RESPIRATORY IMPAIRMENT AND PERSONAL RESPIRABLE DUST EXPOSURE AMONG UNDERGROUND AND OPEN CAST GOLD MINERS IN NORTH-MARA TANZANIA

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By

Matilda Rusibamayila

A Dissertation Submitted in (partial) Fulfillment of the Requirements for the Degree of Master of Science (Environmental and Occupational Health) of

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by Muhimbili University of Health and Allied Sciences dissertation entitled: ***‘‘Respiratory impairment and personal respirable dust exposure among underground and open Cast Gold Miners In North-Mara Tanzania’’*** in (partial) fulfillment of the requirements for the degree of Master of Environmental and Occupational Health (MSc EOH) of Muhimbili University of Health and Allied Sciences

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Dr. Simon Mamuya

(Supervisor)

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Date

DECLARATION AND COPYRIGHT

I, **Matilda Rusibamayila**, declare that this **dissertation** is my own original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

Signature:………………………………………. **Date:**……………………………..

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DEDICATION

I dedicate this dissertation to my beloved mother who has been my pillar of strength throughout my journey of education.

ABSTRACT

Background: Mining is one of the most hazardous sectors to work in because it is a sector that predisposes workers to various hazards including dust. Exposure to dust in the mines is inevitable because the whole process of extracting gold has to involve rock breaking. This dust can penetrate up to the alveoli of the pulmonary system and cause respiratory impairment.

Objectives: To determine respiratory impairment, personal respirable dust exposure levels and associated factors among miners in a gold mine in Tanzania.

Material and methods: Cross-sectional study design was used employing use of questionnaires for data collection on respiratory symptoms. Lung functions were measured using spirometry. Personal respirable dust exposure was collected from similar exposure groups using air sampling pumps. A simple random sampling technique was used to select participants. 112 workers were included in the study. Data analysis was done using SPSS computer software version 20.0.

Results: The overall Geometric Mean of respirable dust was 0.26mg/m^3 (GSD=0.32) over a mean sampling time of 8hours (with a range between 7-11hours). The GM for underground (0.41±0.28mg/m^3) was significantly higher compared to open pit (0.17 ±0.23 mg/m^3) with $p<0.01$. For underground, the GM was highest among bogger operators 0.53mg/m^3(GSD=0.27) while for open pit, the highest GM was found among quality controllers 0.39mg/m^3 (GSD=0.18). Respiratory symptoms were phlegm (49.1%), Breathlessness (42.9%), cough (37.5%), wheezing (18.8%) and chest tightness (10.7%).Cigarette smokers were more likely to suffer from breathlessness compared to non-smokers. Prevalence of airflow obstruction (FEV1/FVC<0.7) was 1.9% while prevalence of lung restriction was 8.8%. Age, smoking and previous exposure to dust could not predict lung function impairment.

Conclusion and recommendations: Despite levels of respirable dust exposure being below recommended occupational exposure limits, prevalence of respiratory symptoms was still high among gold miners. There is a need to conduct further studies on quarts.

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ACRONYMS AND ABBREVIATION

ACGIH	The American Conference of Government Industrial Hygienists
FEV1	Forced Expiratory Volume in one second
FVC	Forced Vital Capacity
GDP	Gross Domestic Product
IARC	International Agency for Research on Cancer
ILO	International Labour Organization
ISO	International Organization for Standardization
MHSC	Mine Health and Safety Council
MRC	Medical Research Council
NORHED	The Norwegian Programme for Capacity Development in Higher Education and Research for Development
OEL	Occupational Exposure Limits
OHS	Occupational Hygiene and Safety
OSHA	Occupational Health and Safety Authority
PEFR	Peak Expiratory Flow
PPE	Personal Protective Equipment
RPE	Respiratory Protective Equipment
SADC	Southern Africa Development Community
SEG	Similar Exposure Groups

SOPs	Standard Operating Procedures
SPSS	Statistical Package for Social Science
TLV	Threshold Limit Values
WCF	Workers Compensation Fund

DEFINITION OF TERMS

FEV 1 The amount of air that can be forced out in one second after taking a deep breath

FEV1/FVC A proportion of person's vital capacity that is expired in the first second of forced expiration

FVC The amount of air that can be forcibly exhaled from the lungs after taking the deepest breath possible

PEFR A test that measures how fast a person can exhale/ breathe out

SEG A group of persons exposed to similar agents

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Each day approximately 6300 people die from occupational accidents or work related diseases totaling to 2.3million deaths annually (1). Not only that but also 4% of the world's Gross Domestic Product (GDP) is lost due to absence from work, treatment costs, disability, compensation and deaths arising from work (1) . These occupational illnesses, injuries and deaths affect developing countries more than others due to lack of adequate technical and economic capacity to reach Occupational Health and Safety (OHS) standards. However majority of these occupational illnesses and deaths are preventable hence they are unacceptable.

Around 30 million people in the world are employed in the mining sector which is approximately 1% of the world's work force; however mining is one of the most hazardous sectors to work in as it contributes by 8% in the total fatal accidents at work worldwide (2). Occupational hazards that miners are exposed to include physical, chemical, biological, ergonomic and psychosocial (3).

Tanzania being rich in various minerals such as tanzanite, diamond, coal and gold; it is a sector that provides employment to many (4). According to Investment Benefit study report of 2011, proportion of nationals employed in mining companies in Tanzania is around 94% (5). In Tanzania, mining sector contributes to the fatality rate by 20.53%, exceeded only by construction (23.73%) and transport (20.61%) sectors (6).

