was no longer an effective predictor of respiratory health outcome. However, there could have been a proportion of women who cooked both at work and at home using biofuels, and this could explain the variations observed in wheezing and breathlessness that were experienced by more women than men.

The results of this study therefore suggest that it is not just women and children who are vulnerable to effects of indoor air pollution from biofuels as has been previously documented, but equally men who work in food catering enterprises. Intervention measures should therefore be equally targeted at them. The findings further imply that the results of household studies cannot be applied to occupational environments, as the conditions that determine exposure in households are different from those that determine exposure in occupational environments.

4.5.1.3 Influence of Income Levels

Income levels of respondents were found to influence respiratory health outcomes, with respondents earning Kshs. 3000 or less reporting the highest prevalence of all symptoms, followed by respondents earning between Ksh. 3001-6000. Respondents earning above Ksh. 6000 per month had the least prevalence of symptoms. For instance, prevalence of cough was 70.5% in respondents earning Ksh. 3000 or less per month. The corresponding figure for those earning above Ksh. 6000 per month was only 25.4% as shown in Figure 4.9.

These findings could be attributed to the fact that income determines fuel choice, as has been shown by previous studies (Reddy, *et al*, 2000). As people's income increases, they tend to use cleaner fuels that have less health consequences. This study found a significant relationship between income levels and type of fuels used (χ^2=15.5; df=3; p=0.001), with higher income earners working in enterprises using processed fuels while low income earners mainly worked in enterprises where biofuels were used (Table 4.9). This could have led to the observed differences in prevalence of symptoms. Those earning higher incomes could have also been using processed fuels at home hence had less exposure to indoor air pollutants from biofuels as opposed to lower income earners.

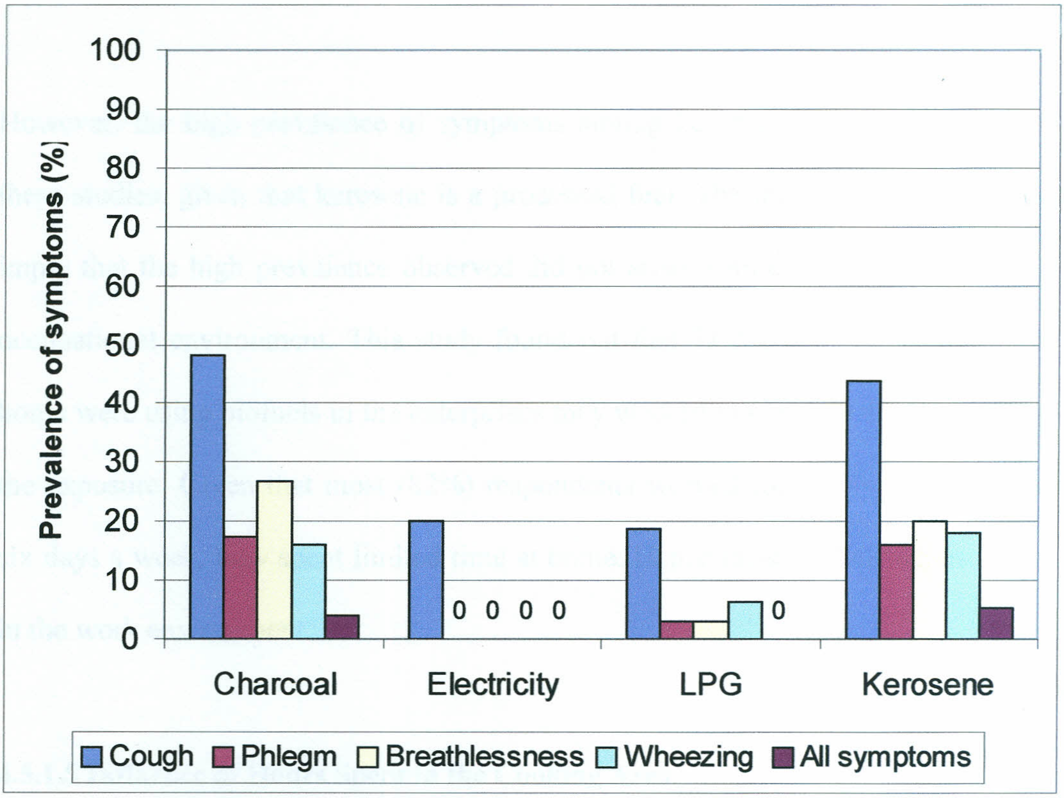


n = 370

Figure 4.9: Distribution of respondents by symptoms and monthly earnings

4.5.1.4 Influence of Fuel Type Used at Home

As shown in Figure 4.10, those who used charcoal at home recorded highest prevalence for most respiratory health symptoms, leading in prevalence of cough (48%), phlegm (17.3%) and breathlessness (26.7%). Kerosene users came in second after charcoal users, even though they recorded highest prevalence of wheezing (18.2%). The only symptom recorded by electricity users was cough, for which they had the second least prevalence (20%) after LPG users (18.8%). Only charcoal and kerosene users had respondents experiencing all the symptoms, with prevalence rates of 4% and 5.2% respectively.



n =370
Figure 4.10: Distribution of respondents by symptoms and fuel used at home

A significant association existed between the type of fuel used at home by the respondents and cough (χ^2=13.04; df=5; p=0.023), with prevalence in charcoal users being nearly three times higher (48.1%) than that in LPG users (17.1%). Breathlessness was also found to be significantly higher in charcoal and kerosene users compared to those using other fuel types (χ^2=11.12; df=2; p=0.049).

