RESPIRATORY DISORDERS ASSOCIATED WITH QUARRY MINING
IN EMBAKASI, NAIROBI, KENYA

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Respiratory disorders associated with quarry
Declaration

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

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Supervisors’ Approval:

We confirm that the work reported in this thesis was carried out by the candidate under our supervision as University Supervisors.

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Dedication

I dedicate this thesis to my husband Kithinji Nguthari and our children Nkatha, Kibaara and Karimi. You made life easy for me during the period of study.

May God bless you mightily.

The study subjects are acknowledged for their cooperation and support. The quarry owners who participated and allowed me to work with their workers are acknowledged. I sincerely thank my special women friends who shared their contribution in kind, especially Ann Mutua, Ann Ohura and Jane Kariuki.

Githinj and Transcoral Systems are recognized for their geological consultation services. Department of mines and Geology Ministry of Natural Resources for the sample with geological chemical analysis of the rock and soil samples.

Illustrations of the University of Nairobi for preparing the X-ray radiography and photographic illustrations shown in this thesis. Last but not least, the advisors and the ones praying with me at a time of despair and hopelessness and all the family members are acknowledged for their material and moral support.

May the Almighty God do you good.
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ABBREVIATION

CWA - Commonwealth of Australia
A.A.S - Atomic Absorption Spectrometer
ILO - International Labour Office
U.SA - United States Of America
WHO - world Health Organization
RD - Respiratory Disorder
SADC- Southern African Development Community
ABSTRACT

Although quarry dust has been associated with respiratory disorders (RD) little systematic research work has been done in Kenya inspite of quarry mining being a major socio-economic activity that generates huge amounts of revenue. This cross-sectional descriptive study was an attempt to determine the extent and scope of RD associated with quarry mining and the RD factors that the workers are subjected to. RD data were collected using structured questionnaires and interviews and clinical examination of the workers while the geological factors were determined by geological analysis of the rock and dust samples. Respondents with clinical evidence of RD were confirmed using roentigenography.

Out of 268 respondents approximately 4.5% of the respondent exhibited an RD ranging from pneumonia (0.4%), pulmonary tuberculosis (0.4%) emphysema (0.8%) to most important chronic bronchitis (2.2%). The most common RD symptomatology found was chest pain (20.9%) while the commonest clinical manifestation was crepitation (3%). The major geochemicals RD factors that was found in quarry rock and dust was Silicon dioxide, which was found to be 58.05% and 60.67% in the rock and dust samples respectively. Also duration of exposure $\chi^2 = 75.276$ p= .000, was the only statistically significance socio-demographic and occupational factor associated with RD genesis.

It is explicit that RD exist among workers in quarry mines. Also protective devices were largely unavailable or unused. Regulatory visit were also lacking. Taken together, it is suggested that stringent regulatory control be imposed while more research work be done to assess environmental impacts of quarry mines and dust characteristics as well as the clinical follow-up of the workers.
CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1: Introduction

Mining is an economic activity that is practiced globally (Lombe, 2003). ILO suggest that about 13 million people in close to 40 countries engage in small-scale mining and over all between 80 and 100 million depend on the mining economically (Lombe, 2003). Mining companies and individual miners dig metals and minerals from the ground for commercial purposes to meet continuously growing needs to manufacture products that are used in the agriculture, high-tech sector and merchandise products (World Bank, 2002).

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

Although mining industry contributes greatly to economic development, it is also an old occupation that has always been hazardous to human health (WHO, 1999), with a history dating back to Hippocrates time (Finkelstein et al., 2005). Studies have established that each day we are exposed to respiratory mineral particles derived from the soil and rocks (Gurhier et al., 1993). Numerous minerals including several varieties of silica have been studied with respect to pulmonary diseases and many appear to be toxic (Gurhier et al., 1995). However, not all dusts have been approved for exposure standards. It should not be assumed that this indicates that dusts that do not present health hazard (CWA, 2003).

Ironically, we breathe minerals and trace elements every day, including those brought to what comes from the environment and into our bodies (Banks, 2005).
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Although mining industry contributes greatly to economic development, it is also an old occupation that has always been hazardous to human health, (WHO, 1999), with a history dating back to Hippocrates time (Finkelman et al., 2005). Studies have established that each day we are exposed to respirable mineral particles derived from the soil and rocks (Guthrie et al., 1995). Numerous minerals including several varieties of silica have been studied with respect to pulmonary diseases and many appear to be toxic (Guthrie et al., 1995). However, not all dusts have been assigned exposure standards. It should not be assumed that this indicates that the unlisted dusts do not present health hazard (CWA, 2003).

Ironically, we breathe minerals and trace elements every day without giving a thought to what moves from the environment and into our bodies (Finkelman et al., 2005).
Inhalation is the most important route of entry of chemical agents into the body, followed by the skin contact and ingestion (Proctor, 1991). Respiratory system is the target organ for action of many environmental pollutants including dust because it serves as portal of entry for most of the pollutants in the work environment (Kashyap, 1994).

Silicosis, among other pneumoconiosis that are associated with inhalation of mineral dust such as lung cancer, pneumonitis and bronchitis (Hathaway et al., 1991) is a preventable fibronodular disease that affect millions of workers worldwide (Fedotov, 2003). Although the prevalence of silicosis has declined markedly in developed countries in recent decades because of effective industrial hygiene measures (Varkey, 2005), the disease still remains a long-term concern for both ILO and WHO, (Fedotov, 2003).

In a recent study, ILO estimated that in United States of America (U.S.A) 1.7 million workers were exposed to silica dust and about 10% were at risk of developing silicosis. In China 60, 000 new cases were reported in (1991- 1995) with incidence of 15 – 40,000, prevalence – 542, 000 (1998) and 1 million in 2002 with 5,000 deaths annually. In India 1.7 million were exposed to silica dust in mining and prevalence of silicosis was up to 55%. In Brazil 6.6 million were exposed to silica dust, and in South Africa there were 600,000 accumulated cases among miners with 30 – 50% prevalence in some industries (Fedotov, 2003).
The ILO/WHO programme for the elimination of silicosis supports national initiatives to participate in the programme to prevent silicosis through enforcement of law and regulations, establishment of standards, government advisory services, effective system of inspection, well organized reporting system and National Action Programme. While Kenya is not classified as a mining nation (World Bank, 2002), people engage in many activities such as quarrying and precious stones prospecting which generates and disperse dusts from the earth’s crust to the environment.

There is little information associating silicosis and other respiratory disease to mining in this country. This work was an attempt to provide basic information on RD associated with quarry mining. It is hoped that the information will provide a basis for further studies and policy reforms against silicosis.

1.2.0: Literature Review

1.2.1: History of Mining

Mining is an economic activity, which is practiced globally (Lombe, 2003). Researches suggest that about 13 million people in close to 40 countries engage in small-scale mining and over all between 80 and 100 million depend on the mining economically (Lombe, 2003). Mining companies and individual miners dig metals and minerals from the ground for commercial purposes to meet continuously growing...
needs to manufacture products that are used in the agriculture, high-tech sector and merchandise products (World Bank, 2002).

Although mining industry contributes greatly to economic development, it is also an occupation that is hazardous to human health (WHO, 1999). The history of the hazardous nature of mining dates back to Hippocrates who admonished his followers to always observe the environment of their patients (Rom, 1983). Similar observations by Georgius Agricola (1494 – 1555), describe disease entity consumption among miners many of whom died prematurely. Agricola emphasized the seriousness of the disease entity by noting that one woman was widowed by husbands who were miners seven times suggesting the frequency of deaths due to mining as an occupation. Further, Bernadino Ramazzini (1633 – 1714), the father of occupational medicine carried out extensive studies on occupational diseases among metal diggers and noted that the workers afflictions originated from inhalation of noxious gases and dusts (Rom, 1983).

Scientists began investigating the links between geologic substances, processes and medical conditions 300 years ago, and dusts have long been linked to human health problems (Finkelman et al., 2002). However, the potential for human exposure to dust released from road building, quarrying and natural weathering is poorly understood (Finkelman et al., 2002). Furthermore, not all dusts have been assigned exposure standards so it should not be assumed that the unlisted dusts do not present hazard to health (C W A, 2003).
Throughout history, different scholars have used different terms to describe the lung disease that is caused by inhalations of the mineral dust. In 1705, Ramazzini cited Diembrock’s to describe the lungs of stonecutters in whom he found heaps of sand. In running the knife through the vesicles, he felt as if he was cutting through sandy body (Varkey, 2005). In 1870, Viscont introduced the term; silicosis derived from Latin silex or flint (Varkey, 2005). Miner’s phthisis was used in South Africa during early 19th century (Marks, 2002). Currently, the commonly used terms are pneumoconiosis and silicosis (Varkey, 2005), which have been observed world wide as cited in the following paragraphs.

In Finland, heavy occupational exposure to quartz dust trace pack to mining in the 16th century, but the first diagnosis of silicosis in Finland was made in 1914 (Partanen et al., 1995).

Epidemics of silicosis have occurred in the United States since 1890’s (Harris, 2003). For example, in 1930 the construction of a water diversion tunnel through sandstone at Gauley Bridge, West Virginia caused many deaths and many other workers suffered ill effect from inhaling the dust (Rom, 1983).

Pneumoconiosis was observed to be one of the commonest serious occupational diseases in China because every year since 1980 there had been about 20,000 workers diagnosed and more that 5,000 workers had died annually from pneumoconiosis throughout the country (Zhong et al., 1995).
Silicosis was reported in South Africa and Zimbabwe in mid 1940s, in Tanzania in late 1940s and in Kagera tin mine, and Kilembe copper mine in 1950s. The First case of silicosis was diagnosed among diatomite workers in Kariandusi, Gilgil in 1946 (Sakari et al., 1996; Marks, 2002).

Although occupational medicine was slow to develop because of early laissez faire, attitude of corporations, the plethora of cheap migrant labour and the lack of unions to organize workers, (Rom, 1983; Marks, 2002), the situation is different now. The developed nations have advanced and expanded occupational medicine by training multidisciplinary professionals and established institutions and organizations that are devoted to controlling, managing and eradicating occupational diseases in mining industry (Rom, 1983). Note worthy are the World Health Organization (WHO) and the International Labour Organization (ILO), the united nations organizations that are implementing the ILO/WHO International Programme on Global Reduction of Silicosis by the year 2010 and eliminating it as an occupational health problem by 2030 (Fedotov, 2003).

1.2.2: The Compounds and Elements of the Earth.

According to the theory of the formation of the earth, the earth’s crust is made of 27.7% silicon, 46% Aluminum, 8% magnesium and 16.2% combination of calcium, potassium, iron and sodium (Parkes, 1974). All these fundamental inorganic compounds and elements form the earth’s crust (Parkes, 1974). The earth’s crust is
made of two zones. The upper zone is made of silica and Aluminium (SAL) while the lower zone is mainly made of silica and magnesium (SIMA) (Parkes, 1974).

Studies have established that each day we are exposed to respirable mineral particles derived from the soil and rocks. (Guthrie et al., 1995). Numerous minerals including several varieties of silica have been studied with respect to pulmonary diseases and many appear to be toxic (Guthrie et al., 1995). Ironically, we breathe minerals and trace elements every day without giving a thought to what moves from the environment and into our bodies (Finkelman et al., 2005).

Aluminum oxide (Al$_2$O$_3$) at a tolerant limit value of 10mg/m$^3$ dust containing no asbestos and <1% free silica was considered nuisance dust but caused minimal evidence of fibrosis (pneumoconiosis) and nonspecific bronchitis (Hathaway et al., 1991). Aluminium (AL) is the most abundant metal in the earth’s crust and the third most common element in the earth’s system by weight (Lide, 2005).