Being a miner is a risk for having reduced life expectancy, increased prevalence of certain bacterial and viral diseases, getting musculoskeletal problems and suffering from cancer of trachea, bronchus, lung, stomach and liver (7). Not only that, but also, alcohol and tobacco consumption together with HIV infection tend to worsen these health problems. This is because they are working away from their families which increases the possibility of being involved in risky sexual behaviors (8).

Short term and long term exposure to dust cause respiratory health problems ranging from acute to chronic (9). Health consequences that can result from dust exposure include chronic bronchitis, silicosis, tuberculosis, emphysema, renal failure and cancer (10).

According to the American Conference of Governmental Industrial Hygienists (ACGIH), the International Organization for Standardization (ISO), and the European Committee for Standardization (CEN) they have reached agreement on the standard definitions of inhalable, thoracic and respirable fractions of airborne particles inhaled and deposited in various regions of respiratory system (11). The smaller the diameter of the airborne particle, the more likely it will be deposited deeply in the respiratory tract (10). Respirable dust fraction is defined as a fraction of the inhaled airborne particles likely to reach the gas exchange region of the lungs where removal mechanisms are less efficient compared to upper airways (11). Examples of respirable dusts include quartz, hard metal dust, cobalt-containing and other dusts containing free crystalline silica (11). The focus of this study was on this type of dust as it can penetrate deep into the alveoli and cause respiratory problems.

ACGIH’s Threshold Limit Value (TLV) for long term exposure 8hour- time weighted average reference period for respirable dust exposure is $3mg/m^3$ (12). Personal monitoring is used to establish the concentration of respirable dust within breathing zone of an employee (11). In order to protect workers from dust, control measures should be kept in place. Personal air samples can also be compared to Occupational Exposure Limit (OEL) in order to check for effectiveness of the available control measures(10).

Many Southern Africa Development Community (SADC) countries including Tanzania, have concentrated on managing work exposures by ensuring provision of Personal Protective Equipments (PPE) to workers, which is actually the last line of defense (13). Unrecognized hazard can never be controlled, so the most important thing is to anticipate the possibility of presence of dust even before operations begin (11). And greater emphasis of control measures should follow the hierarchy order which is; elimination, substitution, isolation, engineering controls, administrative control and PPE (14). In order to implement this, safe technologies and improved work procedures need to be kept in place since planning of the operations and not simply be addressed by inspection and penalties after equipments and work processes have already been designed (13).

1.2 Problem Statement

Tanzania is the third largest gold producer in Africa after South Africa and Ghana (4). In 2013, mining sector contributed by 3.3% to Tanzania GDP(15). It is a sector that provides employment to many Tanzanians either directly or indirectly by purchasing products from villagers and contributing to their development through various projects (5). Hence health of the employees who work in the mines is not only important to them but also to the whole country.

However these workers are exposed to various hazards everyday including dust (16). This is because the whole process of extracting gold has to involve rock breaking through blasting and drilling (17). During loading and unloading of the materials, workers also get exposed to dust. That is why International Labor Organization (ILO) came up with a guide on prevention and suppression of dust in mining. In this guide there are various recommendations such as applying water, ensuring adequate ventilation , proper maintenance of equipments, adequate supervision and proper use of PPE (18)

But these measures of protection seem to be either not in place, inadequate or ineffectual, that is why prevalence of respiratory symptoms among miners is still high (9).In a study done in South Africa proportion of gold miners with silicosis has increased 10 fold from 3% to 32% from 1975 to 2007 (19). There is also significant evidence that shows increasing effect of total cumulative dust exposure on breathlessness which is a respiratory symptom (20).

Little is known about dust exposure in gold mines in Tanzania, even though gold accounts for 90% value of Tanzania mineral exports (4). Even the research that has been done regarding dust in gold mines has mainly focused on either artisanal or small scale miners who are expected to have low technology and not enough funds to put proper control measures. With the application of present day knowledge and dust suppression methods, it is expected that satisfactory conditions are kept in place since the beginning of the operation (18). This study aimed to focus on large scale modern mining so as to see the dust control measures kept in place, levels of exposure of personal respirable dust while studying respiratory problems among miners.