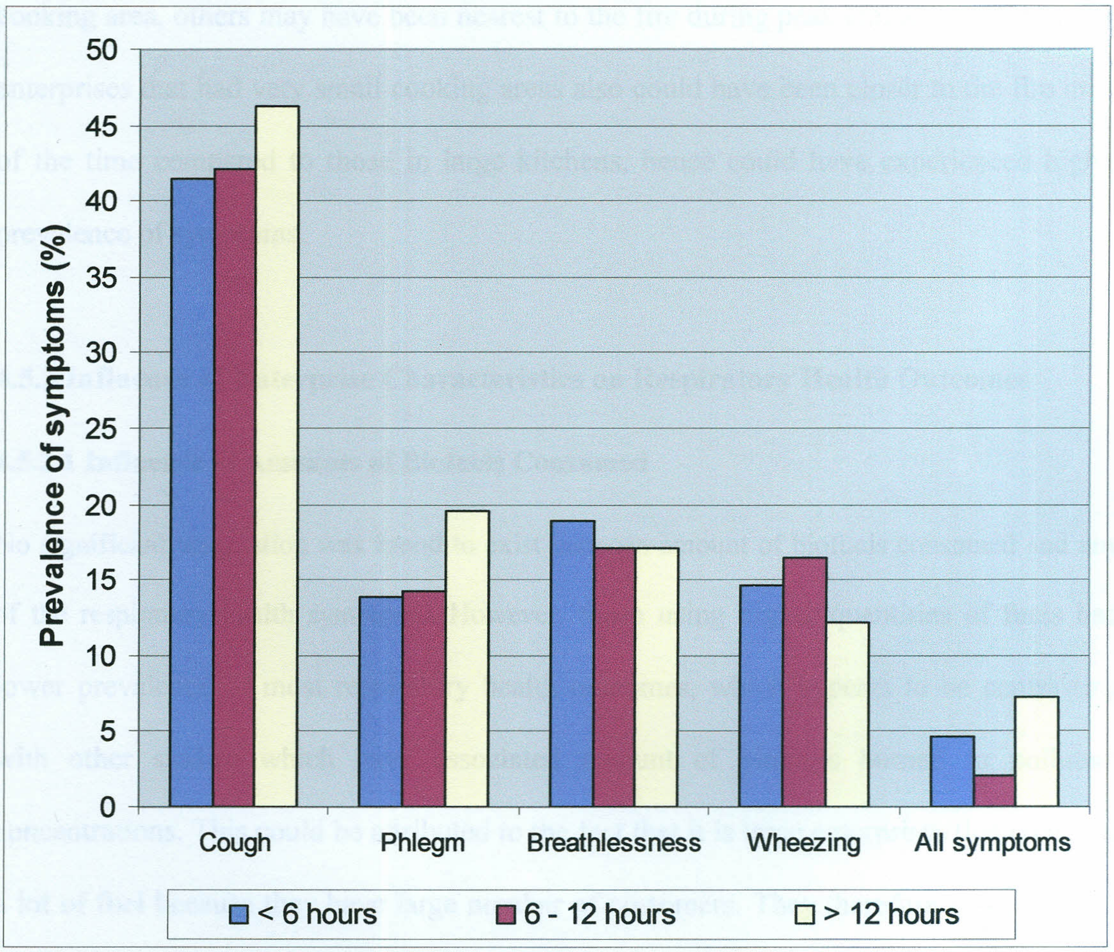
The high prevalence of symptoms in charcoal users and least prevalence in LPG and electricity users established in this study is consistent with findings of household studies (Shrestha, *et al,* 2005; Ezzati, *et al*, 2000) which have found higher prevalence of respiratory health outcomes in biofuel users compared to processed fuel users.

However, the high prevalence of symptoms among kerosene users is inconsistent with these studies, given that kerosene is a processed fuel. The inconsistency could therefore imply that the high prevalence observed did not arise from exposure at home, but from occupational environment. This study found out that 78.7% of those using kerosene at home were using biofuels in the enterprises they worked in (Table 4.10), hence leading to the exposure. Given that most (82%) respondents worked for nearly 12 hours a day for six days a week, they spent limited time at home. Hence most of their exposure occurred in the work environment.

4.5.1.5 Influence of Hours Spent in the Cooking Area

The study also assessed the influence of hours spent in cooking area on respiratory health outcomes. Prevalence of cough was nearly equal among the three categories of respondents. However, as shown in Figure 4.11, respondents who spent over 12 hours in kitchens recorded highest prevalence of most respiratory health outcomes, with the exception of wheezing and all symptoms, which was highest in the group that spent less than six hours in cooking area. The 6-12 hour groups came in second. Respondents who spent less than 6 hours indoors recorded the least prevalence for most of the symptoms. The differences were however negligible, and no significant association was established between hours spent indoors and respiratory health outcomes.

Several studies however have found associations between hours spent in kitchens and respiratory health outcomes, and it is due to this that women and children have tended to be more vulnerable to health outcomes associated with indoor smoke compared to men. This could explain why those who spent longer hours in the kitchen had higher prevalence of most symptoms.



n = 370

Figure 4.11: Distribution of respondents by symptoms and hours spent in kitchens

Recent work on exposure to indoor smoke under actual conditions of fuel use by Ezzati, *et al,*(2000) has shown that stove emissions are highly episodic and that peaks in emissions concentrations commonly occur when fuel is added or moved, the stove is lit, the cooking pot is placed on or removed from the fire, or food is stirred. Hence those closest to the fire during such episodes would be more affected. This could explain the inconsistency observed in wheezing and all symptoms in relation to hours spent in the cooking area. Even though respondents may have spent similar amounts of time in the cooking area, others may have been nearest to the fire during peak emissions. Workers in enterprises that had very small cooking areas also could have been closer to the fire most of the time compared to those in large kitchens, hence could have experienced higher prevalence of symptoms.

4.5.2 Influence of Enterprise Characteristics on Respiratory Health Outcomes

4.5.2.1 Influence of Amounts of Biofuels Consumed

No significant association was found to exist between amount of biofuels consumed and any of the respiratory health symptoms. However, those using higher quantities of fuels had lower prevalence of most respiratory health outcomes, which appears to be contrasting with other studies which have associated amount of biofuels burned to pollutant concentrations. This could be attributed to the fact that it is large enterprises that consume a lot of fuel because they have large number of customers. They therefore generate a lot of income from the enterprises, and would invest some of it in improving the work environment, not just for the workers but for the sake of clients as well. They therefore tend to have better ventilation, which would impact positively on the health of the workers.