Calcium oxide (CaO) at a tolerant limit value 25 mg/ m$^3$ but levels of a 9–10 mg /m$^3$ caused irritation of the mucus membranes, ulceration and perforation of the nasal septum, inflammation of the respiratory track and pneumonia (Hathaway et al., 1991). Calcium is the fifth most common element in the earth system by weight and its compounds are found in many common rocks, for example, limestone and chalk (Lide, 2005).
Iron oxide dust and fumes (Fe$_2$O$_3$) at a tolerant limit value of 5 mg / m$^3$ total particulate as (Fe) When inhaled of they caused benign pneumoconiosis (siderosis) (Hathaway et al., 1991). Iron (Fe) is the fourth most common element in the Earth’s system by weight and it makes up much of earth’s core (Lide, 2005).

Magnesium Oxide (MgO) at a tolerant limit value of 10mg/m$^3$ when inhaled it caused irritation of the nose and metal fumes fever, an illness similar to influenza, characterized by fever, coughing, and oppression in the chest. (Hathaway et al., 1991). Magnesium (Mgo) is the seventh most common elements in the Earth’s system by weight (Lide, 2005).

Manganese and compounds (Mn) at a tolerant limit value of 5 mg/m$^3$ dust and compounds as (Mn) when inhaled it affected the nervous system resulting to manganese poisoning or manganism. Manganism is characterized by headache, asthesia, irritability, muscle weakness, speech impairment, in-coordination, impotence, tremor, excessive salivation, parkinson –like symptoms, mask like face, severe muscle rigidity, gait disorders and manganese psychosis which occurs frequently in miners (Hathaway et al., 1991).

Potassium hydroxide (KOH) at a tolerant limit value of 2mg/m$^3$ when inhaled in form of dust or mist it caused mild to severe destruction of tissues, corrosion of the pharynx and pneumoconiosis (Hathaway et al., 1991). Potassium is the sixth most common element in the earth system by weight (Lide, 2005). Similar observations
were made on the human health among those who inhaled sodium hydroxide (NaOH) (Hathaway et al., 1991). Sodium (Na) is the eighth most common element in the earth system by weight (Lide, 2005).

Crystalline Silica, (SiO₂) at a tolerant limit value of 2mg/m³ when inhaled it caused silicosis and increased incidences of lung cancer among mining, quarrying and tunneling workers (Hathaway et al., 1991). Silicon (Si) is the second most common element in the earth system by weight, (Lide, 2005). Silica occurs naturally in the earth's crust in many forms. However, Quartz, tridymite and cristobalite have been studied more extensively in relation to silicosis, a fibronodular lung disease caused by inhalation of dust containing crystalline silica, which is distributed widely or its polymorphs (tridymite or cristobalite), which are distributed less widely (Varkey, 2005). Quartz is the commonest of these. It occurs in rocks such as granite, sandstone, flint, slate and in certain coal and metallic ores (WHO, 1999). Inhalation of its dust is associated with silicosis and other respiratory diseases such as bronchitis, emphysema, pulmonary tuberculosis and lung cancer (WHO, 1999).

Dusts are small dry solid particles projected into air by natural forces such wind and volcanic eruption, as well as man – made processes such as drilling, crushing, conveying grinding, milling, demolition, shoveling, screening bagging and sweeping (WHO, 1999). Dusts are particles measuring below 75 microns in diameter. The dust particles usually remain suspended in the air for some time then they settle slowly under the influence of gravity (WHO, 1999). The most appropriate measure of dust is
the diameter of a hypothetical sphere of density $1\text{g/cm}^3$. They should have the same terminal settling velocity in calm air as the particle in question, regardless of its geometrical size shape and true destiny (WHO, 1999). This characteristic of dusts particles determines the period that the dust remains airborne, their possibility of being inhaled and where they may be deposited in the respiratory system (WHO, 1999).

When dusts with aerodynamics diameter greater than 30 microns are inhaled, they are deposited in the air passager between the nares, mouth and larynix. These are usually sneezed or spat out. Those with an aerodynamic diameter between 5.0 and 30 are deposited in the trachea, bronchi and bronchioles progressively. If they stay in situ long enough they cause irritation and tissue damage. They are usually coughed out or difused into the blood stream and to the target tissues and organs in the body (WHO, 1999). The smallest dust particles with aerodynamic diameters of 0.5 to 5.0 penetrate to the alveoli (WHO, 1999).

When silica is deposited into the alveoli the particles generate silicon-based radicals that lead to production of hydroxyl, hydrogen peroxide that damage cell membranes by lipid peroxidation and inactivate cell protein (Varkey, 2005). The macrophages are attracted to the site where they ingest the silica dust. The macrophages release cytoknes, tumour necrosis factors, interekun, leukotriene B-4, and factors that recruit other inflammatory cells. These activities cause inflammation, which damages resident cells and free extra cellular matrix transforming growth factors. Alpha
induces proliferation of type 2 pneumocytes, and other cytokines such as platelet and insulin-like growth factor. These stimulate fibroblasts, to proliferate that produce collagen which results to fibrosis. Silica particles outlive the alveola macrophages that ingested them, and results to repetition of the cycle of injury (Varkey, 2005).

Nodules form when the immune system forms fibrous tissue to seal the reactive areas. The disease may stop at this point or it may speed up and destroy large areas of the lungs. The fibrosis may continue even after exposure has stopped (Thomson Corporation, 2001). Silicosis is a cumulative chronic disease that takes 15 or more years of exposure to develop. It is manifested by shortness of breath on exertion, dry cough, congested heart failure, chest pain, hoarseness, anorexia that is accompanied by loss of weight and high risk for pulmonary tuberculosis (Thomson corporation, 2001).

1.2.3: Social demographic characteristics of Miners

In the clinical setting social demographic characteristics constitute the information, which helps the doctor to learn a patients medical history (Vickery et al., 1996). The process allows the patient and the doctor or (clinician) to talk and work together as partners to arrive at the correct diagnosis and choice of the best health care option (Vickery et al., 1996). The medical history provides information about the chief complains, present illness, past health history, social history which include occupational health, review of systems that involves complete physical examination, and laboratory tests or X-ray and other investigations that are necessary in arriving at
the diagnosis and the best treatment (Vickery et al., 1996). However, just as a medical history is important in any medical diagnosis, the evaluation of occupational illness depends on the occupational history finding, physical examination and results obtained from laboratory tests (or X-ray) which are often confirmatory and in some cases they raise the suspicion that the illness is work related (Frank, 1983).

In the light of this, it can be said that the identification of previously unrecognized occupational illness is largely dependent on the alert (clinician) or doctor who has suspected association between work and the patient’s ill health (Letz, 1991). So the literature review for this section sought information on age, sex, race home of origin, level of education, marital status, as well as work address, residences duration of exposure or employment, work location, symptoms, signs, clinical examination and X-ray to confirm respiratory diseases found among miners as explained in the remaining part of this section.

Age is an important component of medical history because certain age groups especially children, women of child bearing age and the elderly as well as certain age brackets in certain occupations are at risk of developing certain diseases more commonly than the general population (Wood et al., 1997). The existing literature points out that silicosis, a cumulative fibrotic lung disease among miners is mostly found in adults aged over 40 years (Thomson corporation, 2001).
Race has been noted to be an important factor for respiratory disease among miners. In South Africa, white miners suffer from silicosis while black miners are prone to tuberculosis, (Marks, 2002). In America silicosis mortality among black miners exceeds that among white miners (Varkey, 2005).

Literature has underscored sex as an important factor for pneumoconiosis. A study titled Silicosis in Women: experience from the Swedish pneumoconiosis register, 1931-1980 established that silicosis remained primarily a male disease because out of 4,700 cases in the records, only 53 were women (Gerhardsson, 1985). Although pneumoconiosis in women has not been studied extensively; it is a known fact that silicosis predominantly affects male workers. This reflects the occupational risk they face (Verkey, 2005).

Marital status informs whether a worker has dependants, and in most cases they acts as a driving force behind sustaining hazardous occupation among mine workers. In support of this argument (Lombe, 2003) pointed out that, in many Latin American, Asian and African countries endowed with mineral resources, small-scale mining supports entire rural communities providing in many cases the only source of household income. Further more, small-scale mining is a means of survival. No amount of legislative fire and brimstone or threat of physical dangers can prevent small-scale mining activities from occurring (Lombe, 2003). (Danielson, 2003) pointed out that the millions of people who make part or their entire livelihood from small scale or artisan exploitation of deposits support many more millions of family
members (Danielson, 2003). All these arguments point out that miner will sustain their employment to meet their households (family) economic needs, inspire of serious hazards in the work place.

General education and subsequently professional training in mining operations would be expected to inform mine workers of health hazards associated with the occupation and the protective measures. However, this is not feasible because information about mining in developing countries is often lacking and when available it is of poor quality since the occupation has not received the attention it deserves (Danielson, 2003). A recent meeting of occupational health professionals in the South Africa developing community (SADC) region noted the need for training and development of occupational health professionals across all the major categories of personnel (Loewenson, 1999). In the light of these the miners remain uniformed of health hazards associated with inhalation of mineral dust in their work place.

Inhalation is the most important route of entry of chemical agents into the body, followed by the skin contact and ingestion (Proctor, 1991). Respiratory system is the target organ for action of many environmental pollutants including dust because it serves as portal of entry for most of the pollutants in the work environment (Kashyap, 1994).

Occupational history is a critical component of making a diagnosis of an occupational disease (Frank, 1983). The respiratory occupational history constitute information on
the nature of occupation, duration of employment (duration of exposure), past occupational history (previous employment or exposure) and other non occupational practices that may result to respiratory diseases, which included cigarette smoking (Frank, 1983). The physical form and state of the chemicals which may be dust, fumes, mist, gas, liquid, solid and combination is the other component of making a diagnosis of an occupational respiratory diseases (Piantanida, 1991). Further, the operation information in relation to chemical activities and in this case dust generating are identified and they include cutting, drilling, dumping, pounding, shacking, shoveling, which may be indoor or outdoor (WHO, 1999).

Symptomatology is an essential aspect of making an occupational respiratory disease diagnosis, but it must be noted that this depends on the physician’s (Clinicians) ability to think of symptoms and their association with specific exposures (Frank, 1983). Symptoms for dust exposure include dyspnoea, chest pain, cough and weight loss (Varkey, 2005). The clinical signs of occupational respiratory mine dust related disease include rales, wheezing and other unusual sounds in the chest may be as a result of dust exposure in the work place (Frank, 1983). The central occupational respiratory evaluating laboratory tests includes chest X-ray that helps to confirm suggestions from the history or suspicions developed during the physical examination (Frank, 1983).

Use of protective measures, and individual work practices are an important factor in making an occupational respiratory disease diagnoses. (Piantanida et al., 1991).
Personal worker protective equipment includes use of respirators, face mark, gloves, prons, boots, face shields and goggles and appropriate clothing (Piantanida et al., 1991). Use of these protective measures protect the workers from inhaling the dust and minimize the evolution and development of occupational respiratory diseases (Piantanida et al., 1991).

Working and residing in the mines is another factor for making occupational respiratory disease diagnoses among miners. (Marks, 2002). During the apartheid era in South Africa, black miners remained migrants with no urban residence and they spent most of their working lives often on the same mine (Marks, 2002). Observation revealed that the longer the contracts, the longer the time the black miners spent on the mines and therefore the more they were exposed. That increased their chances of reactivating tuberculosis infection and the likelihood of contracting silicosis (Marks, 2002).