1.3 Problem Analysis Diagram

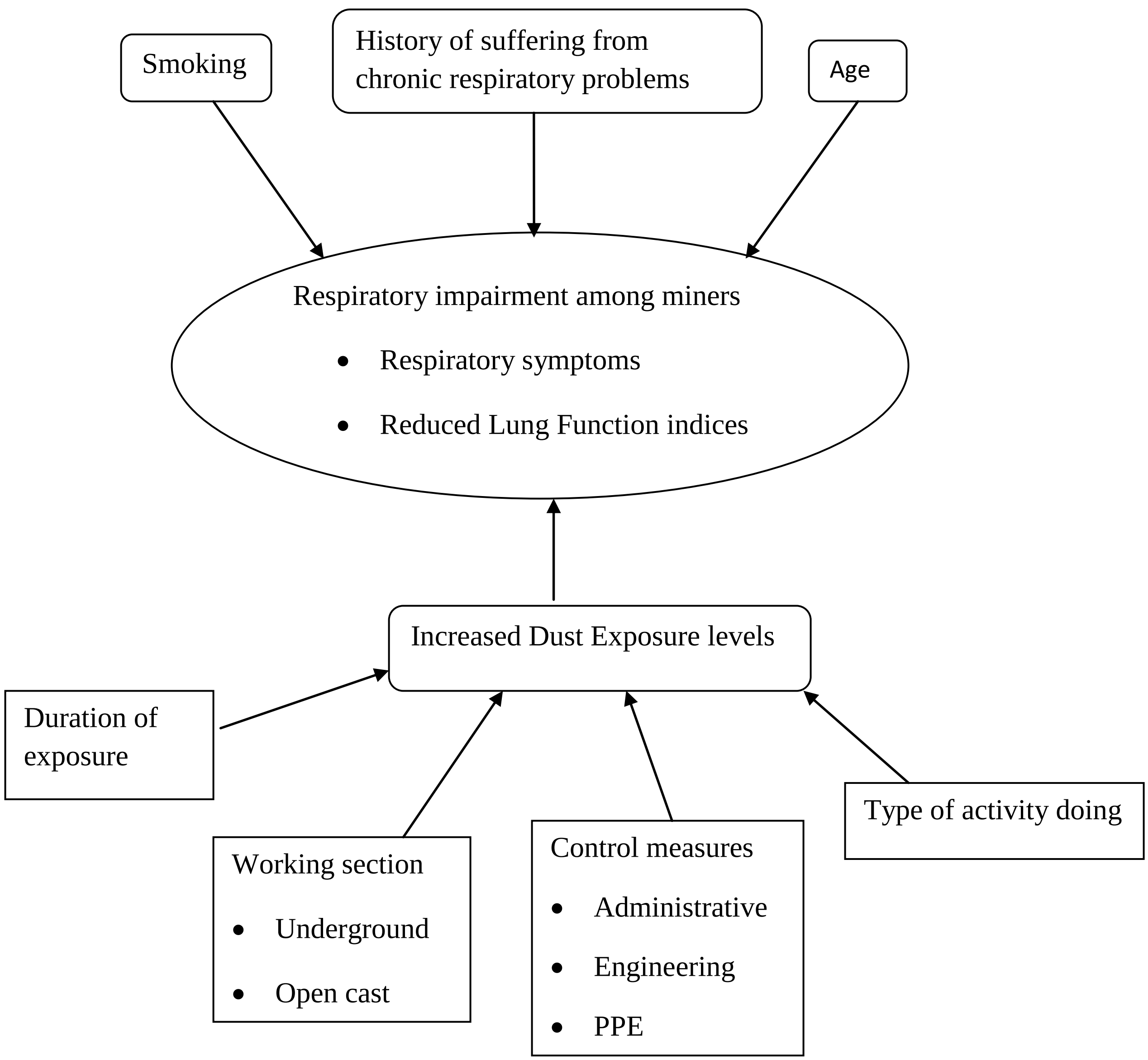

Figure 1.1: Problem Analysis Diagram

1.4 Rationale

This study was useful to the company as it highlighted areas that need improvement so that they can work on them before workers continue to suffer. Also they got have scientific proof on areas that they are doing well as far as dust is concerned hence possibly receive little disturbance from the government authorities.

Results of this study can also be useful to OSHA by providing a true picture hence facilitate their activities of protecting the health of workers in the mines. The findings of the study may be taken by policy makers for intervention purposes. Also will add up to the body of literature regarding dust and respiratory health among gold miners in developing countries.

1.5 Research Questions

i. What is the prevalence of respiratory symptoms among miners working in a gold mine?
ii. What is the level of exposure of personal respirable dust among miners working in a gold mine?
iii. What are the lung function indices of miners working in a gold mine?
iv. What are the available dust control measures in a gold mine?

1.6 Study Objectives

1.6.1 Broad Objective

To determine respiratory impairment, personal respirable dust exposure levels and associated factors among miners in a gold mine in Tanzania.

1.6.2 Specific Objectives

i. To determine the prevalence of respiratory symptoms among miners working in a gold mine in Tanzania.
ii. To determine the level of personal respirable dust exposure among miners working in a gold mine in Tanzania.
iii. To determine lung function indices of miners working in a gold mine in Tanzania.
iv. To determine the available dust control measures in a gold mine in Tanzania.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Respiratory Symptoms in miners

Gold mining operations include activities such as drilling, blasting, loading and unloading of ore and dust (17). During these activities, substances harmful to health such as dust are released thus affecting respiratory system (17). Exposure to workplace dust, silica, asbestos, diesel particulate matter has been associated with airway obstruction hence leading to respiratory diseases among miners (21). Then miners start to experience respiratory symptoms such as coughing, phlegm, bronchitis and breathlessness. In a study done in Ghana, prevalence of chronic bronchitis and Medical Research Council (MRC) breathlessness grade ≥ 2 were 21.2% and 31.3% respectively(20). Prevalence of chronic bronchitis was associated with rock breaking, smoking and cumulative dust exposure. However there was no association of prevalence of chronic bronchitis with age, duration of underground service, current occupations and current exposure(20). On the other hand, age, cumulative dust exposure, duration of underground service and smoking were significantly associated with breathlessness grade (20).

In a study done among Basotho gold miners, where 65.4% and 25.6% had high and medium dust exposure jobs respectively, prevalence of various respiratory problems were high, such as silicosis 24.6%, chronic productive cough 17.7%, past tuberculosis 26% and current tuberculosis 6% (22). In a study done in Tanzania, “never smoking workers” who worked in the development section of the coal mine were found to have high prevalence of respiratory symptoms; running nose 48.7%, dry cough 43.7%, sneezing 33.3%, breathlessness 30.8%, blocked nose 15.4%(9). And there was a significant difference between similar exposure groups in both acute and chronic respiratory symptoms (9). Prevalence of respiratory symptoms among study participants at Nyabirama open conventional gold mine in Tanzania was found to be; cough 70%, phlegm 61%, chest tightness 37%, shortness of breath 21%, wheezing 12% and duration of employment was found to be a significant predictor of all five respiratory symptoms whereby those with a longer duration of employment (6-15 years) were more likely to have respiratory symptoms compared to those with a shorter duration of employment (1-5 years) (23).