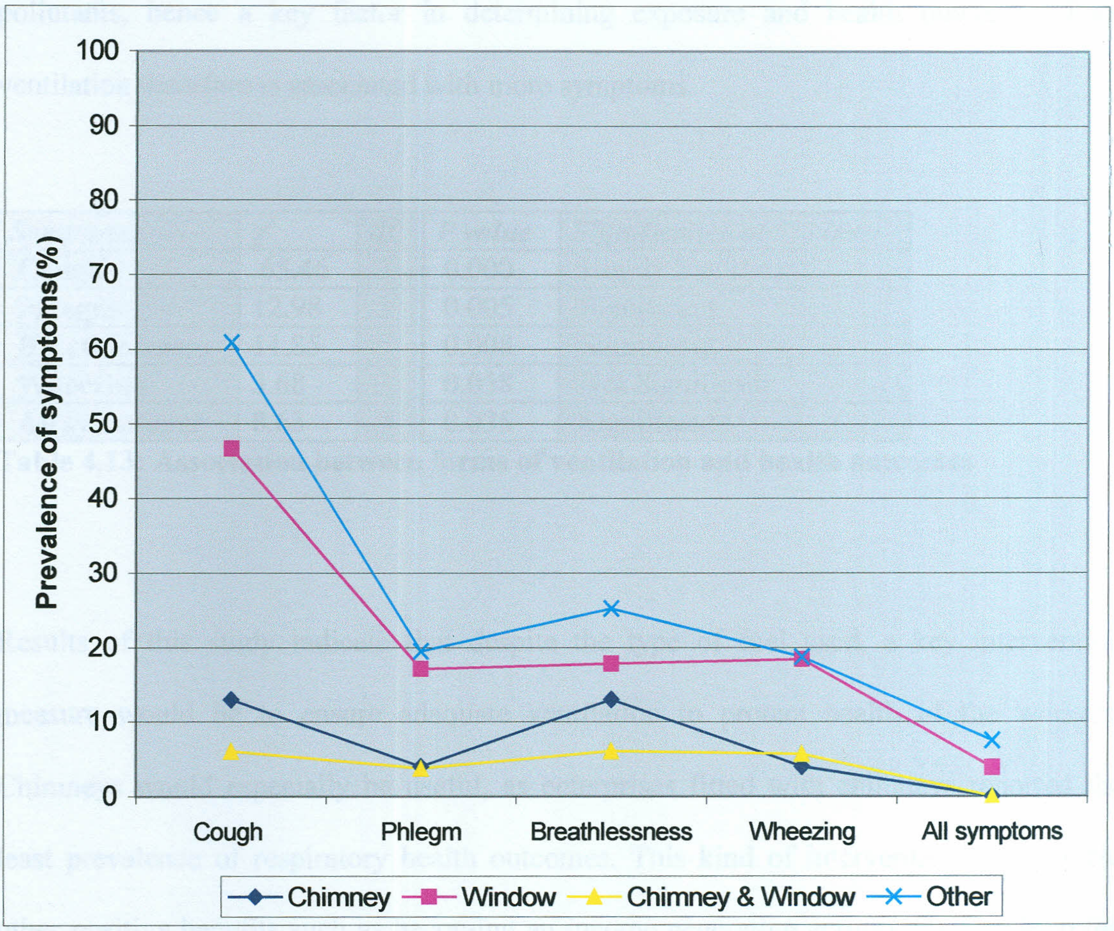
4.5.2.2 Influence of Size of Cooking Area

Most of the enterprises had very small cooking areas, with 86.4% measuring less than $7m^2$. This could imply higher levels of exposure and health outcomes, given that pollutants are highly concentrated and not well dispersed, hence large quantities can be inhaled compared to if the room was larger. In this study however, the size of cooking area was found not to significantly influence respiratory health outcomes. This is inconsistent with findings by Ezzati, *et al*, (2000) in rural Kenyan households, who found higher prevalence of health outcomes in households with smaller rooms. In this study therefore, other factors such as ventilation or fuel type could have had a greater influence on health outcomes.

4.5.2.3 Influence of Forms of Ventilation

The prevalence of respiratory health symptoms and ventilation followed a sequence whereby respondents in enterprises that had neither chimneys nor windows but other forms of ventilation were leading, followed by those in enterprises that had only windows. Those with chimney came in a distance third, and those with chimney and window had the least prevalence. The largest differences were observed between those with other forms of ventilation and those with chimney & window.

As indicated in Figure 4.12, those using other forms of ventilation recorded the highest prevalence of nearly all respiratory health outcomes. For instance, prevalence of cough was 46.7% in these enterprises, and only 3% in enterprises that had both chimney and window. Similarly, prevalence of phlegm and breathlessness were 24% and 31% respectively in enterprises that had chimneys and windows. The corresponding figures for enterprises with other forms of ventilation were 3.8% and 6.1% respectively.



n = 370

Figure 4.12: Distribution of respondents by symptoms and forms of ventilation

There was significant association between forms of ventilation and nearly all the health outcomes as presented in Table 4.13, with enterprises having chimney & window recording significantly lower prevalence of symptoms compared to those that had other forms of ventilation.

Many studies show that biofuels are a major health threat in kitchens that are poorly ventilated; therefore implying that ventilation is a crucial parameter in determining respiratory health outcomes. Ventilation is a major factor influencing concentration of pollutants, hence a key factor in determining exposure and health outcomes. Poor ventilation therefore is associated with more symptoms.

Symptoms	χ^2	*df*	*P value*	*Significance at 5% level*
Cough	65.46	3	0.000	Highly Significant
Phlegm	12.98	3	0.005	Significant
Breathlessness	11.85	3	0.008	Significant
Wheezing	3.68	3	0.058	Not Significant
All symptoms	8.63	3	0.035	Significant

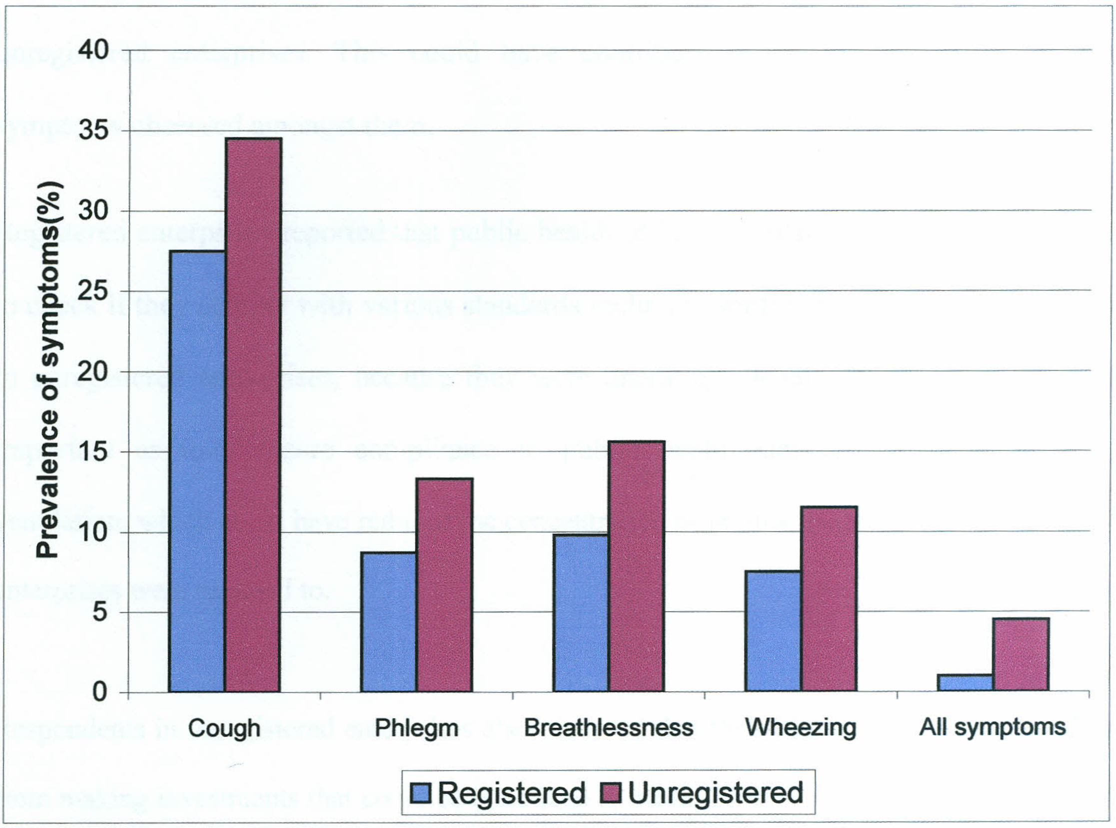
Table 4.13: Association between forms of ventilation and health outcomes