The work location is also important factor in making occupational respiratory disease diagnosis among miners and this has been established in several studies. During the construction of Gauley Bridge tunnel in western Virginia, in 1930 – 1931) the worst epidemic of silicosis occurred (Varkey, 2005). More than 400 of the estimated 2000 men who drilled rock died of silicosis, and almost all the survivors developed silicosis (Varkey, 2005). In 1902 it was calculated that a rock drill worker in Cornwall had an average of eight years work before dying of phthisis (silicosis) and in South Africa it was four years (Marks, 2002). This statement also points out that
duration of exposure is an important factor for evolution and development of silicosis.

Silicosis, (Among other disease that are associated with inhalation of mineral dust in the mining industry such as lung cancer, pneumoconiosis, bronchitis and emphysema), (Hathaway et al., 1991) is a preventable well-known fibrotic lung disease. It causes progressive permanent physical disability and affects millions of workers worldwide (Fedotov, 2003). Although the prevalence of silicosis has declined markedly in developed countries in recent decades because of effective industrial hygiene measures (Varkey, 2005), the disease remains a long-term concern for both ILO and WHO (Fedotove, 2003).

In a recent study, ILO estimated that in United States of America (U.S.A) 1.7 million workers were exposed to silica dust and about 10% were at risk of developing silicosis. In China 60,000 new cases were reported in (1991-1995) with incidence of 15 – 40,000, prevalence – 542,000 (1998) and 1 million in 2002 with 5,000 deaths annually. In India 1.7 million were exposed to silica dust in mining and prevalence of silicosis was up to 55%. In Brazil 6.6 million were exposed to silica dust, and in South Africa there were 600,000 accumulated cases among miners with 30 – 50% prevalence in some industries (Fedotov, 2003).

The ILO / WHO programme for the elimination of silicoses that aims at eradicating silicosis by the year 2030, supports national initiatives to participate in the
programme to prevent silicosis through enforcement of law and regulations, establishment of standards, government advisory services effective system of inspection, well organized reporting system and national action programmes (Fedotove, 2003). While Kenya is not classified as a mining nation (World Bank, 2002) people engage in many activities such as quarrying that generate and disperse dusts from the earth’s crust to the environment.

There is little information associating silicosis and other respiratory disease to mining in this country. This work aimed to collect broad information from quarry mines in Embakasi to inform that quarry dust inhalation could be associated with frequently reported respiratory disease symptoms and signs among the quarry mine workers. It is hoped that the information will result to further studies and policy reforms to fight silicosis and eliminate it by the year 2030.

1.3.1: Justification

Mining is one of the oldest industries and it has always been a hazardous occupation since Hippocrates time (ROM, 1983). Silicosis, the pulmonary disease, which is caused by inhalation of mineral dust, silica, is commonly found among miners (WHO, 1999). Silica is the most abundant disease-causing mineral in the earth’s crust (Lide 2005). Studies have established that exposure to mineral dust containing silica causes pneumoconiosis ‘dusty lungs’, and other respiratory diseases such as bronchitis, chronic air flow limitation, emphysema, lung cancer and increased risk of pulmonary tuberculosis (WHO, 1999) Although there is scanty information on
diatomite dust hazards, nothing has been done on quarry mining occupational hazards in Kenya and yet quarry mining in this country is a major social economic activity generating huge revenues and a major employer. Dust and associated minerals induce an array of medical disorders especially in association with the respiratory system. There are no systematically set out studies that are published which address the occupational health effects of quarry mining anywhere. Thus the health concerns of the workers in this industry, in this country and elsewhere remains undressed. Hence, this study is an attempt to address mineral and dust respiratory health effects affecting quarry mine workers in Embakasi.

1.3.2 Null Hypothesis

There is no association between RD occurrences, sociodemographic and occupational factors among quarry mine workers in Embakasi.

1.3.3 General Objective

To identify the types of occupational respiratory disorders and the risk factors that are associated with the development of respiratory disorders among quarry mine workers in Embakasi.
1.3.4 Specific Objectives

1. To identify the social demographic characteristics and occupational factors of quarry mine workers in Embakasi quarry mines.

2. To identify the common occupational respiratory disorders among quarry mine workers in Embakasi.

3. To determine the chemical nature of quarry rock and dust quarry in Embakasi quarries.

4. To determine the occupational history of the workers and its relation to RD development among Embakasi quarry workers.
2.0: MATERIALS AND METHODS

2.1: The Study Area

The study was carried out among quarry workers in Mihang'o and Mukami Locations, in Embakasi Division, Eastern part of Nairobi City. The city lies at 1,570 meters above sea level, 0° and 34' south of the equator and longitude 36° and 38' east. The quarries were started between 1956 and 1982 and they are situated along the Embakasi River. They lie on either side of the river and extend from behind Sinai to behind Njiri slums (Appendix 1). The quarries are bordered by former colonial white settlers sisal plantation. The land has since been subdivided and legally or illegally allocated to the local government, societies and private developers who have built housing schemes which include Donholm, Uniaa Kiongozi, Kayole and Mihang'o. The slum includes Njiri, Metopeni, Soweto, Kware and Sinai.

Most quarries had one-roomed residential houses that were situated in the quarry sites. The Embakasi river valley forms an informal settlement that has temporarily residential rooms. These rooms house quarry workers and the general public.

The quarries are bordered by large heaps of boulders and dust. The wind blows dust from the quarries and over the neighboring residential areas, causing them to travel from east to west.

There were several quarries which were naturally organized into two towns and four. The dominant operating quarries were named after prominent river acts.
2.0: MATERIALS AND METHODS.

2.1: The Study Area
The study was carried out among quarry workers in Mihang’o and Mukuru Locations, in Embakasi Division, Eastern part of Nairobi City. The city lies at 1,670 meters above sea level, 0° and 34° south of the equator and longitude 36° and 38° east. The quarries were started between 1956 and 1982 and they are situated along the Embakasi River. They lie on either side of the river and extend from behind Sinai to behind Njiru slums (Appendix 1). The quarries are bordered by former colonial white settlers sisal plantation. The land has since been subdivided and legally or illegally allocated to the local government, societies and private developers who have built housing schemes which include Donholm, Umoja Komarock, Kayole and Mihango. The slum includes Njiru, Matopeni, Soweto, Kware and Sinai.

Most quarries had one-roomed residential houses that were situated in the quarry sites. The Embakasi river valley forms an informal settlement that has temporally residential rooms. These rooms house quarry mine workers and the general public. The quarries are bordered by large heaps of ballasts and dust. The wind blows over the quarries and over the neighboring residential areas soaking them with quarry dust from east to west.

There were sixteen quarries, which were naturally organized into clusters of threes, twos and one. The thirteen operating quarries were naturally stratified into five sets.
based on their geographical proximity and therefore assumed to share the same rock. Each quarry had a different owner and the workers varied in number ranging from 6–40 mine workers. The quarries were conveniently situated to access them for clinical examinations and follow up of study respondents.

2.2: Study Population

The study population constituted individuals who worked in the Embakasi quarry mines and were listed as quarry mine workers by quarry mine operators. In each of the 13 operating quarries the study population included all the individuals who met the inclusion criteria as described in part 2.5 below. It was difficult to estimate the quarry miners at the time of the study due to high worker turnover and mass lay offs due to economic hardships also in response to the demand to close the quarries by neighbouring community.

2.3: The Study Design

The study was descriptive cross-sectional in design that allowed narrative description of the social demographic characteristics prevailing respiratory disorders and occupational factors that may be associated with the genesis of respiratory diseases among the quarry mine workers.
2.4: Sampling Procedure and Sample Size Determination

The sample size was determined using cluster sampling in a two-stage sampling scheme in accordance with (Kirkwood, 1988). Briefly the method allows random sampling of first-stage unit and investigation of all second-stage unit when little extra costs is involved, when the respondents are to be remunerated and when it appears illogical to remunerate a portion of the respondents instead of the total study population.

2.4.1: The sample size determination

The Nairobi area was randomly sampled as the province of study among the eight provinces of Kenya. Embakasi division was purposively selected against no other quarry site in Nairobi. In Embakasi there were 16 quarries but in the pilot study 3 quarries were closed. The remaining 13 quarries suffered worker-lay-offs so that probability sampling was not possible. Consequently, the procedure, which was adapted, was cluster sampling in accordance with (Kirkwood et al., 1988).

2.4.2: Sample Size Determination Using Cluster Sampling.

All the second-stage unit (study population) from the selected first-stage unit (Embakasi, cluster) in a two-stage sampling schemes were investigated (Kirkwood, 1988) after permission was sought from the relevant authorities to carry out the study.
as explained in part 2.5 of this chapter. Only the 13 operating quarries were investigated because they provided quarry workers, dust and rock samples, and the factors that this study set out to investigate. The operating quarries were visited one at a time permission was sought from the administration to access the workers in each quarry. The list of quarry workers, which was provided by the administration, was used to verify that each respondent worked in the specific quarry. Only 268 (262 males and 6 females) respondents were sampled.

Within the context of investigating all the second-stage unit (study population) from the selected first-stage unit (Embakasi cluster) in a two-stage sampling scheme (Kirkwood, 1988), rock and dust were sampled from each of the 13 operating quarries (Kirkwood, 1988). To determine the work location where rock and dust were to be sampled from: drilling, crushing, sorting and gate keeping were identified as the work locations where quarry workers were deployed to work always. The four-work locations were listed down. The work locations were numbered 1 to 4. Each number was assigned a random number from the ten thousand random digit tables (Kirkwood, 1988). The random numbers were arranged chronologically in ascending orders. The random numbers were traced retrogressively and matched with the work location it corresponded with. The sorting work location appeared on top of the list of the work locations. This way, the sorting work location was randomly sampled as the area where rock and dust were sampled from (Kirkwood, 1988).
To sample the rock, a wooden spatula measuring 1 inch wide and 6 inches long was pushed into the ballast heap horizontally then lifted gently. The rocks that rested on the spatula were stored in a plastic bag paper. To sample the dust, another wooden spatula measuring 1 inch wide and 6 inches long was pushed into the dust heap horizontally and lifted gently. The dust that rested on the spatula was stored in a separate plastic bag. Rock and dust samples were collected using the same procedure. A new spatula was used to collect each sample, and stored in separate new plastic bags. A total of 13 rock samples and 13 dust samples were collected from all the 13 operating quarries. (Juvenen, 1989).

However, the Department of Geology, Ministry of Natural Resource of the Government of Kenya was the only one that offered to analyze the rock and dust sample at a reasonable cost and without any other strings tied to the exercise. They advised analysis of one rock and one dust sample, for reasons that the geochemicals that were required were known to them and they were similar in all the quarries; and that analyzing all the samples would be a waste of their scarce resources. This new development called for the representative rock and dust sampling for analysis.

The representative quarry and subsequently the rock and dust were sampled randomly in accordance with (Kirkwood, 1988). The names of the 13 operating quarries were each written on a separate card. The cards were turned upside down and shuffled. The top card was picked and turned upside up and the name Virji Vishram was on the
card. This way Virji Vishram quarry was sampled randomly and the rock and dust samples labeled with the name were presented for analysis in accordance with (Juvenen, 1989).