2.2 Lung Function Impairment

One of the major health problems affecting gold miners is having reduced lung function indices (24). Lung function loss in miners has been associated with exposure to dust, duration of employment, age and smoking (25). However older persons have a higher risk of having reduced indices of lung functioning tests because their lungs are aged compared to youth hence they have reduced physiological capacity and also they have been more frequently exposed to tobacco smoke, respiratory infections, air pollutions and occupational dusts (26). In a study done among gold miners in Ghana, there was a decline in all lung function indices (FEV_1,FVC, FEV_1% and FEF $_{25-75\%)}$ with age (20). However gold miners aged 50-55 years seem to have greater loss in lung function tests compared to that predicted in the general population (27). In South Africa, prevalence of airway obstruction was found to be 13.4% for FEV/FVC< 0.7 and 26.3% for FEV1/FVC< 0.75(22). While among Tanzania coal miners, prevalence of FEV1/FVC< 0.7 was found to be 17.3% and there was an association between coal mine dust and airway limitation(28).

2.3 Factors associated with Lung function Impairment

2.3.1 Age

Increase in age is associated with aging lungs as well. There are various immunological and physiological changes that occur with age (29). These include a decrease in respiratory muscle strength, volume of thoracic cavity, lung volumes and pulmonary reserve (30). As a result cough strength is decreased and clearance of particles through mucociliary elevator is decreased. Not only that, but also elderly is associated with decreased immune response from both innate and adoptive immune systems. Hence when tested in absence of respiratory diseases, older adults have reduced lung function indices compared to younger adults (31).

2.3.2 History of Suffering from Chronic Respiratory Problems

Usually during recruiting employees, it is mandatory for medical examination to be performed, and also if an employee gets very sick to the extent of not being able to perform his activities then will automatically not be found at work during occupational studies. This “health selection” of workforce and “survivor effect” tend to weaken the relationship between respiratory impairment and dust exposure (32).

However lung infections such as TB have proved to be a significant contributor to loss of pulmonary functions (33). Miners have a higher risk of getting tuberculosis because they are exposed to silica which can cause silicosis and they are also known to have a high prevalence of HIV which weakens their immunity (34). This is because of working while separated from their families which increases the risky sexual behaviors (8). There is also a strong relationship between recurrence of lung infections such as tuberculosis and impairment of pulmonary functions. Percentages of subjects with impaired lung functions (FEV1<80%) were 18.4%, 27.1% and 35.2% in those with one, two and three episodes of tuberculosis respectively (35). Loss of lung function was highest in those diagnosed within 6months and then stabilized over time (35).

2.3.3 Smoking

In a study done in South Africa, it was found that 94% of miners who had severe respiratory impairment were smokers (36). So smoking exacerbates the effect of dust on respiratory symptoms (36). Some studies concluded that, the respiratory impairment in miners are associated with smoking and there was no correlation with cumulative exposure to respirable dust and FEV_1%.(20)(27). When comparative study of lung function tests between smokers and non-smokers was done, $FEF_{25\text{-}75}$, PEFR and FEV_1 were found to be significantly lower among smokers than non-smokers (37). Non- smoking miners in the highest quartile of dust exposure seemed to have better lung function tests compared to non miners smoking one pack a day for 30 years (27). And in addition to that smoking miners seem to be having a double burden as they had much lower lung function indices compared to smoking non miners (27).

2.4 Personal respirable dust exposure

Respirable particles are formed whenever a silica containing rock is blasted, crushed or drilled(16). This leads to silicosis which is strongly associated with cumulative exposure to silica dust, even after exposure is ended for example 67.4% of the ex-miners in a study done in China developed silicosis at the mean of 3.7years after exposure (38). Silica is also a human carcinogen in International Agency for Research on Cancer (IARC) group 1(16).

However there are different activities done in the mine, hence personal respirable exposure to dust will also depend on the job category. In a study done in Tanzania, exposure measurements taken during drilling and blasting were 15.5mg/m^3, 2.4mg/m^3 and 28.4mg/m^3 for respirable dust, respirable crystalline silica and total dust respectively (16). While during shoveling and loading of sacks, median levels of respirable dust where relatively lower (4.3mg/m^3) compared to during drilling and blasting. In a study done at Nyabirama open cast conventional gold mine in Tanzania, personal respirable dust exposure levels among selected 4 similar exposure groups were 2.2±1.52 mg/m^3 for field staff, 1.40±2.12 mg/m^3 for crusher operators, 0.93±1.18mg/m^3 for dump truck operators and the least exposed group was excavator operators 0.79mg/m^3 (23) .

In an underground goldmine in China, concentration of respirable crystalline dust was estimated to be 89.5mg/m^3(24) while in underground goldmine in Ghana, total cumulative exposure to dust was 10.34mg/m^3(20). In a study done among artisanal small scale gold miners in Tanzania, airborne crystalline silica average exposure for underground drilling was 16.85mg/m^3 while for aboveground operations was 0.19mg/m^3 whereby these measurements were 337 fold and 4 fold above recommended exposure limits published by US- NIOSH respectively (39). However the situation in large scale mines seem to be different, for example in China and South Africa the exposure to crystalline silica is less 0.5mg/m^3 (16).

2.5 Control Measures

The fact that small scale mines use poor technology and stringent capital to run, (40)emphasis on control measures is not as strong as in large scale mines which use advanced technology, modern equipments and strictly regulated by the government agencies to ensure that OHS standards are followed. In many SADC countries, the focus is on inspection of control measures and if not found, the employer is fined heavily (13). It is high time that the focus shifts and start during planning of the operation by anticipating hazards such as dust before they occur; it is only then when the most effective methods of control which are elimination, substitution and isolation can be performed.