Results of this study indicate that despite the type of fuel used, a key intervention measure would be to ensure adequate ventilation to protect health of the workers. Chimneys would especially be useful, as enterprises fitted with chimneys reported the least prevalence of respiratory health outcomes. This kind of intervention would yield other positive benefits such as becoming an income generating activity for people in the informal sector, as most of the chimneys were *jua kali* made.

Education and awareness creation would also be important in these areas, as most enterprise owners could not justify why they had only small windows or tiny holes for letting out smoke. Security could have been a factor, but they need to be made aware of the danger they are exposing themselves to by cooking with biofuels in poorly ventilated conditions.

Registration of the enterprises is also key, as this would enable them to make investments in ventilation knowing they will be able to operate those facilities for a given period of time. Most of the unregistered enterprises had very small kitchen that could not fit in chimneys even if they had that option.

4.5.2.4 Influence of Registration Status



n = 370

Figure 4.13: Distribution of respondents by symptoms and registration status

Most of the enterprises were unregistered (71%). Only 29% were registered. Respondents working in unregistered enterprises recorded higher prevalence of all the symptoms compared to those in registered enterprises as shown in Figure 4.13. Significant differences were observed between registration status and cough (χ^2=5.76; df=1; p=0.016), breathlessness (χ^2=6.46; df=1; p=0.011) and all symptoms (χ^2=16.56; df=1; p=0.000), with respondents in unregistered enterprises recording higher prevalence compared to those in registered enterprises.

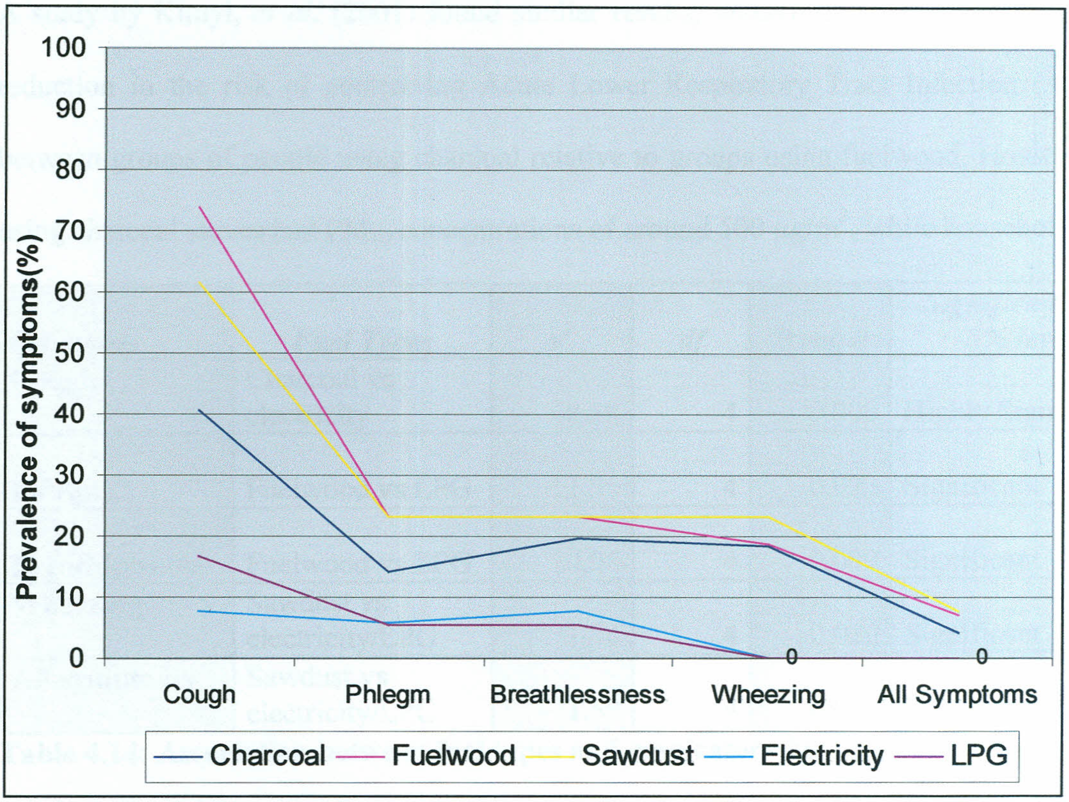
Registration status of enterprises was found to influence fuel choice, with more respondents in registered enterprises using processed fuels compared to respondents in unregistered enterprises. This could have contributed to the lower prevalence of symptoms observed amongst them.

Registered enterprises reported that public health officers regularly visited the enterprises to check if they comply with various standards including ventilation. This wasn't the case in unregistered enterprises, because they were operating illegally. Such inspections are important as they ensure compliance to public health standards such as adequate ventilation, which could have reduced the concentration of pollutants the respondents in these enterprises were exposed to.

Respondents in unregistered enterprises also observed that their illegal status prevented them from making investments that could be beneficial to health for instance fitting in chimneys or buying appliances such as cookers due to fear of demolitions.

4.5.3 Influence of Fuels Used

Two analyses were made on respiratory health symptoms and fuel types. The first was based on all fuel types while the second involved the binary classification scheme, separating the study population into those using biofuels and those using processed fuels.



n = 370

Figure 4.14: Distribution of respondents by fuel types and respiratory symptoms

As shown in Figure 4.14, fuelwood and sawdust users reported the highest prevalence of most of the respiratory health symptoms, followed by charcoal users. LPG users came in third while electricity users had the least prevalence of symptoms, with none of them reporting experiencing wheezing. Similarly, none of the respondents in enterprises using electricity and LPG experienced all the symptoms, yet in enterprises where fuelwood and sawdust were used, the prevalence was 8%. Significant association was established between fuel types and most respiratory health outcomes as shown in Table 4.14, with respondents using charcoal, fuelwood and sawdust recording higher prevalence than those using electricity and LPG.