2.5: Inclusion and Exclusion Criteria

The persons who had worked in the quarry mines for one or more days on the day the questionnaire was administered and those who had never smoked were included in the study. Those persons who had not worked in the quarry mines for at least one day on the day the questionnaire was administered those who had ever smoked and those who participated in the pilot study were excluded from the study.

2.6: Ethical Consideration

Permission was sought from the Ministry of Education Science and Technology; quarry Administrators and Participants to carry out the study (Appendix 8). Participation was voluntary and participants were allowed to terminate their participation at any stage of the study process unconditionally. The respondents were also assured of confidentiality.
2.7: Data Collection

2.7.1: Pilot Study

A pilot study was carried out to including 20 respondents who were subsequently excluded from the actual study. The purpose of the pilot study was to assess the questionnaire instrument in a real situation.

2.7.2: Interviews

The questionnaire was administered to obtain the social demographic data, family medical history, and personal medical and occupational histories. The data were used to determine the background, the respiratory disorder symptoms and exposure factors, which may augment the evolution and development of respiratory disorders.

2.7.3: Rock and Dust Analysis

The rock and dust samples were analyzed in accordance with (Juvenen, 1989). The representative rock sample was ground into fine dust (75 microns) using pulverizing machine for 36 seconds. The fine dust samples weighing 0.1000g were dissolved in 100 ml plastic bottles and digested overnight in total solution of 0.5 ml hydrochloric acid (HCL) and 0.5 ml nitric acid (HN03). Then, 5mls boric acid (H3BO3) was added and the solutions were left to stand for two hours. These preparations were subjected to geo-chemical analysis using Atomic Absorption Spectrometer (A.A.S.) in accordance with (Juvenen, 1989) to identify silica, aluminium, calcium, magnesium,
sodium, manganese, potassium, titanium and iron, mineral that are known causes of pneumoconiosis and other respiratory diseases in accordance with (Parkes, 1974).

2.7.4: Clinical Assessment

2.7.4.1: Respondent Physical Examination

The respondents were verified from official list of the quarry mine works for clinical physical examination. The examinations were carried out by the researcher (experienced nurse clinicians) at the quarry mines. Blood pressure was measured in the standard clinical way using a sphygmomanometer and a stethoscope to capture heart failure that is usually a complication of respiratory diseases. Respondents were evaluated for stooping gait, clubbed fingers, cyanosis and pulling up to increase lung capacity and are suggestive of airflow limitation. Further, the nostrils were inspected for purulent or bloody nasal discharges and polyps suggestive of persistent irritation the throats for congestion, inflammation and enlarged tonsils suggestive of upper respiratory tract infection. The chests were observed for abnormal shape or movement as the respondents breathed quietly. The chests were auscultated using a stethoscope, to identify the position of the trachea, airflow on inspiration and expiration, rales, rhonchi, wheezing and crepitations all of which may characterize respiratory disorders. The respondents with symptomatology and clinical sign were recruited to undergo chest radiography.
2.7.4.2: Confirmation of symptomatology and clinical features

In addition, respondents with symptoms and sign of respiratory disorder were referred to a physician for confirmation of clinical features and diagnosis.

2.7.4.3: Roentigenography of the respondents

Respondents presenting with clinically confirmed respiratory disorders and symptomatology were accessed for chest x-ray examination by the project. All x-ray tests were done at a professional institution in Afya Centre, Nairobi. The results interpreted by a practicing clinical radiologist at the same center. The results were then medically illustrated from x-ray films by the department of human pathology, University of Nairobi (Medical Illustration Unit) Subsequently, these were presented as recommended by (WHO, 1986).

2.8: Data Management and Analysis.

Data were checked to ensure accuracy at the end of each day’s work and subsequently entered into the computer regularly. Further, data were analyzed using SPSS (Statistical Package for Social Sciences, Chicago, Illinois) computer package to quantify social demographic, symptoms, clinical signs, confirmed respiratory disorders as well as occupational exposure factors. Cross-tabulation and Chi-Square test statistic were used to establish significance levels. The mine worker environmental factors that are associated with pneumoconiosis and other respiratory diseases in the mining industry namely participant age, duration of exposure to mine
dust, residence, work locations (drilling, crushing, sorting, loading and gate keeping), the high dust exposure zones were organized into tables to establish their relationship with those found in the literature (WHO, 1999).

The rock and dust samples were analyzed for fundamental minerals those exits naturally in the earth’s crust and are known causes of pneumoconiosis and respiratory diseases in accordance with (Juvenen, 1989; Parkes, 1974). The results were organized in a table to show the relationship between the minerals quantities in the quarry rock and dust samples.
CHAPTER THREE: RESULTS

3.0.0: SOCIAL DEMOGRAPHIC CHARACTERISTICS

3.0.1: Work Address

The respondents were recruited from thirteen quarries, which were all situated in the Embakasi quarry site. Most of the respondents (36.3%) were recruited from Kenya Builders Quarry Mines. Virji Vishram and Grisit Quarries accounted for 12.3% and 10.5% of the respondents respectively. Brokers supplied a further 7.5% (Table 1).

3.0.2: Sex Distribution

Quarry mining was found to be a male dominated occupation (97.8%) and only 2.2% of the workforce was women (Table 2).

3.0.3: Race

The majority of quarry workers were African (97.4%) and the rest were Indians who worked as site foremen and managers (Table 3).
3.0.0: SOCIAL DEMOGRAPHIC CHARACTERISTICS.

3.0.1: Work Address

The respondents were recruited from thirteen quarries, which were all situated in the Embakasi quarry site. Most of the respondents (30.3%) were recruited from Kenya Builders Quarry Mines. Virji Vishram and Orbit Quarries accounted for 12.3% and 10.5% of the respondents respectively. Brokers supplied a further 7.5% (Table 1).

3.0.2: Sex Distribution

Quarry mining was found to be a male dominated operation (97.8%) and only 2.2% of the workforce was women (Table 2).

3.0.3: Race

The majority of quarry mineworkers were Africans (97.4%) and the rest were Indians who worked as site foremen and managers (Table 3).
Table 1: Respondent Work Address (n=268)

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Respondent (n=268)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samji Vishram</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td>Orbit</td>
<td>28</td>
<td>10.5</td>
</tr>
<tr>
<td>Rabadia</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Twiga</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>National Concrete</td>
<td>12</td>
<td>4.5</td>
</tr>
<tr>
<td>Kay Company</td>
<td>14</td>
<td>5.2</td>
</tr>
<tr>
<td>Kenya Builders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quarry mines</td>
<td>40</td>
<td>14.9</td>
</tr>
<tr>
<td>Karsan Murji</td>
<td>22</td>
<td>8.2</td>
</tr>
<tr>
<td>Virji Vishram</td>
<td>33</td>
<td>12.3</td>
</tr>
<tr>
<td>Patel Concrete</td>
<td>5</td>
<td>1.9</td>
</tr>
<tr>
<td>Bhimji Ramji</td>
<td>21</td>
<td>7.8</td>
</tr>
<tr>
<td>Diamond</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td>Mugoya</td>
<td>21</td>
<td>7.5</td>
</tr>
<tr>
<td>Others</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>268</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

* Brokers from all the quarries were officially recognized and they worked in the quarries full time.
### Table 2: Sex Distribution

<table>
<thead>
<tr>
<th>Sex</th>
<th>Respondents (n=268)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>262</td>
<td>97.8</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Total</td>
<td>268</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 3: Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Respondent (n= 268)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africans</td>
<td>261</td>
<td>97.4</td>
</tr>
<tr>
<td>Indians</td>
<td>7</td>
<td>2.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>268</td>
<td>100</td>
</tr>
</tbody>
</table>

### 3.0.4: Respondent Age Distribution

The quarry mineworkers were aged between 18-68 years. The youngest group aged 18-20 years were 5 (1.9%) of the 268 respondents. Most respondents (80.6%) were aged between 21 and 50 years. The oldest workers were in the group 51-68 years and were 47 (17.5%), (Figure 1).

### 3.0.5: Origin of the Respondent

The data revealed that out of 268 respondents, the majority 90 (33.6%) of quarry mine workers came from Eastern Province, followed by Western Province 64
(23.9%), Nyanza Province 46 (17.2%) and Central 31 (11.6%). Rift Valley Province had 23 (8.6%) while Nairobi had the least 6 (2.2%) Indians. Among all regions of Kenya, North Eastern Province was not represented and only one (0.4%) respondent came from Korongwe, Tanga, Tanzania. One (0.4%) of the Indians came from Kiambu, Central Province (Table 4).

More detailed data analysis by districts revealed that certain districts contributed more quarry workers than others. For instance Kakamega and Vihiga districts had 52 (19.4%), Machakos had 43 (16%) and Makueni had 34 (12.7%). Siaya district was fourth with 23 (8.9%) respondents. Kuria, Bomet, Nakuru, Nandi, Kwale, Wundanyi and Korongwe contributed 1 (0.4%) respondent each (Table 4).
### Table 4: Respondents District of Origin

<table>
<thead>
<tr>
<th>Province/District</th>
<th>Respondent (n=268)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nairobi</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Central Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiambu</td>
<td>5</td>
<td>1.9</td>
</tr>
<tr>
<td>Nyandarua</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>Murang’ a</td>
<td>10</td>
<td>3.7</td>
</tr>
<tr>
<td>Nyeri</td>
<td>7</td>
<td>2.6</td>
</tr>
<tr>
<td>Thika</td>
<td>5</td>
<td>1.9</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>Eastern Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mbeere</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Meru</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Machakos</td>
<td>43</td>
<td>16.0</td>
</tr>
<tr>
<td>Mwingi</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Makueni</td>
<td>34</td>
<td>12.7</td>
</tr>
<tr>
<td>Kitui</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Coast Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kwale</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Wundanyi</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Tanzania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanga-</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Province/District</th>
<th>Respondent (n=268)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Busia</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Butere Mumias</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Bungoma</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Kakamega Vihiga</td>
<td>52</td>
<td>19.4</td>
</tr>
<tr>
<td>Rift Valley Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakuru</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Maralal</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Bomet</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Trans-Nzoia</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Samburu</td>
<td>14</td>
<td>5.2</td>
</tr>
<tr>
<td>Nandi</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Nyanza Province</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bondo</td>
<td>5</td>
<td>1.9</td>
</tr>
<tr>
<td>Kisumu</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>Migori</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>Kisii</td>
<td>7</td>
<td>2.6</td>
</tr>
<tr>
<td>Kuria</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Homa Bay</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Suba</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Siaya</td>
<td>23</td>
<td>8.6</td>
</tr>
</tbody>
</table>
3.0.6: Respondents Working Residence.

 Majority of the respondents 156 (58.2%) resided in the quarry site while working. 94 (35.1%) resided in the quarry neighborhood and only 18 (6.7%) of the 268 respondents resided away from the quarry site (Figure 2).
3.0.7: Respondent Education Level

Majority of quarry mine labour force (91.8%) had formal education and only (8.2%) had no formal education. The level of education found among respondent included adult literacy (1.1%), primary education (58.2%) and secondary (31.7%), (Figure 3).

Figure 3: Respondent Education Level (n=268)
3.0.8: **Respondent Professional Training**

In terms of professional training, no quarry mineworkers had formal institutional training on operation of quarry mines. Out of the 268 respondents, 119 (44.4%) had no formal training in any profession. 29 (10.8%) had different trainings, which were unrelated to quarrying, and therefore the skills were not being utilized. These included book keeping, secretarial, spraying and painting, water technology, surveying and earthwork, sale and marketing, community development, construction and plant engineering, pharmacy technology, welding, carpentry, electrical technology, security, store keeping and masonry. Among them, 120 (44.8%) had formal or informal training and the skills were being utilized. The skills included driving, crusher operation, motor vehicle mechanic and drilling. Both employees and the management did not value institutional training as necessity for quarry operations (Table 5).