2.5.1 Engineering Controls

The next best way of controlling hazards after elimination, isolation and substitution is to use engineering controls which involve the use of equipments or workplace designs to eliminate hazards (14)(41). These engineering controls are different for surface and underground operations. Open pit workers who are most frequently exposed to respirable dust are operators of heavy equipments such as drills, bull dozers, front end loaders and crushers(42). Engineering controls required for surface operations include having drill dust collection systems, heavy machines having enclosed cab filtration systems and AC, water spillers to reduce dust(42). Underground mines on the other hand require having a local ventilation system that will help to dilute, transport and remove dust in addition to water sprays and using enclosed cab heavy equipments for operators (42). Using air and water systems alone can significantly reduce dust concentration up to 80%(43).

In a comparative study done between Chinese and Australian underground mines, the commonly found practiced controls were; the use of water infusions, water sprays ,deep and wet cutting (44). In South Africa, newly advanced and proven technology dust control measures are being applied to 80% of bord and pillar sections of their coal mines(45).

2.5.2 Administrative controls

Administrative controls are very important because they show commitment of the employer to the health of his employees, however they can only be effective when used in conjunction with other control measures (41). These include presence of SOPs at the workplace, alerting and ensuring removal of personnel during blasting, ensuring availability and quality RPE, presence of hygiene facilities (for changing, handling dusty clothes and body washing), proper medical surveillance (entry, periodic and exit), auditing of dust prevention programs and planning to eliminate or minimize dust in case of new expanding operations (46).

South Africa is a good example of using administrative controls, in 2003 Mine Health and Safety Council (MHSC) set a target that 95% of all exposure measurement results should be below OEL of 0.1mg/m^3 for respirable crystalline silica by 2003. And in 2014, MHCS renewed their target to 95% of all exposure limits being below OEL of 0.05mg/m^3 of respirable crystalline silica by 2024(47).

2.5.3 Respiratory Protective Equipments

PPE is the least effective control measure and should only be used when other better effective control methods are developed and installed(14)(41). PPE used for dust control are called RPE. In order for RPE to be effective, should not only be available but must also be of quality standard, appropriate for the task performed, comfortable and above all workers should be trained on importance and proper practice of using RPE(46).

In Ethiopia, factors associated with the use of PPE were found to be; availability, alcohol drinking and smoking, even though the percentage of the workers using PPE was 82.4% (48). To the knowledge of researcher, there is scarcity of research addressing RPE use in gold mines.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Design

This was a cross sectional study design that took place between April - July 2017.

3.2 Study Area

The study took place at North Mara gold mine located at Tarime district in Mara region, Tanzania. It is a large scale mine with combined open pit and underground operations from two deposits Nyabirama and Gokona respectively. North Mara started operating in 2002 and has produced up to 2 million ounces of gold up to date (49) but underground operations started in 2014.

It is 20 Km southern of Kenyan boarder and 100Km eastern on Lake Victoria with coordinates 01°28'S 034°31'E.