A study by Kituyi, *et al.* (2001) found similar results, whereby there was a significant reduction in the risk of contracting Acute Lower Respiratory Tract Infection (ALRI) between groups of people using charcoal relative to groups using fuelwood. Households using charcoal stoves had PM_{10} concentrations of around 500 μg/m^3, while households

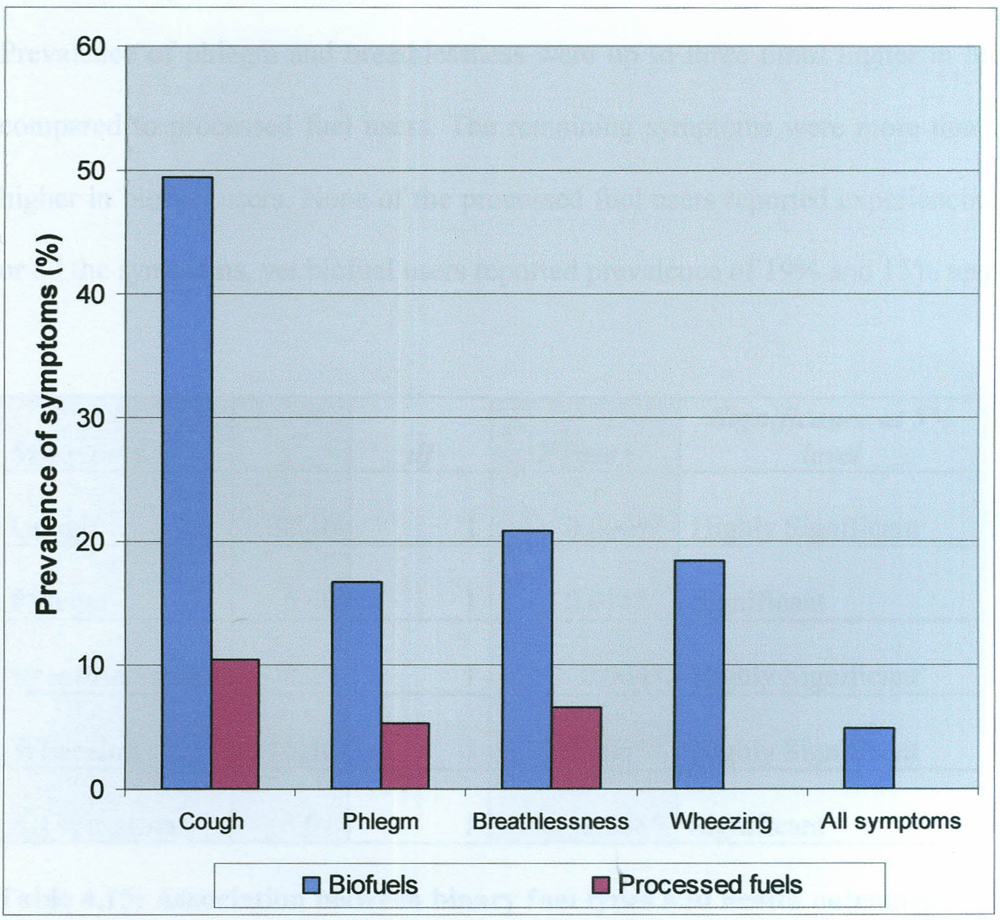
Symptoms	*Fuel Types*	χ^2	*df*	*P value*	*Significance at 5% level*
Cough	Charcoal vs electricity	68.48	4	0.000	Highly Significant
Phlegm	Fuelwood vs LPG	11.35	4	0.023	Significant
Breathlessness	Fuelwood vs LPG	10.06	4	0.039	Significant
Wheezing	Sawdust vs electricity/LPG	17.4	4	0.020	Significant
All symptoms	Sawdust vs electricity/LPG	1.58	4	0.051	Not Significant

Table 4.14: Association between fuel types and respiratory health outcomes

using wood in an open fire had concentrations over 3000 μg/m^3. The risk of adult men contracting ALRI was 44% lower in households using charcoal rather than fuelwood, while reduction in risk for adult women was 65%.

Although charcoal has poorer combustion efficiencies than other biofuels, the charcoal production process creates a fuel that burns with far less smoke than wood at the point of end-use, leading to lower emissions of PM_{10}. This is because charcoal has undergone some form of processing during which some of its PM content has been released, unlike raw wood. During the study, it was observed that enterprises using fuelwood and sawdust were visibly smoky, and respondents were coughing during the interviews. Enterprises using charcoal were however less smoky, and after the charcoal had caught fire, no smoke was visible. This would therefore explain why charcoal users had lower prevalence of respiratory symptoms compared to fuelwood and sawdust users, and why charcoal was not significantly associated with most symptoms.

Charcoal users however reported higher prevalence of all the symptoms under investigation compared to electricity and LPG users. For instance, they recorded 75% prevalence of cough compared to only 19% recorded by electricity users. This is because charcoal is a biofuel, and biofuels have generally been associated with significant emissions of PM_{10} in relation to processed fuels.



n > 370 – Multiple responses allowed
Figure 4.15: Distribution of respondents by symptoms and binary forms of fuel

When classified on the basis of binary fuel types, biofuel users reported higher prevalence of all the symptoms compared to those using processed fuels as shown in Figure 4.15 above. Prevalence of cough was nearly 5 times higher (49%) in biofuel users compared to processed fuel users (10%). For phlegm and breathlessness, the prevalence was up to three times higher in biofuel users compared to processed fuel users. None of the processed fuel users reported experiencing wheezing or all the symptoms, yet biofuel users reported prevalence of 19% and 15% respectively. The differences were found to be statistically significant for all the symptoms as shown in Table 4.15.

Prevalence of phlegm and breathlessness were up to three times higher in biofuel users compared to processed fuel users. The remaining symptoms were more than four times higher in biofuel users. None of the processed fuel users reported experiencing wheezing or all the symptoms, yet biofuel users reported prevalence of 19% and 15% respectively.

Symptoms	χ^2	*df*	*P value*	*Significance at 5% level*
Cough	38.16	1	0.000**	Highly Significant
Phlegm	6.46	1	0.011**	Significant
Breathlessness	8.29	1	0.004*	Highly Significant
Wheezing	16.56	1	0.000**	Highly Significant
All symptoms	3.91	1	0.048*	Significant

Table 4.15: Association between binary fuel types and health outcomes

These findings are consistent with most studies that have related biofuel use to respiratory health outcomes, even though the previous studies were done in households. In a household study by Shrestha, *et al.* (2005) that used case-control design by reporting fuel type (wood vs. cleaner fuel) as a proxy for exposure, those who were exposed to smoke from biofuels reported higher prevalence of respiratory abnormalities as compared with users of cleaner fuels. For instance, prevalence of Chronic Obstructive Pulmonary Disease (COPD) and ALRI among unprocessed fuel users was three times higher compared to those using processed fuels. Similarly, much higher prevalence of all respiratory symptoms were found for the unprocessed fuel users. Studies in Kenya by Ezzati, *et al*, (2000) in Mpala ranch also revealed significantly higher prevalence of respiratory ailments among biofuel users.