3.0.9: **Respondent Marital Status**

Majority of quarry mineworkers 216 (80.6%) were married, 37 (13.8%) was single, 8 (3%) were divorced, 6 (2.2%) were widowed while (1.1%) were widowed but remarried (Figure 4). Thus, the majority over 85% of the quarry mineworkers were obliged to work in order to support their families. In this instance 231 (86.2%) of the respondents had children, a figure including even workers who were divorced. Some of the singles supported their children as single parents. They also supported their
own parents and relatives. Only 10 of the 37 singles indicated that they had no dependants.

**Table 5: Distribution of Respondent based on their Professional Training (n=268)**

<table>
<thead>
<tr>
<th>Type of Professional Training</th>
<th>(n=268)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crusher Operator</td>
<td>53</td>
<td>19.8</td>
</tr>
<tr>
<td>No Training</td>
<td>34</td>
<td>12.7</td>
</tr>
<tr>
<td>Driller</td>
<td>119</td>
<td>44.4</td>
</tr>
<tr>
<td>Welder</td>
<td>10</td>
<td>3.7</td>
</tr>
<tr>
<td>Storekeeper</td>
<td>10</td>
<td>3.7</td>
</tr>
<tr>
<td>Mechanic</td>
<td>2</td>
<td>.7</td>
</tr>
<tr>
<td>Security Officer</td>
<td>23</td>
<td>8.6</td>
</tr>
<tr>
<td>Sales and Marketing</td>
<td>2</td>
<td>.7</td>
</tr>
<tr>
<td>Spray painting</td>
<td>2</td>
<td>.7</td>
</tr>
<tr>
<td>Office keeping</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td>Construction work</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td>Carpentry</td>
<td>2</td>
<td>.7</td>
</tr>
<tr>
<td>Surveying</td>
<td>7</td>
<td>2.6</td>
</tr>
<tr>
<td>Masonry</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td>Total</td>
<td>268</td>
<td>100%</td>
</tr>
</tbody>
</table>
Out of 268 respondents, 62 (23.1%) presented single or multiple respiratory disorder symptoms. In total, there were six (6) symptoms that respondents complained of, with the highest frequency of 56 (20.9%) breathlessness, 24 (9.0%), 23 (8.6%), 15 (5.6%), 14 (5.2%) and 10 (3.8%), none or irrelevant symptoms 107 (40.0%).

Figure 4: Respondent Marital Status (n=268)
3.2.0: RESPIRATORY DISORDERS AMONG THE RESPONDENTS

3.2.1: Respondent Respiratory Disorders Symptoms

Out of 268 respondents, 62 (23.1%) presented single or multiple respiratory disorder symptoms. In total there were six (6) symptoms that respondents complained of repeatedly. Chest pain had the highest frequency of 56, (20.9%) breathlessness, 28, (10.4%), tightness in the chest, 24 (9%), (daily) coughs, 38, (14.2%), cough with phlegm 14, (5.2%), bloody sputum 1, (0.4%), none or irrelevant symptoms 107 (40.1%) (Figure5).

Figure 5: Respondent Respiratory Disorders Symptoms (n=268)
3.2.2: Clinical Findings among Symptomatic respondents

Out of 268 respondents 62 had respiratory disorder symptoms. There were 6 defaulters among the 62 symptomatic respondents who did not present themselves for clinical examinations. Hence only 56 respondents were clinically examined. Those respondents who were examined revealed that the nasal polyps had frequency of 16 (6%), inflamed nostrils 1 (0.4%), congested throat 7 (2.6%), enlarged inflamed uvula 1 (0.4%) Further, 3 (1.1%), had stooping gait and 5 (1.9%), had clubbed fingers (Table 6).

Table 6: Physical Examination Finding Among The Symptomatic Respondents

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Respondent Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gait</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>53</td>
<td>94.64</td>
</tr>
<tr>
<td>Stooping</td>
<td>3</td>
<td>5.36</td>
</tr>
<tr>
<td><strong>Fingers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clubbed</td>
<td>1</td>
<td>1.79</td>
</tr>
<tr>
<td>Normal</td>
<td>50</td>
<td>89.29</td>
</tr>
<tr>
<td><strong>Nose</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyps</td>
<td>16</td>
<td>28.57</td>
</tr>
<tr>
<td>Inflamed nostrils</td>
<td>1</td>
<td>1.79</td>
</tr>
<tr>
<td>Normal</td>
<td>39</td>
<td>69.64</td>
</tr>
<tr>
<td><strong>Throat</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congested</td>
<td>7</td>
<td>13.87</td>
</tr>
<tr>
<td>Inflamed tonsils</td>
<td>9</td>
<td>16.07</td>
</tr>
<tr>
<td>Enlarged inflamed uvular</td>
<td>1</td>
<td>1.79</td>
</tr>
<tr>
<td>Normal</td>
<td>39</td>
<td>69.64</td>
</tr>
<tr>
<td><strong>Chest Appearance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swelling on left clavicle</td>
<td>1</td>
<td>1.79</td>
</tr>
<tr>
<td>Normal</td>
<td>55</td>
<td>98.21</td>
</tr>
</tbody>
</table>
3.2.3: Clinical Sign Manifested by Symptomatic Respondents

Further clinical examination of the 56 out of 268 study respondents showed that some individuals had single while others had multiple signs of lower respiratory disorders. Crepitations and wheezing had the highest frequency of, (3%) each. Rhonchi and Pleural rub had a frequency of (2.2%) each while reduced air entry into the lungs and rales had a frequency of (1.5%) and, (1.1%) respectively. Trachea deviation to the right and loud systolic heartbeat had a frequency of, (0.7%) each. Heart murmur and chest pain with tenderness had a frequency, (0.4%) each. Nothing abnormal detected, (26.8%) (Figure 6).
3.2.4: Radiographic Findings

Only, 15 of the 56 symptomatic respondents presented themselves for radiography and 3 (5.36%) of them had normal chests while 12, (21.43%) of X-ray films showed 5 respiratory disorders. chronic bronchitis had the highest frequency of 6, (10.71%), emphysema 5, (8.93%) bronchiectasis 2, (3.57%). Pneumonia 2 (3.57), pulmonary tuberculosis had a frequency of 1, (1.79%) (Figures & and plate 1-15).

![Pie chart showing radiographic frequencies]

Figure 7: Radiographic (RD) Frequency
Plate 1: Chest radiograph of a 51 years old man with 10 years of quarry dust exposure. Working as a drilling supervisor and blasting expert. The radiograph shows that the heart and the mediastinum are within normal. There are healed fractures of the right 5th, 6th, and 7th posterior ribs noted accident was sustained 5 years ago. There are generalized bilateral increased bronchovascular markings noted over both lung fields. Conclusion: Bilateral chronic Bronchitis.
Plate 2: Chest radiograph of a 52 years old man with 15 years of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There is generalized increase in the broncho-vascular markings bilaterally with bronchial cuffin in the hilar region, suggesting bilateral bronchitis.
Plate 3: Chest radiograph of a 32 years old woman with 10 years of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There is generalized bilateral increase in broncho vascular markings with some degree of air trapping noted an indication of bilateral chronic bronchitis.
Plate4: Chest radiograph of 42 years old man with 25 years of quarry dust exposure shows that the heart and mediastinum are within normal. There is cystic dilation of the bronchi in both bases suggestive of cystic bronchiectatic changes secondary to chronic bronchial irritation.
Plate 5: Chest radiograph of 68 years old man with 48 years of quarry dust exposure.

The radiograph shows that the heart and mediastinum are within normal. There is flattening of both diaphragms with increase in the intercostals air space and reduction of the bronchovascular markings suggestive of emphysematous changes. There is increase in the pleural size in both bases suggestive of past pleural infection that is indicative of bilateral emphysema with past-healed pleural infection.
Plate 6: Chest radiograph of a 35 years old with 15 years of quarry dust exposure.

The radiograph shows that the heart and mediastinum are within normal. There is cystic dilatation of the bronchi in both bases suggestive of cystic bronchiastic changes secondary to chronic bronchia irritation, an indication of bilateral basal cystic bronchiectasis.
Plate 7: Chest radiograph of a 41 years old man with 12 years of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There are bilateral basal increases in lung markings. Minimal flattening of the diaphragm suggestive of early emphysematous changes noted.
Plate 8: Chest radiograph of a 49 years old woman with 12 years of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There is widening of inter-costal spaces ‘dark’ aspects of lung tissue due to reduced lung parenchyma. There is flattening of diaphragm and increased opacity in the right lower lobe, suggestive of pneumonia with generalized chronic obstructive pulmonary airway disease.
Plate 9: Chest radiograph of a 38 years old man with 15 years of quarry dust exposure. The radiograph shows that the heart and the mediastinum are within normal. There are generalized bilateral increased broncho vascular markings noted over both lung fields, and indication of bilateral chronic bronchitis.
Plate 10: Chest radiograph of a 60 years old man with 27 years of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There are increased bilateral broncho vascular markings all over lung fields, which affect the bronchi and fellow vessels, consistent with chronic bronchitis. Healed pleuritic infection is noted in the right base. Both hemidiaphragms are flattened consistent with chronic obstructive pulmonary airway disease, suggestive of healed pleuritic infection chronic bronchitis with chronic obstructive pulmonary airway disease.
Plate 11: Chest radiograph of a 28-year-old female with one year of quarry dust exposure. The radiograph shows that the heart and mediastinum are within normal. There is increased opacity of the lung parenchyma in both lung fields consistent with pneumonia. Air is replaced by fluid, appears more white. Breakdown of the lung parenchyma causes thin walled cavities in the areas of pneumonic processes, which are in both mid zones. Suggestive: of Bilateral pneumonia with an early cavitation consistent with pulmonary tuberculosis.
Plate 12: Chest radiograph of a 65 years old man with 37 years of quarry dust exposure. The radiograph shows that the heart and the mediastinum are within normal. There is some flattening of both diaphragms with widening of intercostal spaces suggestive of generalized emphysematous changes.
Plate 13: Chest radiograph of a 26 years old man with 6 years of quarry dust exposure. The radiograph shows that the heart is normal size and configuration. There is no hilar or mediastinal lesion. The pulmonary vasculature is normal. The thoracic case is normal. Indicating a normal chest radiograph
Plate 14: Chest radiograph of a 28-year-old woman with 3 years of quarry dust exposure. The radiograph shows that the heart is within normal limits. Both lungs are clear. The right breast shadow is not seen. Thoracic cage is normal indicative of normal chest radiograph with right mastectomy.
Plate 15: Chest radiograph of a 20-year-old man with 3 years of quarry dust exposure. The radiograph shows that the heart is within normal size and configuration. There is no hilar of mediastinal lesion. The pulmonary vascular is normal. The thoracic cage is normal, an indication of a normal radiograph.
3.3.0: Respiratory Disorder Factors

3.3.1: Rock and Dust Analysis

The Atomic Absorption Spectrometer (A.A.S) analysis identified the samples as Kapiti phonolite rock and dust. Both samples had the same geo-chemical profile although the constituents were variable between rock and dust.

The respiratory disorder factors found in quarry rock were Silicon dioxide (58.05%), Aluminium dioxide (16.90%), Calcium oxide (1.10%), Magnesium oxide (1.15%), Sodium oxide (6.95%), Potassium oxide (5.95%), Titanium dioxide ((1.93%), Manganese oxide (0.30%) and Iron dioxide (4.09%) (Table5).