Figure 3.1: Open pit gold mine at North Mara

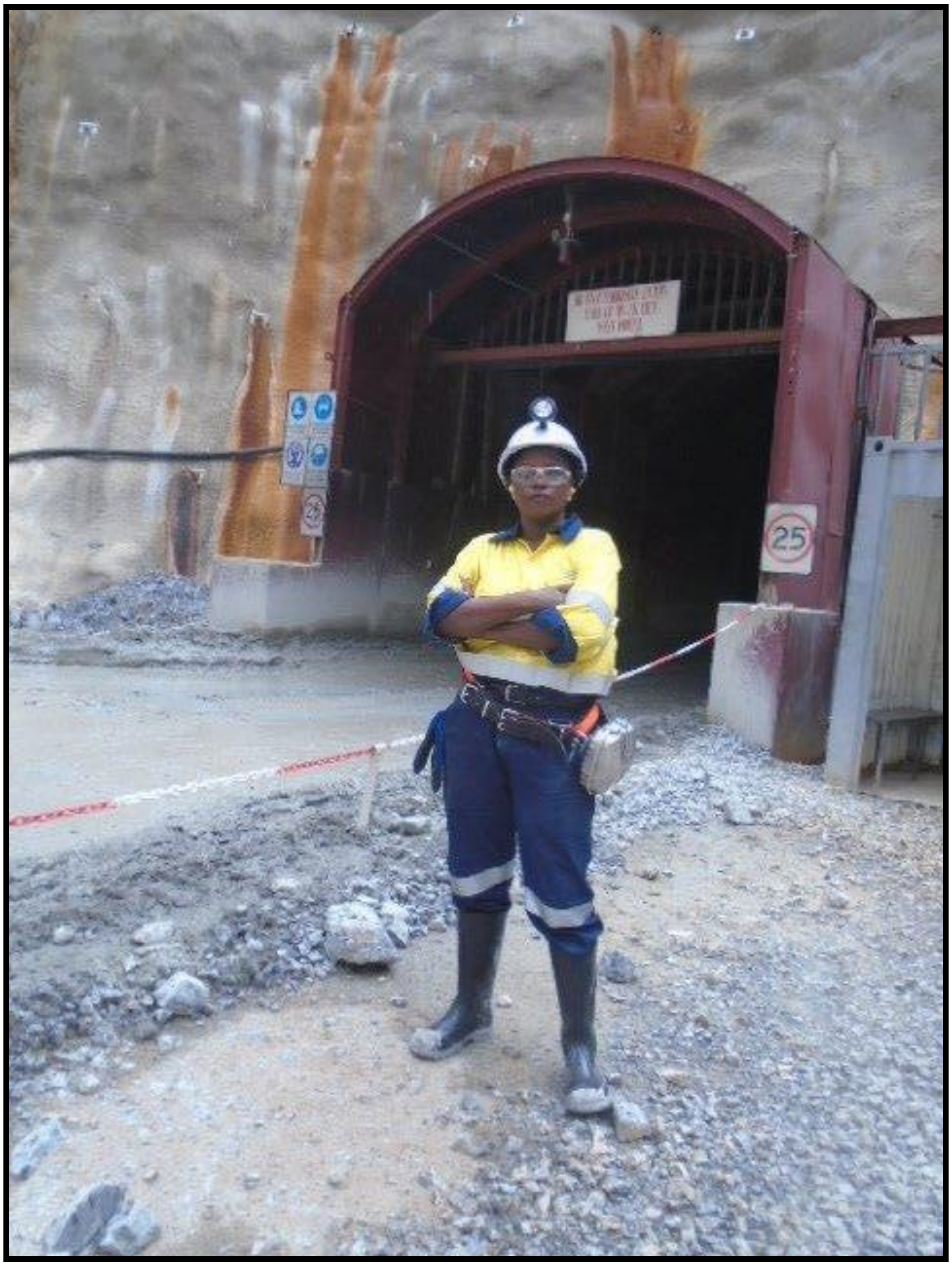

Figure 3.2: Ms. Matilda Rusibamayila in front of west wing entrance and exit portal of an underground mine at North Mara.

3.3 Study Population

The study population consisted of miners working in both Gokona underground mine and Nyabirama open pit within the study period.

3.3.1 Inclusion criteria

- Miners who had worked in dusty areas for not less than one year by the time of study.
- Consent to participate in the study

3.3.2 Exclusion criteria

- Workers who had had chest surgery
- Workers who had had recent abdominal surgery
- Workers with heart diseases

3.4 Sample size

3.4.1 Sample size for Respiratory Assessment

In a study conducted in Basotho gold mines in South Africa, the prevalence of airflow obstruction (FEV1/FVC< 0.7) was found to be 13.4% among mine workers.(22)

The total number of population in two mines is 236; the sample size was obtained through OpenEpi Version 3, open source calculator.

Therefore,

Population size(for finite population correction factor or fpc)(*N*): 236

Hypothesized % frequency of outcome factor in the population (*p*):13.4%+/-5

Confidence limits as % of 100(absolute +/- %)(*d*): 5%

Design effect (for cluster surveys-*DEFF*):

Sample size ***n*** = $[DEFF*Np(1-p)]/ [(d^2/Z^2_{1-\alpha/2}*(N-1)+p*(1-p)]$

For a 95% confidence interval the sample size is 102

This sample size was adjusted for 10% non response rate:

N = 102 x 1/R

$N = \frac{102}{0.9}$ Hence N = 113 rounded off to 115

Therefore the sample size for this study was 115

3.4.1 Sample size for personal respirable dust exposure.

Sample size 'n' was drawn from similar exposure groups of size 'N' using NIOSH sample size determination table (50).

Table 3.1: Sample size Determination by NIOSH

Size of Group 'N'	Number of Samples 'n'
8	7
9	8
10	9
11-12	10
13-14	11
15-17	12
18-20	13
21-24	14
25-29	15
30-37	16
38-49	17
k50	18

Personal respirable dust exposure samples size were obtained from the similar exposure groups in both open pit and underground operations. 4 Similar Exposure Groups (SEGs) were selected from underground mine and 4SEG were selected from an open pit mine. Then half of the sample size 'n' for each SEG were repeated in order to account for within and between worker sources of variability(51).

Table 3.2: Sample size determination for the similar exposure groups- Underground operation

Similar Exposure Group	Number of Population 'N'	Number of Sample size 'n'	Number of repeated samples 'n'	Total number of samples
Truck operators	20	13	6	19
Bogger operators	16	12	6	18
Jumbo operators	12	10	5	15
Offsiders	16	12	6	18

Figure 3.3: Dump trucks used for haulage activities.

Figure 3.4: Bogger machine used for pushing materials and loading trucks underground.

Figure 3.5: Jumbo machine used for drilling underground

Table 3.3: Sample size determination for similar exposure groups- Open pit operation

Similar Exposure Group	Number of Population 'N'	Number of Sample size 'n'	Number of repeated sample 'n'	Total number of sample
Dump Truck operators	42	18	9	27
Excavator operators	14	11	5	16
Dozer operators	15	12	6	18
Quality controllers	6	6	3	9

Figure 3.6: Excavator machine used for loading dump trucks with materials at the open pit mine.

Figure 3.7: Dozer machine used for pushing materials

3.5 Sampling Techniques

Simple random sampling technique was used to obtain study participants for respiratory impairment from the two strata which were open pit and underground mine. From each cluster, proportional sampling was done so that the probability of a unit being selected was proportional to the size of the ultimate unit, giving a larger cluster a greater probability of selection than a smaller one so as to enhance representativeness. Same sampling technique was used to collect personal respirable dust samples from the SEGs. Payroll and shift lists were used to select workers from respective sections.

3.6 Study Variables

3.6.1 Dependent Variables

- Lung Functioning Tests indices
- Respiratory symptoms (cough, breathlessness, chest tightness)

3.6.2 Independent Variables

Age, duration of exposure, job category, level of education and working section.

3.7 Potential Confounders

The study had confounders such as smoking and history of suffering from respiratory diseases. Information concerning confounder variables was collected using prepared questionnaire and analysed.

3.8 Data collection tools and techniques

3.8.1 Exposure assessment

Full shift personal dust monitoring was done using air sampling pumps (Air check XR 5000). Sampling heads (cassettes) were placed on the lapel at workers' breathing zone. All these equipments were available at North-Mara Acacia. Air sampling pumps were calibrated before and after using Dry calibrator (Defender 610) and flow rate was set at 2.0+/- 0.1 litres/min.