The results confirm what has been established by previous studies, that indoor air pollution from biofuels greatly compromises respiratory health of exposed populations. The study has thus demonstrated that workers in food catering enterprises who use biofuels are facing a great public health risk that needs attention. The results imply that switching from biofuels to processed fuels would lead to significant reductions in the prevalence of respiratory health outcomes.

At the same time, the results indicate that some forms of biofuel are more harmful to health compared to others. In this instance, those using charcoal had significantly lower prevalence of respiratory health outcomes compared to those using fuelwood. Therefore a switch from fuelwood to charcoal could significantly reduce the health threat.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of major findings of the study and their implications, conclusion and recommendations. Areas for further research are also presented in this section.

5.2 Major Findings and their Implications

5.2.1 Demographic Profiles of Respondents

Most respondents were aged 21-30 years, with primary level education. The low education levels imply lack of awareness on the link between use of biofuels and respiratory health. Most were casual employees earning less than Ksh.3000, which could explain why only few of them used electricity or LPG for home cooking. Most of the respondents did not own the enterprises they worked in, implying that they did not make decisions regarding fuel choice and other enterprise parameters that could impact on health. A large proportion of them spent greater than 6 hours a day in the cooking area, which is many times higher than those who cook in households, and suggests long durations of exposure.

5.2.2 Enterprise Characteristics

The enterprises were found to consume large quantities of biofuels, implying high quantities of pollutants generated. The enterprises were small in size and poorly ventilated, which could suggest high residence time for pollutants indoors.

5.2.3 Types of fuels used and factors determining their choice

Most enterprises used biofuels in form of charcoal and fuelwood. The major factor governing fuel choice was cost. There were misconceptions about health consequences associated with various fuel types. The findings thus suggest that for the enterprises to switch from using biofuels to processed fuels, measures must be put in place to reduce cost of processed fuels. Education levels and registration status were found to significantly influence fuel choice. This implies that enterprise owners who are well educated are aware of health consequences associated with biofuel use hence chose to use processed fuels unlike their counterparts with lower levels of education. Registering the enterprises also enables them use cleaner fuels as they can make investments in expensive cooking appliances.

5.2.4 Factors Influencing Prevalence of Respiratory Health Symptoms

A large proportion of respondents reported experiencing respiratory health symptoms, with cough being the most reported symptom.

5.2.4.1 Influence of Respondents' Demographic Profiles

Significant associations were not established between respiratory health outcomes and most of the background characteristics of respondents. The exceptions were education and income, and even then, there were significant associations with only a few outcomes.

Unlike household studies where most background characteristics such as age and gender have a direct effect on health outcomes, in food catering enterprises, they are only important in as far as they determine fuel choice and enterprise characteristics such as ventilation. The influence of education suggests that with education and awareness creation, the enterprise owners could adopt measures that would reduce negative health consequences experienced.

5.2.4.2 Influence of Enterprise Characteristics

Most of the enterprise characteristics were found to relate to health outcomes, with ventilation and registration status of enterprises significantly influencing the outcomes. Some enterprise owners could not explain why they had inadequate ventilation. This could imply lack of awareness, which can be changed through education. Registration status of enterprises significantly influenced fuel choice, with most respondents in unregistered enterprises using biofuels. These findings suggest that some form of regulation of the sector is necessary, as this encourages investments in cleaner fuels and healthier work environments.

5.2.4.3 Impact of Biofuel Use on Respiratory Health

Fuel types were found to significantly influence health outcomes. Those using biofuels had significantly higher prevalence of all respiratory health outcomes compared to respondents using processed fuels. Given that 81% of the enterprises used biofuels, these findings imply that biofuel use in food catering enterprises is major public health threat that requires urgent intervention, as the health of many workers in the sector is compromised. Previous household studies have reported that majority of this health burden falls on women and children, and intervention measures should be focused on them. This study has however clearly demonstrated that workers in food catering enterprises where biofuels are used are also vulnerable, and intervention measures should be equally targeted at the sub-sector. The findings of this study further imply that a switch from biofuels to processed fuels would lead to significant health improvements for the workers.

Prevalence of respiratory health outcomes was not evenly distributed among the biofuel users. Respondents using fuelwood and sawdust reported significantly higher prevalence of most symptoms compared to those using charcoal. This finding suggests that health benefits can also be realised by fuel switch even within biofuels, from fuelwood and sawdust to charcoal, which can reduce exposure to lower levels.

There were misconceptions on health effects of various fuel types, with some respondents believing that smoke from fuelwood was less harmful compared to smoke from charcoal. Yet this study and other previous studies have proven that smoke from fuelwood is more dangerous than fumes that emanate from charcoal burning. This implies that there is need of awareness creation on the risks attributed to various fuel types, so that people can make informed choices on which fuels to utilise.

Fuel choice was governed by several factors, with cost being paramount. This suggests that it may not be easy to accomplish a switch from biofuels to processed fuels, or from fuelwood to charcoal unless the intervention is accompanied by measures aimed at reducing cost.

5.3 Conclusion

1. Food catering enterprises were found to mainly use biofuels in form of charcoal and fuelwood. Only 29% of the enterprises used processed fuels.
2. Various factors governed fuel choice including cost, income, education levels of enterprise owners and registration status of the enterprises.
3. Nearly half (49%) of the respondents reported experiencing respiratory health symptoms, with cough being the most prevalent.
4. Type of fuel used was found to significantly influence health outcomes. Respondents in enterprises using biofuels had significantly higher prevalence of respiratory health symptoms compared to their counterparts in enterprises where processed fuels were used. *P* values were significant for cough (χ^2=38.16; df=1; *P*=0.000), phlegm (χ^2=6.46; df=1; *P*=0.011), breathlessness (χ^2=8.29; df=1; *P*=0.004), wheezing (χ^2=16.56; df=1; *P*=0.000) and all symptoms (χ^2=3.91; df=1; *P*=0.048).
5. Other factors that had significant influence on respiratory health symptoms exhibited included demographic profiles such as age, sex and income; and enterprise characteristics such as registration status and ventilation.
6. The study therefore rejects the null hypotheses that there is no association between use of biofuels and respiratory health symptoms exhibited by the workers in food catering enterprises in Nairobi; and that demographic and enterprise characteristics have no influence on prevalence of symptoms exhibited.