Dust constituents included Silicon dioxide (60.67%), Aluminium dioxide (18.5%), Calcium oxide (0.85%), Magnesium oxide (0.89%), Sodium oxide (7.5%), Potassium dioxide (5.55%), Titanium dioxide (1.53%), Manganese oxide (0.35%) and Iron dioxide (3.88%) (Table5). Silicon dioxide the most important risk factor for respiratory disorders was more in the dust than in the rock samples.

Table 5: Rock and Dust Samples Geochemical Analysis

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>TiO₂</th>
<th>MnO</th>
<th>Fe₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonolite Rock</td>
<td>58.05</td>
<td>16.90</td>
<td>1.10</td>
<td>1.15</td>
<td>6.95</td>
<td>5.25</td>
<td>1.93</td>
<td>0.30</td>
<td>4.09</td>
</tr>
<tr>
<td>Phonolite Dust</td>
<td>60.67</td>
<td>18.5</td>
<td>0.85</td>
<td>0.89</td>
<td>7.25</td>
<td>5.55</td>
<td>1.53</td>
<td>0.35</td>
<td>3.88</td>
</tr>
</tbody>
</table>
3.3.2: Duration of Exposure to Quarry Rock and Dust, and Respiratory Disorders

Out of 268 respondents, (57.8%) had an exposure duration of 1-10 years, with RD prevalence of 3.2%, $\chi^2 = 18.846$, $P = .277$. Seventy (26.1%) had an exposure duration of 11-20 years, with a prevalence of 5.7%, $\chi^2 = 7.939$, $P = .439$. In addition, (13.4%) had an exposure duration of 21-30 years, with a prevalence of 2.8% ($\chi^2 =2.8\%, \chi^2 = 8.164$, $P = .515$). Seven (2.6%) had an exposure duration of over 30 years, with a prevalence of 2.8.6% $\chi^2 =75.276$ $P$. This finding indicated that there is direct relationship because as the years of exposure increased also the prevalence of RD increased (Table 8).

Table 8: Duration of Exposure to Quarry Dust and Respiratory Disorders (n=268)

<table>
<thead>
<tr>
<th>Exposure Duration in years</th>
<th>Total Exposed Participants</th>
<th>Exposed but With RD</th>
<th>Exposed Without Rd</th>
<th>$\chi^2$</th>
<th>df</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>57.8</td>
<td>1.9</td>
<td>56.0</td>
<td>18.846</td>
<td>16</td>
<td>.277</td>
</tr>
<tr>
<td>11-20</td>
<td>26.1</td>
<td>1.5</td>
<td>24.6</td>
<td>7.939</td>
<td>8</td>
<td>.439</td>
</tr>
<tr>
<td>21-30</td>
<td>13.4</td>
<td>0.4</td>
<td>13.1</td>
<td>8.164</td>
<td>8</td>
<td>.418</td>
</tr>
<tr>
<td>Over 30</td>
<td>2.6</td>
<td>0.75</td>
<td>1.9</td>
<td>75.276</td>
<td>8</td>
<td>.000</td>
</tr>
</tbody>
</table>
3.3.3: Age Distribution and Respiratory Disorders

Out of 268 respondents (1.9%) were aged 15-20 years, and none had respiratory disorders. (35.1%) were aged 21-30 years, with RD prevalence of 3.2%, \( \chi^2 = 6.927, \ P = .554 \). 24.6% were aged 31-40 years, with, a prevalence of 4.5%, \( \chi^2 = 5.658, \ P = .666 \). (20.9%) were aged 41-50 years, with a prevalence of 3.6%, \( \chi^2 = 10.219, \ P = .250 \). (17.5%) were over 50 years of age, with a prevalence of 8.5%, \( \chi^2 = 12.309, \ P = .138 \), this finding indicated that as age progressed the prevalence of RD increased (Table 9).

Table 9: Age and Respiratory Disorders (n = 268)

<table>
<thead>
<tr>
<th>Participant Age in Years</th>
<th>Total Exposed Participants</th>
<th>% Participants with RD</th>
<th>Participants without RD</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 20</td>
<td>1.9</td>
<td>0.0</td>
<td>1.9</td>
<td>239</td>
<td>8</td>
<td>1.000</td>
</tr>
<tr>
<td>21 – 30</td>
<td>35.1</td>
<td>1.1</td>
<td>34.0</td>
<td>6.927</td>
<td>8</td>
<td>.544</td>
</tr>
<tr>
<td>31 – 40</td>
<td>24.6</td>
<td>1.1</td>
<td>23.5</td>
<td>5.658</td>
<td>8</td>
<td>.686</td>
</tr>
<tr>
<td>41 – 50</td>
<td>20.9</td>
<td>0.75</td>
<td>20.1</td>
<td>10.219</td>
<td>8</td>
<td>.250</td>
</tr>
<tr>
<td>Over 50</td>
<td>17.5</td>
<td>1.5</td>
<td>16.0</td>
<td>12.309</td>
<td>8</td>
<td>.138</td>
</tr>
</tbody>
</table>
3.3.4: Residence and Respiratory Disorders

Out of 268 respondents, (58.2%) resided in the quarry site, with RD prevalence of 4.9%, $\chi^2=7.057$, $P=0.530$. Another (35.1%) resided in the quarry neighborhood, with a prevalence of 5.3%, $\chi^2=7.778$, $P=0.455$. However, (6.7%) resided far away from the quarry site, and none of them had confirmed respiratory disorders. This finding indicated that the RD prevalence was higher among respondents residing in quarry site than those in the neighborhood, while those residing away had no RD, (Table 10).

Table 10: Residence and Respiratory Disorders Among Quarry Mineworkers (n=268)

<table>
<thead>
<tr>
<th>Participant Residence</th>
<th>Total Exposed %</th>
<th>Exposed with RD %</th>
<th>Exposed Without RD %</th>
<th>$\chi^2$</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarry site</td>
<td>58.2</td>
<td>2.6</td>
<td>56</td>
<td>7.057</td>
<td>8</td>
<td>0.530</td>
</tr>
<tr>
<td>Quarry neighborhood</td>
<td>35.1</td>
<td>1.9</td>
<td>33.2</td>
<td>7.778</td>
<td>8</td>
<td>0.455</td>
</tr>
<tr>
<td>Far from Quarry site</td>
<td>6.7</td>
<td>0.0</td>
<td>6.7</td>
<td>0.904</td>
<td>8</td>
<td>0.999</td>
</tr>
</tbody>
</table>
3.3.5: Work Location and Respiratory Disorders

Out of 268 respondents, (7.5%) worked in the drilling work location with a prevalence of 5%, $\chi^2 = 13.769$, $P = .842$, (32.1%) worked in the crushing work location with a prevalence of 2.3 %, $\chi^2 = 13.47$, $P = .859$, (43.3%) worked in the loading work location and with a prevalence of 5.9, $\chi^2 = 13.47$, $P = .859$, (3.4%) worked in the sorting work location with a prevalence of 11.1%, $\chi^2 = 4.771$, $P = 1.000$, (15.3%) worked in the gate keeping work location with, a prevalence of 7.3 %, $\chi^2 = 9.111$, $P = .522$. These findings suggest that all work locations were hazardous since RD prevalence was distributed in all work-locations. However the loading section had the highest prevalence perhaps because of forceful dispersion of dust by falling products from a height (Table 11).

Table 11: Participant Work Location and Respiratory Disorders (n=268)

<table>
<thead>
<tr>
<th>Participant Work location</th>
<th>Total Exposure %</th>
<th>Exposed with RD %</th>
<th>Exposure Without RD %</th>
<th>$\chi^2$</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td>7.1</td>
<td>0.4</td>
<td>7.1</td>
<td>13.769</td>
<td>20</td>
<td>.842</td>
</tr>
<tr>
<td>Crushing</td>
<td>32.1</td>
<td>0.75</td>
<td>31.3</td>
<td>5.573</td>
<td>10</td>
<td>.850</td>
</tr>
<tr>
<td>Loading</td>
<td>43.3</td>
<td>2.6</td>
<td>4.7</td>
<td>13.421</td>
<td>20</td>
<td>.859</td>
</tr>
<tr>
<td>Sorting</td>
<td>3.4</td>
<td>0.4</td>
<td>3.0</td>
<td>4.771</td>
<td>20</td>
<td>1.000</td>
</tr>
<tr>
<td>Gate keeping</td>
<td>13.8</td>
<td>0.4</td>
<td>13.4</td>
<td>9.111</td>
<td>10</td>
<td>.522</td>
</tr>
</tbody>
</table>
3.3.6: Use of Respiratory Protective Devices and Practices

Out of 268 respondents, majority (64.6%) said they worked for normal eight hours while the remaining said they worked for more than eight hours a day. However, whenever the quarry products were in high demand everybody worked for longer hours than usual to meet the demand, and to earn extra income. (35.5%), $\chi^2 = 10.826$, P 37/1 took annual leave while the remaining 173 (64.6%) did not. However, handkerchiefs over the mouth and nose, dust masks- filter type, respirators, pre-medical and periodic medical examinations and work rotation from high to low dust exposure and vice versa respiratory protective devices and practices were used by less than 25% of the study population each. This finding established that the Embakasi quarry mine workers rarely used the respiratory system protective devices or practices. Thus exposing themselves to greater risk of developing RD (Table 12).

Table 12: Use of Respiratory Protective Devices and Practices Among Quarry Mine Workers n = 268

<table>
<thead>
<tr>
<th>Protective Devices and Practices</th>
<th>Yes</th>
<th>No</th>
<th>$\chi^2$</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handkerchief over mouth and nose</td>
<td>3.0</td>
<td>97.0</td>
<td>.559</td>
<td>20</td>
<td>1.000</td>
</tr>
<tr>
<td>Dust filter type</td>
<td>20.9</td>
<td>79.1</td>
<td>8.256</td>
<td>20</td>
<td>.990</td>
</tr>
<tr>
<td>Air oxygen Respirator</td>
<td>0.75</td>
<td>99.3</td>
<td>.136</td>
<td>10</td>
<td>1.000</td>
</tr>
<tr>
<td>Pre-employment medical exam</td>
<td>0.4</td>
<td>99.6</td>
<td>.068</td>
<td>10</td>
<td>1.000</td>
</tr>
<tr>
<td>Periodic medical exam</td>
<td>1.1</td>
<td>98.9</td>
<td>.205</td>
<td>10</td>
<td>1.000</td>
</tr>
<tr>
<td>Worked normal 8 hrs a day</td>
<td>64.6</td>
<td>35.4</td>
<td>5.900</td>
<td>10</td>
<td>.824</td>
</tr>
<tr>
<td>Work rotated from high</td>
<td>1.1</td>
<td>98.9</td>
<td>.205</td>
<td>10</td>
<td>1.000</td>
</tr>
<tr>
<td>Dust to low and vice versare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take annual leave regularly</td>
<td>35.4</td>
<td>64.6</td>
<td>10.826</td>
<td>10</td>
<td>.371</td>
</tr>
</tbody>
</table>
CHAPTER FOUR: DISCUSSION

This study was an attempt to identify the factors that encourage respiratory disorders development, and the common occupational respiratory disorders (RD) among quarry mine workers in Embakasi. Before this work, no systematic studies had been done to delineate the occupational health problems of quarry mine workers in this country, even though quarry mining in Embakasi dates back to 1930.