Air sampling pumps were turned on and attached to an employees' belt. At the end of the shift, pumps were removed from employees and the cassette removed from cyclones.

Respirable dust collection equipments were labeled each day for field control. A dust collection form was used to collect information such as ID number, name, job category, and date, pump number, filter number, pre and post calibration and total time sampled.

3.8.2 Respiratory Symptoms

A questionnaire on respiratory symptoms adopted from British council of medical research that had been pre-tested and used in Tanzania was used. Translation of the questionnaires form English to Swahili and then back to English was done using different competent individuals. Because the questionnaire had been modified to suit the purpose of this study, pre testing was done prior data collection and necessary modification was done. This tool was used to ensure validity and reliability of data obtained in this study.

3.8.3 Lung Function Tests

Lung function tests were performed before and after working shift. KoKo Legend Sx1000 Spirometer, nspire Health which was available at North-Mara Acacia was used to measure forced vital capacity, forced expiratory volume in 1 second, and the ratio of forced expiratory volume in 1second to forced vital capacity (FEV1/FVC) values. Before measuring lung function tests; participants were asked for their age, took off their shoes and removed all items that were in their pockets if any so that they could stand on a scale to be weighed, then they were asked to place their backs along the long thin rod so as to measure their height. The physician did pre-calibration, inserted information on the participants' age, body weight, height sex and ethnicity then performed the test on workers using forced expiratory maneuvers at least three times in standing position. The lung functioning tests were expressed as percentages of the expected values adjusted for age, body weight, height, sex and ethnicity. (52)

3.8.4 Control measures

Walk through survey was done throughout open pit and an underground mine so as to see control measures that were kept in place while focusing on engineering, administrative and PPE. Medical clinic was visited so as to see if they had a timetable for medical surveillance and if it was done. Also PPE store was visited so as to see the available PPE and if they were appropriate for different tasks performed at the mine. Collected information on dust control measures was gathered using an observation checklist.

3.9 Data Analysis

Field data was coded, cleaned and analysed using SPSS version 20 and significance level set at $p<0.05$.Independent t-test was used to compare the arithmetic and geometric means of personal respirable dust exposure levels between SEG with truck operators as a reference group for both underground and open pit miners. One way analysis of Variance (ANOVA) using Bonfferoni as a post- hoc test was used to compare mean differences of personal respirable dust within and between similar exposure groups for both underground and open pit miners. Fishers exact test and Chi-square tests were used to compare proportions of workers having an outcome variable (respiratory symptoms or respiratory impairment) and independent variables such as duration of employment, education level and working section. Multivariate logistic regression analysis was used to analyze how well a set of variables can predicted an outcome. Duration of employment was categorized as short duration (1-5 years) and long duration (>5years).

3.10 Reliability of the tool and its validity

Sampling pumps were charged and calibrated before the start of sampling and after the sampling and at any other time for checks. The study participants were trained on proper use of dust sampling pumps. The principal investigator did a close follow up so as to ensure quality data is obtained. Pre-calibration of spirometer was done and LFTs before and after shift were performed by the same physician.

3.11 Ethical clearance

Muhimbili University of Health and Allied Sciences Research and Publications committee was asked for ethical clearance. Permission to conduct a study was asked from North Mara Acacia authority. Each study participant was provided with informed consent form where he/she read, understood, asked any question that needed further clarification and signed on the form willingly. Assurance on the confidentiality of information obtained was provided by using code numbers instead of their names. Any study subject was free to proceed or terminate his/her participation at any time in the course of the interview or measurement collection even when they had already agreed to participate and signed the informed consent form. Those who were found to have respiratory impairment were referred to medical superintendent of the North-Mara Acacia clinic for further management.

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-demographic characteristics

The results for socio-demographic characteristics are summarized in table 4.1. This study had participants with mean age of 37.4 years (SD=6.4) ranging from 23-57 years. 95.5% were males. Among study participants, 69.6% had been working for a short duration of employment (1-5).

12.5% were current smokers, 65.2% had worked in a dusty job before, 3.6% had been exposed to gas or chemical fumes in a previous work. Response rate was 97.4%.

Table 4.1: Socio-demographic characteristics of study participants (n=112)

Variable	Frequency(n)	%
Age in group (years)		
21-30	18	16.1
31-40	58	51.8
41-50	34	30.4
51-60	2	1.8
Sex		
Male	107	95.5
Female	5	4.5
Education Level		
Primary Education	27	24.1
Secondary Education	78	69.6
Tertiary Education	7	6.2
Duration of Employment		
1-5 years	78	69.6
Above 5 years	34	30.4
Smoking		
Current smokers	14	12.5
Ever smokers	6	5.4
Previous occupational exposure		
Ever worked in a dusty job before?	73	65.2
Ever exposed to gas or chemical fumes in previous job?	4	3.6

4.2 Personal respirable dust exposure levels among gold miners

A total of 140 respirable dust samples were collected from 4 underground observational groups and 4 open cast observational groups. Arithmetic mean (AM) for respirable dust was 0.35mg/m^3 (SD=0.28) ranging from 0.08-2.11mg/m^{3}over a mean sampling time of 8 hours ranging between 7-11 hours. The overall Geometric mean (GM) was 0.26mg/m^3 (GSD=0.32). GM for underground (0.41±0.28mg/m^3) was significantly higher compared to open pit (0.17±0.23mg/m^3), t (131.9)=9.15, p<0.01.