5.4 Recommendations

1. Measures should be put in place that would encourage food catering enterprises to use processed fuels instead of biofuels. These can be achieved through targeted energy sector policies and financial support measures aimed at reducing the cost of processed fuels, given that cost was found to be a major determinant of fuel choice.
2. Where its not possible to use processed fuels, food catering enterprises should be encouraged to use less polluting biofuels such as charcoal as opposed to highly pollution ones such as fuelwood. Reduction in charcoal costs can also be achieved through change of current policy that makes charcoal production and transportation illegal yet legalizes its sale.
3. Education and awareness Creation is important to remove the misconceptions on what fuels are harmful, and for workers in the enterprises to take measures such as have adequate ventilation necessary for health. Given that there is constant interaction between the Nairobi City Council and the enterprises on a weekly basis, the officials could be assigned the role of not just collecting levies but providing education as well after being trained.
3. Improvement in ventilation is another measure for reducing the prevalence of respiratory health outcomes. This can be achieved through enforcement of the public health and occupational health and safety standards, and through educating enterprise owners on the need for adequate ventilation in their premises.
4. The study also recommends formalisation of activities of food catering enterprises by registering them. This would enable them to make investments in the sector

that are beneficial to health. In addition, prior to registration, the enterprises would be inspected by public health officials to ensure they adhere to the required health standards.

5. Finally, the study recommends that a stakeholders' forum be held to discuss the findings of this study and chart a way forward for reducing respiratory health effects associated with use of biofuels in food catering enterprises.

5.5 Areas for Further Research

In this study, it was not possible to measure the concentration of pollutants in the enterprises due to limitations mentioned earlier. A future study should therefore be carried out where concentration of pollutants are measured in enterprises using biofuels and processed fuels, and these are compared with prevalence of respiratory health outcomes.

Additionally, a study could also be carried out to determine the association between indoor air pollution from biofuels and respiratory diseases such as asthma, ALRI and COPD in food catering enterprises.

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APPENDICES

APPENDIX I: QUESTIONNAIRE

INTRODUCTION

I am doing a study on respiratory health effects associated with biofuel use, and would like to ask you some questions. The questions will take about 15 minutes to answer. I will not ask you to give your name, so your answers will be completely secret.

Questionnaire Number…………………………………………
Enumeration Area………………………………………………
Name of Interviewer…………………………………………
Date…………………………………………………………………

PART 1: GENERAL QUESTIONNAIRE

SECTION A: DEMOGRAPHIC INFORMATION

A1 Sex of Respondent

□Male □Female

A2 Age in years □ <20 □ 20-30 □31-40□>40

A3 Level of education

□Primary □Secondary □Tertiary □Informal Education

Average monthly income

□<5000 □5000-10000 □10000-15000 □>15000

SECTION B: EMPLOYMENT INFORMATION

B1 Employment status

□Paid employee – permanent/casual/temporary/contract/seasonal (tick)

□Employer □Own account worker □Unpaid family worker □Other (Specify…………..

B2 For how long have you worked in food catering enterprises? ....

□<6 months □6-12 months □13-24 months □> 2 years

B3 How long have you been in this particular job?

□<6 months □6-12 months □13-24 months □> 2 years

B4 Main work activity (e.g. cooking): ....

B5Days worked per week, on average □<3 □3-5 □6-7

B6Hours worked per day, on average □<6 □6-12 □>12

B7Hours spent in combustion room per day, on average □<6 □6-12 □>12

B8Is the establishment: □Registered □Unregistered

B9How many employees are in the establishment? ....

SECTION C: ENERGY CONSUMPTION RATES

C1What main fuel type do you use?

□Electricity □LPG □Kerosene □Firewood □Charcoal □Other (Specify) ......

C2Average use per month

□<2 weeks □2-3 Weeks □4 or more weeks

C3Indicate, in order of preference, other fuel types you used (1 for most preferred, 5 for least preferred, blank if not used)

□Electricity □LPG □Firewood □Charcoal □Other (Specify) ....

C4If electricity, what is the monthly consumption in Kwh....... Bill last month...........

C5If gas (LPG) what quantity was consumed last month in Kg...... Cost last month......

C6If kerosene, what quantity is consumed daily/weekly/monthly in litres? ....

C7Average cost for last month..

C8If firewood, what quantity is consumed daily/weekly/monthly in kg/units?..............

C9Average cost for last month……………………………………………………………..

C10If charcoal what is the quantity consumed daily/weeklay/monthly in Kg/bags?………

C11Average cost for last month? ……………………………………………………

C12If firewood/charcoal, what is the source? ……………………………………………

C13Type of firewood used (state species and whether roundwood or split)………………

C14If other, give the units consumed daily/weekly/monthly………..Cost per month…...

C15Number of units of firewood used in firing per batch………………………………

C16Number of units of charcoal used in firing per batch………………………………

C17Main fuel used at home □Wood □Kerosene □Charcoal □LPG □Electricity □Other

(Specify)…………………………………………………………………………………

C18State if there were any months when there were variations in □ Fuel Consumption

□Fuel type □Fuel cost □Other conditions ……………………………………………

C19What caused the variations…………………………………………………………

C20What fuel type do you use at home?

□Electricity □LPG □Kerosene □Firewood □Charcoal □Other (Specify) …...

SECTION D: INDOOR AIR POLLUTION EXPOSURE

Where are you during the following operations:

E1When fuel is added or moved

□Responsible for the activity □less than 1 m away □more than 1 m away

E2When the stove is lit

□Responsible for the activity □less than 1 m away □more than 1 m away

E3The cooking pot was placed on or removed from the fire

□Responsible for the activity □less than 1 m away □more than 1 m away

E4Food is stirred

□Responsible for the activity □less than 1 m away □more than 1 m away

E5If you are involved in the above activities, state how often (number of times per day/week)?...

E6Stove type □ stove/Jiko □ 3-stone □ KCJ □ other

PART II: RESPIRATORY HEALTH SYMPTOMS

The questions in this section, unless specified, apply to health problems experienced in the past 12 months. Enter 9 if non-responsive.

F1Have you experienced any of the following health problems in the past 12 months? (tick more than one if applicable)

□Cough □Phlegm □Breathlessness □Wheezing

□Other respiratory problems (Specify).........................

F2How many episodes of coughing have you had?

□12 or more episodes □Continuous (Enter Number)...................................

F3Do you usually cough on most days for 3 consecutive months or more during the year?

□Yes □No

F4Have you had a dry cough at night not counting a cough associated with a cold or chest infection lasting 14 days or more? □Yes □No

F5Has your chest sounded wheezy during or after strenuous activity? □Yes □No

F6How many attacks of wheezing or whistling have you had?

□12 or More Episodes□Less that 12 Episodes (Enter number)........................

F7Has the wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?