Over all, this study has revealed the common respiratory disorders among quarry mine workers, and also, the quarry mine workers were exposed to local factors that may drive the genesis of respiratory diseases of this group of workers. The study revealed that duration of exposure was the most important factor in RD development. However, age, residence, work location and lack of use of protective devices were also associated with RD genesis. These findings find support in published literature. Where, quarry mine workers have been shown to develop pneumoconiosis. In this study 5 RD were found among the quarry mine workers. The most important RD was chronic bronchitis. In published information on quarry occupational environments, silicosis is usually the leading pneumoconiosis. However, it was evident that chronic bronchitis and emphysema were the most observed. Although literature shows that little attention has been given to other respiratory diseases that affect miners, there is scanty evidence to report this result (Amanah et al., 1995, WHO, 1987, Marka, 2002, WHO, 1998, ILO, 1974).
4.0: DISCUSSION

This study was an attempt to identify the factors that encourage respiratory disorders development, and the common occupational respiratory disorders (RD) among quarry mine workers in Embakasi. Before this work, no systematic studies had been done to delineate the occupational health problems of quarry mine workers in this country, even though quarry mining in Embakasi dates back to 1956.

Over all, this study has revealed the common respiratory disorders (RD) affecting quarry mine workers, and also, the quarry mine rock and the dust geo-chemical factors that may drive the genesis of respiratory disorders in this group of workers. The study revealed that duration of exposure was the most important factor in RD development. However, age, residence, work location and lack of use of protective devices were also associated with RD genesis. These findings find support in published literature. Where, quarry mineworkers have been shown to develop pneumoconiosis. In this study 5 RD were found among the quarry mine workers. The most important RD was chronic bronchitis. In published information on dusty occupational environments, silicosis is usually the leading pneumoconiosis. However, it was evident that chronic bronchitis and emphysema were the key RD found. Although literature shows that little attention has been given to bronchitis and other respiratory diseases that affect miners, there is scanty information that supports this result (Amandus et al., 1995; WHO, 1999; Marks, 2002; Varkey, 2005; Parkes, 1974).
Firstly, this study established that the Embakasi quarry mine workers were exposed to factors that cause pneumoconiosis among miners. Their work environment was heavily polluted by clouds of dust inherent of quarrying processes. The processes included drilling, blasting, crushing, sweeping, conveying, grinding, filling and emptying movers, dumping, storing ballasts and dusts in huge heaps. These processes generated and dispersed potentially respirable dust to the work environment, neighborhood and beyond. This allowed the wind to blow about the dust; an indication that the quarry mine workers, neighbors and people living in far distances were exposed to mineral dusts that causes pneumoconiosis. Pneumoconiosis is the general term for diseases that develop as a result of accumulation of inhaled mineral dust in the lungs and the tissue reaction to its presence (WHO, 1999). Pneumoconiosis is associated with dusty occupations, which include mining, quarrying, tunneling, stone cutting, construction and demolition, pottery, tombstone and brick work among others (WHO, 1999).

Secondly, this study established that the quarry mine workers suffer from an array of RD that ranged from the most important chronic bronchitis and emphysema to Bronchiectasis, pneumonia and pulmonary tuberculosis, but failed to establish silicosis, literature shows that little attention has been given to other respiratory disorders that affect miners when compared to silicosis. However, there is scanty published information that support this finding.
Silicosis is a fibronodular lung disease caused by inhalation of dust containing crystalline Silica (Varkey, 2005). Silica is a general term for Silicon dioxide (SiO₂). The commonest polymorphs of silica are Quartz, Tridymite and cristobalite. Of these, quartz is the most widely distributed. It is found in numerous rock types, soils and beach sands, (Guthrie et al., 1995). Silicon makes up to 25.7% of the earth's crust by weight and it is the second most abundant element after oxygen. Silicon occurs mostly as oxide, silicate, sand, quartz, rock crystal, amethyst, agate, flint, jasper, opal chalcedony and chert. Miners, stonecutters and others engaged in work where dust is breathed in large quantities often develop the serious lung disease silicosis (Lide, 2005). A study titled Silicosis and lung cancer among workers in North Carolina dusty trades (Amandus et al., 1995) found increased mortality for white male silicotics due to bronchitis, emphysema and other respiratory diseases which included, influenza, asthma, lung cancer and tuberculosis (Amandus et al., 1995).

In my view, (Amandus et a., 1995) study findings paint a picture of exposure of mixed dust to workers in the dusty trades who subsequently suffered mixed respiratory diseases and silicosis. In view of these it can be concluded that Embakasi quarry mine workers suffered mixed RD as a result of exposure to mixed quarry dust which constituted 58.05% and 60.67% SiO₂ for rock and dust samples respectively. The remaining portion constituted Al₂O₃, CaO, MgO, Na₂O, K₂O, TiO₂, MnO, and Fe₂O₃. However, the absence of silicosis among quarry mine workers could be attributed to reduced levels of Silica (SiO₂) and mixed dust. This is a concern for future research.
Thirdly, this study found duration of exposure to be statistically significant while age residence, work location and luck of use of respiratory protective devices and practices had insignificant statistical association for RD genesis among the quarry mine workers. This finding was expected and it finds support in the published work.

Duration of exposure is the most important factor for respiratory disease genesis among miners (WHO, 1990). Miners, stone cutters and others engaged in work where dust-containing Silica is breathed in large quantities often develop a serious lung disease known as silicosis (Lide, 2005). Chronic Silicosis may take 15 or more years of exposure to develop. Accelerated Silicosis appears after 5-10 years of intensive exposure. Acute Silicosis develops within six months to 2 years of intense exposure with high risk for tuberculosis (Thormson Corporation, 2005).

In this study it appeared that the prevalence of RD increased as age advanced. Those aged below 30 years hardly suffered RD, while those aged 30-40 years mainly suffered from chronic bronchitis. The older, aged 40-60 years suffered from an array of chronic conditions including emphysema, a serious disease characterized by irreversible destruction of alveoli walls. This finding was expected but it found scanty support from occupational health literature.

One source stated that Silicosis is mostly found in adults aged over 40 (Thormson Corporation, 2005). Another source stated that no precise information associating age with (pneumoconiosis) and specifically Silicosis was available (Varkey, 2005).
However, community health literature argued that everyone in the general population is at risk of getting ill and dying. Old people are more at risk because they suffer from chronic and degenerative diseases like bronchitis and heart failure. (Wood et al., 1997).

In view of this argument, inhalation of mine dust causes bronchitis and heart failure or cor pomonale as they call it while aging process causes similar conditions. In this respect, it can be concluded that exposure to quarry mine dust coupled with degenerative aging process accounted for increased RD among older quarry mine workers.

Increased RD prevalence was observed among quarry mine workers who worked and resided in the quarry site followed by those who worked in the quarries but resided in the neighborhoods. None of the workers who resided away from the quarry site exhibited RD. This result was expected and it finds support in the published literature.

During the South African apartheid era, it was observed that black miners remained migrant with no urban residence. An increasing majority of the black mine workers spent most of their working lives mostly in the same mine. The longer the contract the longer the total time they spent on the mines and this exposed black miners to conditions which reactivated tuberculosis and their likelihood of contracting Silicosis (Marks, 2002).
The majority quarry mine workers were rural to urban migrant from all over Kenya except North Eastern province. They have no urban residence, they worked and resided often in the same quarry site or worked in the quarry site and resided in the neighborhood; the environments that were heavily polluted by quarry dust. This increased exposure resulting in the increased prevalence of RD.

The loading work location had increased prevalence of RD among other work locations which included drilling, crushing, sorting and gate keeping. This finding was unexpected since drilling has been cited as the most hazardous work location in the published literature.

The activities carried out in the loading work location included filling and emptying movers using shovels and tippers. The processes involved dropping ballast and dust from heights. The forceful falls dispersed clouds of dust. In my view, in the absence of use of respiratory protective devices such as face masks, the forceful air containing the dust penetrated the respiratory system with the dust that resulted in the increased prevalence of RD among the workers in the loading work location.

Respiratory protective devices such as face mask, handkerchief over the mouth and nose were largely unused. Respiratory protective practices such as pre and periodic medical examination, working for 8 hours a day, rotation from high to low dust
concentration zones and vice versa, and taking annual leave regularly were largely unused. This finding was expected and it finds support in the published literature.

In the early 1980's, sandblasters were employed in Permian Basin, in West Texas to prepare pipes, tanks and manifolds. They were exposed to high respirable free Silica of 400-700 µg/m³. The workers used little or no respiratory protection and as a result they development accelerated Silicosis (Harris, 2005).

The RD Prevalence was predominantly increased among males who were also married rural to urban African migrants. This finding had support in various published sources (Gerhardsson, 1995; Marks, 2002; Amandus et al., 1995; Rom, 1983).
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1: Conclusions

From the findings of this study the following conclusions are drawn:

1. The majority of Embakasi quarry mine workers are young, single, urban African male migrants.

2. This study established that the Embakasi quarry mine workers suffer from mixed exposure to silica dust and other airborne pollutants such as lead, X-rays, bronchitis, bronchiectasis, pneumonia, pulmonary fibrosis, and emphysema. (Table 6 and Figures 5-22).

3. The quarry dust is hazardous to Embakasi quarry mine workers because the mixed dust particles were potentially respirable and SiO₂, the most abundant mineral in the earth's crust that is known to cause pneumoconiosis constituted over 58% of rock and dust samples. (Table 7).

4. Duration of exposure was found to be most significant factor in the general health among Embakasi Quarry mine workers.
5.0: CONCLUSION AND RECOMMENDATIONS

5.1: Conclusions

From the findings of this study the following conclusions are made:

1. The majority of Embakasi quarry mine workers were unskilled, rural to urban African male migrants.

2. This study established that the Embakasi quarry mine workers suffer from mixed respiratory disorders, which were confirmed and categorised by chest X-rays as bronchitis, bronchiectasis, pneumonia, pulmonary tuberculosis, and emphysema. (Table 6 and Figures 5-22).

3. The quarry dust is hazardous to Embakasi quarry mineworkers because the mixed dust particles were potentially respirable and SiO₂, the most abundant mineral in the earth’s crust that is known to cause pneumoconiosis constituted over 58% of rock and dust samples. (Table 7).

4. Duration of exposure was found to be most significant factor for RD genesis among Embakasi Quarry mine workers.
5.2: Recommendations

1. An education programme should be implemented. The purpose of the programme will be to educate the employers and the workers that quarry dust is hazardous to health and that it is necessary to put in place the necessary measures to control the work environment and to use respiratory protective devices and administrative practices.

2. Legal framework should be put in place to provide for policy regulations, alternate hazards and exposure controls and to facilitate administrative RD preventive practices.
REFERENCES


APPENDICES
APPENDIX 1

MAP OF KENYA NAIROBI AREA SHOWING THE STUDY AREA

- PROVINCIAL BOUNDARY
- RIVER
- MAIN ROAD
- QUARRIES

NAIROBI CITY CENTER
E mbakas RIVER
NGONG ROAD
KAREN/ LAGATA
E mbakas RIVER
Nairobi INTERNA PONAL AIRPORT
JOMO KENYATTA
Ruaraka, KASSARANI
Dandora
Komo Rock Road
Quarries

KENYA
Appendix 2

CONSENT FORM

About the researcher and the study

My names are Lucy Kithinji. I am a second year Master of Public Health and Epidemiology student in Kenyatta University. I am carrying out a study in quarry mining to meet part of the requirements for the course.

The information that you will give will be treated in confidence. However, should your questionnaire response sound to be suggestive of disorder, you will be requested to undergo further testing.