□No Words or Language □Yes □No □Don't Know

F8Do you bring up phlegm on most days for 3 consecutive months or more during the year? □Yes □No

F9How often do you experience the problem (s)

□All of the time □At least daily □3–6 days per week □1–2 days per week

□Less than one day per week

For all the health problems

F10For how many years have you had the problem? □ 1 year or less □More than a year (Enter Number)……………………..

F11What time of the day do your symptoms usually occur?

□In the morning □At work □At night □At various times during the day

F12How often do your symptoms make physical activity difficult?

□All of the time □At least daily □3–6 days per week □1–2 days per week

□Less than one day per week

F13How often, on average, do your symptoms cause sleeping problems?

□Most nights □5 or more nights a month □3 or 4 nights a month

□Less than 3 nights a month □Never

F14About how much work do your symptoms cause you to miss?

□Days per week □Days per month □Days per year

F15How much did you limit your usual activities due to the health problem? Would you say □Not at all □A little □A fair amount □A moderate amount □A lot

F16How many times have you gone to the doctor's office or the hospital emergency room for one or more of these problems? □Never □If you've gone, Enter number..............

F17Have you taken any medication for the problem? □Yes □No

F18Was the medicine prescribed by a doctor? □Yes □No

F19How often do "flare–ups" (worsening of your condition) happen that cause severe breathing trouble for an hour or more? □At least daily □1–2 days per week □3–6 days per week □Less than one day per week

F20Has anyone else in your workplace suffered from the above health problems?

□Yes □No

F21Do you smoke? □Yes □No □Used to

F22Does anyone else in your family experienced any of the above health problems for over a year? □Yes □No

PART III: INTERVENTION

G1What, in your opinion, is the cause of these health problems? ....

....

....

G2If it's work environment, what changes, in your opinion, should be made?..............

....

....

THANK YOU VERY MUCH FOR YOUR COOPERATION

APPENDIX II: OBSERVATION CHECKLIST

1. Cooking done □Indoors □Outdoors

Construction material

2. Wall material □Concrete □Brick □ Mud □tin □wood

□other(Specify)…………..

3. Roof material □cement □brick □ mud □tin □wood other(Specify)……

4. Size of cooking area (sq metres)…………………………………………………………..

5. Ventilation □ chimney □ window □ Door □other

6. Number ………………………………………………………………………………

7. Size/Area (sq metres)…………………………………………………………………

APPENDIX III: INTERVIEW GUIDE

SECTION 1: ENTERPIRSE OWNERS AND MANAGERS

1. What are the major factors governing your fuel choice?
2. Would you associate types of fuels you use with any health problems?
3. Which health problems would you associate with the fuels you use?
4. Which fuels do you believe are most harmful to health?
5. In your opinion, what measures can be taken to reduce the health impacts?
6. Who, in your opinion, should institute the above measures?
7. What major challenges do you face in your business operation?
8. What, in your opinion can be done by government and other stakeholders to surmount the challenges?

SECTION 2: NAIROBI CITY COUNCIL, MINISTRY OF LABOUR AND OTHER STAKEHOLDERS

1. Would you associate the type of fuels used in food catering enterprises with respiratory health problems?
2. Has your organisation taken any measures to reduce these health problems or their cause?
3. What measures, in your opinion, should be taken to reduce these health problems?
4. What long-term measures do you have in place for food catering enterprises that relate to fuels they use?
5. In your opinion, would registering the enterprises help in making the work environments healthier?

THANK YOU.

APPENDIX IV: WORK PLAN

TIME PLAN (JANUARY 2005 – DECEMBER 2007)

TIME PERIOD	**ACTIVITY**	**MAJOR CHALLENGES ENCOUNTERED**
January 2005 – August 2005	Proposal Development and Approval	Delay in release of first year results; and in formation of Post Graduate Board for the School of Health Sciences. These led to delay in proposal approval
September 2005	Pre-testing of research instruments	Some of the questions on respiratory health were technical and were therefore modified
	Modification of research instruments	
October 2005 – December 2005	Data Collection	Respondents were interviewed at places of work hence were busy; interviews were therefore conducted early morning or late evening
January 2006 – March 2006	Data Analysis	An expert had to be consulted in the analysis of responses relating to respiratory health symptoms
April 2006 – December 2006	Thesis writing and correction	Delay occurred due to unavoidable circumstances
January 2007	Presentation of Findings	No major challenges
March 2007	Submission of Thesis	No major challenges
August 2007	Thesis Defence	No major challenges
December 2007	Graduation	

APPENDIX V: BUDGET

BUDGET ITEM	AMOUNT	TOTAL
1. Proposal writing		
a. Stationery/photocopy	5000	
b. Literature review	4000	9000
2. Materials and research instruments		
a. Acquiring, organising and preparing	10000	
b. Pre-survey and pre-testing tools	15000	25000
3. Data collection		
a. Transport and subsistence	10,000	
b. Remuneration to data collection assistants	15,000	25000
4. Data management		
a. Statistical package and data analysis	4000	
b. Remuneration to medical statistician	35000	39000
5. Thesis preparation		
a. Typing, photocopying and seminar materials	15,000	
b. Transport	5000	20000
6. Contingencies		
	13000	13000
TOTAL	**131000**	**131000**

APPENDIX VI: CLASSIFICATION OF INFORMAL SECTOR ACTIVITIES IN KENYA

Informal sector in Kenya, 1999-2003: No. of persons engaged by activity, '000s

Informal Sector Activities	1999	2000	2001	2002	2003
Manufacturing	862	934	1,030	1,116	1,199
Construction	126	133	140	150	159
Wholesale& Retail trade, hotels& restaurants	2,146	2,405	2,619	2,974	3,256
Transport and communications	107	121	136	150	165
Community, social and personal services	329	370	418	466	514
Others	170	188	210	231	252
TOTAL	**3,739**	**4,151**	**4,624**	**5,086**	**5,545**

Source: Economic Survey, 2005

MINISTRY OF EDUCATION, SCIENCE & TECHNOLOGY

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NAIROBI
KENYA

MOEST 13/001/35C 499/2

30th September, 2005

Caroline A. Ochieng
Kenyatta University
P.O. BOX 43844
NAIROBI

Dear Madam

RE: RESEARCH AUTHORIZATION

Please refer to your application for authority to carry out research on "Effect of indoor air pollution from Bio fuels on respiratory Health of workers in Food catering enterprises in Nairobi" I am pleased to inform you that you have been authorized to carry out research in Food catering Enterprises in Nairobi for a period ending 30th April, 2006.

You are advised to report to the Provincial Commissioner, the Provincial Director of Education Nairobi and the General Managers of the Food enterprises you will visit before embarking on your research project.

On completion of your research, you are advised to submit two copies of your research report to this Office.

Yours faithfully

M. O. ONDIEKI
FOR: PERMANENT SECRETARY