Your participation will be voluntary.

CONSENT

1. Respondent

Name........................................... Date..................................................

Signature...........................................

(a) Quarry site

(b) Quarry neighbourhood

2. Interviewer

Name........................................... Date..................................................
Appendix 3

QUESTIONNAIRE ON RESPIRATORY SYSTEM DISORDERS

Instructions:
(a). Answer all questions correctly and to the best of your knowledge.
(b). The information you will give will be treated in confidence.
(c). Should your information be suggestive of respiratory system disorder, you will be required to undergo further testing to determine diagnosis and referral for treatment. All further procedures will be carried out with your consent.

Personal Data:
1. Date of interview
2. Name of cluster
3. Name of the respondent
4. Sex [ ] Male [ ] Female
5. Age in completed years
6. Home address
   (a). District
   (b). Province
7. Residence while working (tick correct answer)
   (a). Quarry site
   (b). Quarry neighbourhood
   (c). Far from the quarry site?
8. Educational level (tick correct answer)
   (a). Std 1 4
   (b). Std 5 7/8
   (c). Form 1 2
   (d). Form 3 - 4/6
   (e). Others...
9. State your career / Professional training.
10. State the year when you last attended school.
11. Marital status
(a). Single
(b). Married
(c). Divorced
(d). Widowed

12. Indicate the number of dependants and their relationship to you
   How many children (under 18 years) ...........................................
   How many adults (over 18 years) ............................................

   Medical History (Family)

13. Indicate if there is a member of your family who suffered / suffers from any of the following. Also indicate their relationship to you.

   Relationship Disease ................................................. Yes No.
   .........(a). Asthma .................................................
   ......... (b). Chronic Cold with persistent running nose ........
   .........(c). Pulmonary tuberculosis ................................

   Past Personal Medical History

14. Have you ever had any of the diseases listed?
   (Tick correct answer only)
   (a). Injury or operation affecting your chest ................................
   (b). Pleurisy ...............................................................
   (c). Bronchitis ..........................................................
   (d). Pneumonia ......................................................
   (e). Pulmonary Tuberculosis ........................................
   (f). Heart trouble ...................................................
   (g). Hay fever ........................................................
   (h). Any other chest trouble ...........................................

   Tobacco Smoking Habits

15. Have you ever smoked? ................................................
16. Have you given up smoking in the last month? ...............
17. How old were you when you started smoking regularly?
   ...................... Year ......................... Months
18. Which brand of cigarette do you smoke? .........................
19. Smokers only - How old were you when you gave up smoking?

............. Year ............. Months

20. Those who quite smoking - Why did you stop smoking.

Present Personal Respiratory Medical History

<table>
<thead>
<tr>
<th>Cough</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Do you usually cough first in the morning? (On getting up?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Do you usually cough during the day or at night?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Do you cough most on any particular day of the week?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Do you cough like this for most days, as much as 3 months each year?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. If “Yes”, which day (s)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Do you usually bring up any phlegm from your chest first thing in the morning? (On getting up)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Phlegm

27. Do you usually bring up any phlegm from your chest during the day or at night? | | |

28. Do you bring up phlegm like this on most days for as much as 3 months each year? | | |

If “yes” to 29. ask:

29. How long have you had this phlegm? Years months

Periods of cough and phlegm

30. In the past 3 years have you had the period increased? | | |

Cough and Phlegm lasting for 3 weeks or more? | | |

31. Have you had more than one such period? | | |

Tightness in chest

32. Does your chest ever feel tight or your breathing becomes difficult? | | |

33. Do you get this apart from colds? | | |

If “yes”, when | |

34. Is your chest tight or your breathing difficult on any particular days? | | |

If “yes”, specify:

(a) Most of the first days back at work only? | | |
35. Has your chest ever been tight or your breathing difficult on any particular days?
   If "yes", specify:

   (a) Most of the first days back at work only                  ☐ ☐
   (b) Other day(s) also?                                      ☐ ☐
   (c) Only other days?                                         ☐ ☐

   If "no" to (34), ask (35)

36. Are you troubled by shortness of breath when hurrying on level ground or
    walking up a slight hill?
   If "yes", ask:

37. Do you get short of breath walking with other people of your own age on level
    ground?
   If "yes", specify:                                           ☐ ☐

38. Is your breathlessness worse on any particular day?
   If "yes", specify: ..............................................

**Past personal occupational history**

39. Have you ever worked in a dusty job
   Yes ☐ No ☐ For how many years ________________

40. __ in a coal mine?
   Yes ☐ No ☐ ________________

41. __ in any other mine?
   Yes ☐ No ☐ ________________

42. __ in a quarry?
   Yes ☐ No ☐ ________________

43. __ in a foundry?
   Yes ☐ No ☐ ________________

44. __ in a pottery?
   Yes ☐ No ☐ ________________

45. __ in cotton, flax, or hemp mill?
   Yes ☐ No ☐ ________________

46. __ with asbestos?
   Yes ☐ No ☐ ________________

47. __ in any other dusty Job?
   Yes ☐ No ☐ ________________

   If "yes", specify:.................................................................
48. Have you ever been exposed regularly to an irritating gas or to chemical fumes?

Present personal occupational history

49. Which one of the following is your present work place?

- (a) Drilling
- (b) Crushing
- (c) Sorting
- (d) Loading
- (e) Gate keeping

50. How long have you worked in your present occupation _____ years _____ months

51. How long have you worked in your present work area _____ years _____ months

52. Do you work in shifts? No

53. How many hours in a day do you work in the quarry? _____ hours per day.

54. How many days a week do you work in the quarry? __________

55. Which is your first work day of the week? Monday

56. Which are your week days off the quarry (Fill in the space)

57. How many days in a year are you off the quarry (Holiday _____ days per year. Where do you stay during the holiday (Fill in the space)

58. Which was your previous work area in the quarry before your present position and for how long?

Protective measures (observe and fill)

59. (a) Respiratory system protection (tick correctly) Yes No

- Handkerchief over the mouth and nose
- Dusty masks (filter type)
<table>
<thead>
<tr>
<th>Respirator</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (Oxygen supplied respirator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) <strong>Hearing and ears protection</strong> (tick correctly)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ear plugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ear muffs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) <strong>Hygiene/personal practices</strong> (tick correctly)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall/dusty coat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gloves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leggings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goggles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel toe capped shoes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helmet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing conveniences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin protective creams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) <strong>Administrative protective practices</strong> (tick correctly)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-employment medical examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodic medical examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Works normal 8 hours per day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work rotated from less dusty areas to more dusty areas and vice versa regularly at least twice a year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takes annual leave regularly away from work place.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
60. **Physical medical examination**

**Factor**

a. Gait

b. B.P.

c. Cyanosis

d. Clubbing of fingers

e. Nose

f. Throat

g. Chest

**Percussion and auscultation**

a. Trachea

b. Rales

c. Ronchi

d. Pleural rub

e. Crepitations

f. Wheezing

g. Others

61. **Radiological Chest Examination**

(a) Anterior posterior (AP) exposure with deep inspiration

(b) Lateral oblique exposure with deep breathing.

**Conclusive Remarks**
APPENDIX 4

ASSAY CERTIFICATE

SENDER'S NAME: Mrs. Lucy Mwari Kithinji
P.O. Box 26475,
NAIROBI.

Charges Kshs:
Off. Receipt No.

INSTRUCTIONS:

*Carry out complete chemical analysis on the samples submitted by the above firm*

LABORATORY NO: 2821

SENDER'S REF.: *As given below*

<table>
<thead>
<tr>
<th>Lab. NO.</th>
<th>Ref.</th>
<th>SiO₂ %</th>
<th>CaO %</th>
<th>MgO %</th>
<th>Na₂O %</th>
<th>K₂O %</th>
<th>TiO₂</th>
<th>Fe₂O₃ %</th>
<th>Al₂O₃ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2821</td>
<td>Phonolite Dust</td>
<td>60.67</td>
<td>0.85</td>
<td>0.89</td>
<td>7.25</td>
<td>5.55</td>
<td>1.53</td>
<td>3.88</td>
<td>18.5</td>
</tr>
</tbody>
</table>

This is to certify that the above results were obtained from this office

*For: Commissioner of Mines & Geology*

*Phillip K. Bor (Chief Chemist)*
ASSAY CERTIFICATE

SENDER’S NAME: LUCY MWARI KITHINJI

INSTRUCTIONS:

Carry out complete chemical analysis on the gypsum sample submitted by the above firm

LABORATORY NO: 2807

SENDER’S REF.: (KAPITI PHONOLITE)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>TiO₂</th>
<th>MnO</th>
<th>Fe₂O₃</th>
<th>LOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2807</td>
<td>58.05</td>
<td>16.90</td>
<td>1.10</td>
<td>1.15</td>
<td>6.95</td>
<td>5.25</td>
<td>1.93</td>
<td>0.30</td>
<td>4.09</td>
<td>3.55</td>
</tr>
</tbody>
</table>

Phillip K. Bor (Chief Chemist)
For: Commissioner of Mines & Geology
Appendix 6

KENYATTA UNIVERSITY
DEPARTMENT OF ZOOLOGY

The Administrator/Manager,
Embakasi Quarries Mines,
Nairobi,
Kenya.

Dear Sir,

RE: LUCY M. KARI KITHINJI

The above name is a second year Master of Public Health and Epidemiology student in this University. She is interested in carrying out a study on quarry mines as part of her course requirement.

The purpose of this letter is to introduce Lucy M. Kithinji to you and to request you to assist her to meet her study objectives.

Thank you in advance for your kind help.

Yours faithfully,

[Signature]

DR. MBITHI
CO-ORDINATOR, HEALTH SCIENCES
KENYATTA UNIVERSITY.

e.c. - Dr. Sakari V. A.O.
Director of Occupational Health and Services,
Ministry of Labour.

Enc. List of quarry sites.
The Administrators/Managers
Embakasi Quarry Mines
Nairobi
KENYA

Dear Sir,

RE: LUCY MWARI KITHINJI

The above named is a second year master of Public Health and Epidemiology student in Kenyatta University. She is interested in carrying out a study on quarry mining as part of her course requirement.

The purpose of this letter is therefore to introduce Lucy M. Kithinji to you and to request you to assist her to meet her study objectives.

Thanking you in advance for your co-operation and assistance.

Yours faithfully

Dr. Sakari W.D.O.
DIRECTOR
DIRECTORATE OF OCCUPATIONAL HEALTH AND SAFETY SERVICES

C.C. Dr. J.N. Mbithi
Kenyatta University
Co-ordinator Health Science

Encl. List of quarries
Appendix 8

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

Telegram: "Education", Nairobi
Telephone: Nairobi 334411
When replying please quote
Ref. No. MOE 13/001/31C 75/2
and date

Lucy Mwari Kithinji
Kenyatta University
P.O. BOX 43844
NAIROBI

Dear Madam

RESEARCH AUTHORIZATION

Please refer to your application for authority to conduct research on 'Respiratory Disorders Associated with Quarry Mining'.

I am pleased to let you know that you have been authorised to conduct research in Nairobi for a period ending 31st December, 2001.

You are advised to pay courtesy calls to the Provincial Commissioner and Provincial Director of Education Nairobi before commencing your research project.

You are further expected to avail two copies of your research findings to this Office upon completion of your research project.

Yours faithfully

A. O. KARIA
FOR: PERMANENT SECRETARY/EDUCATION

CC
The Provincial Commissioner
Nairobi

The Provincial Director of Education
Nairobi