For underground, GM was highest among bogger operators 0.53mg/m^3(GSD=0.28) and the least among articulated dump truck operators 0.29mg/m^3 (GSD=0.36). For open pit GM was highest among quality controllers 0.39mg/m^3 (GSD=0.18) and least among truck operators 0.13mg/m^3 (GSD=0.15). These findings are summarized in Tables 4.2 and 4.4

Table 4.2: Personal respirable dust exposure levels among Similar Exposure Groups-Underground

Similar Exposure Groups	Type of Activities	No. Samples	Mean Concentrations(mg/m3)			
			AM (SD)	GM(GSD)	Median	Range
Truck operators	Haulage	19	0.38(0.24)	0.29(0.37)	0.45	0.08-0.80
Jumbo/Long hole Drill Operators	Drilling	15	0.39(0.18)	0.36(0.20)	0.35	0.17-0.75
Bogger Operators	Loading materials	18	0.65(0.49)	0.53(0.28)	0.44	0.17-2.11
Offsiders	Assisting Jumbo	18	0.56(0.17)	0.52(0.15)	0.52	0.23-0.82

The independent t-test on log transformed data comparing personal respirable dust exposure among four underground exposure groups using truck operators as a reference group showed that offsiders had statistically significant higher personal respirable dust exposure levels (GM; 0.52±0.15mg/m^3) compared to truck operators (GM; 0.29±0.37,g/m^3), t(24.2)=-2.85,p=0.009.

Also bogger operators had statistically significant higher personal respirable dust exposure levels (GM;0.53±0.28mg/m^3), compared to truck operators (GM; 0.29±0.37,g/m^3), t (33.15)=-2.46, p=0.019.

Table 4.3: Comparison of personal respirable dust exposure levels between similar exposure groups among underground gold miners.

Similar Exposure Groups	No.Samples	GM(GSD)	Range	95%CI of the difference	P-Value
Truck operators	19	0.29(0.37)	0.08-0.80	Reference	
Jumbo/Long hole Drill Operators	15	0.36(0.20)	0.17-0.75	-0.29-0.11	0.37
Bogger Operators	18	0.53(0.28)	0.17-2.11	-0.47--0.04	0.019*
Offsiders	18	0.52(0.15)	0.23-0.82	-0.45--0.07	0.009*

One way analysis of variance (ANOVA) with Post-Hoc test (Bonferroni) was used to conduct further analysis of personal respirable dust exposure levels between the four similar exposure groups. There was statistically significant difference at the $p<0.05$ in personal respirable dust levels between the four similar exposure groups [$F(3,66)=4.4$,p=0.007]. Post-hoc comparisons using Bonferroni test indicated that the mean personal respirable dust concentrations for offsiders (GM=0.52, GSD=0.15) was significantly different from truck operators (GM=0.29, GSD=0.37) with p=0.023. Also the mean personal respirable dust concentrations of bogger operators (GM=0.53, GSD=0.28) was significantly different from truck operators (GM=0.29, GSD=0.37) with p=0.023.

Table 4.4: Personal respirable dust exposure levels among Similar Exposure Groups-Open pit

Observational group	Type of Activities	No. Sam ples	Mean Concentrations(mg/m3) AM (SD)	GM(GSD)	Median	Range
Truck operators	Haulage	27	0.14(0.06)	0.13(0.15)	0.11	0.09-0.27
Excavator Operators	Loading materials	16	0.18(0.09)	0.16(0.21)	0.14	0.10-0.33
Dozer Operators	Clearance and pushing materials	18	0.17(0.08)	0.16(0.18)	0.16	0.10-0.32
Quality Controller	Measuring depth of holes	9	0.41(0.15)	0.39(0.18)	0.46	0.21-0.61

The independent t-test on log transformed data comparing personal respirable dust exposure levels among four open pit exposure groups using truck operators as a reference group showed that quality controllers had statistically significant higher personal respirable dust exposure levels (GM;0.39±0.18mg/m^3) compared to truck operators(GM;0.13±0.15mg/m^3), t(34) = -7.67,p=<0.01. The difference between excavator, dozer and truck operators was not statistically significant as shown in Table 4.5

Table 4.5: Comparison of personal respirable dust exposure levels between similar exposure groups among open pit gold miners.

Similar Exposure Groups	No.Samples	GM(GSD)	Range	95%CI of the difference	P-Value
Truck operators	27	0.13(0.15)	0.09-0.27	Reference	
Excavator Operators	16	0.16(0.21)	0.10-0.33	-0.20-0.45	0.21
Dozer Operators	18	0.16(0.18)	0.10-0.32	-0.19-0.02	0.12
Quality Controller	9	0.39(0.18)	0.21-0.61	-0.59--0.34	p<0.001*

Further analysis of personal respirable dust exposure levels was conducted between the four similar exposure groups of open pit mine using one way analysis of variance (ANOVA) with Post-Hoc test (Bonferroni). There was statistically significant difference at the $p<0.05$ in personal respirable dust levels between the four similar exposure groups [$F (3,66)= 15.6$, $p<0.001$]. Post-hoc comparisons using Bonferroni test indicated that mean respirable dust concentrations of quality controllers (GM=0.39, GSD= 0.18) was significantly higher compare to truck operators (GM=0.13±0.15mg/m^3,$p<0.001$), dozer operators (GM=0.16±0.18mg/m^3,$p<0.001$) and excavator operators (GM=0.16±0.21mg/m^3,$p<0.001$). There was no statistically significant difference in mean respirable dust concentrations between dozer operators and excavator operators. Also mean respirable dust concentrations of truck operators differed significantly with neither that of dozer nor excavator operators. The effect size calculated using eta squared was 0.7.

4.3 Respiratory symptoms among gold miners

4.3.1 Prevalence of respiratory symptoms

All study participants (n=112) were interviewed for respiratory symptoms, the highest prevalence was phlegm (49.1%) followed by breathlessness (42.9%), cough (37.5%), wheezing (18.8%) and chest tightness (10.7%).

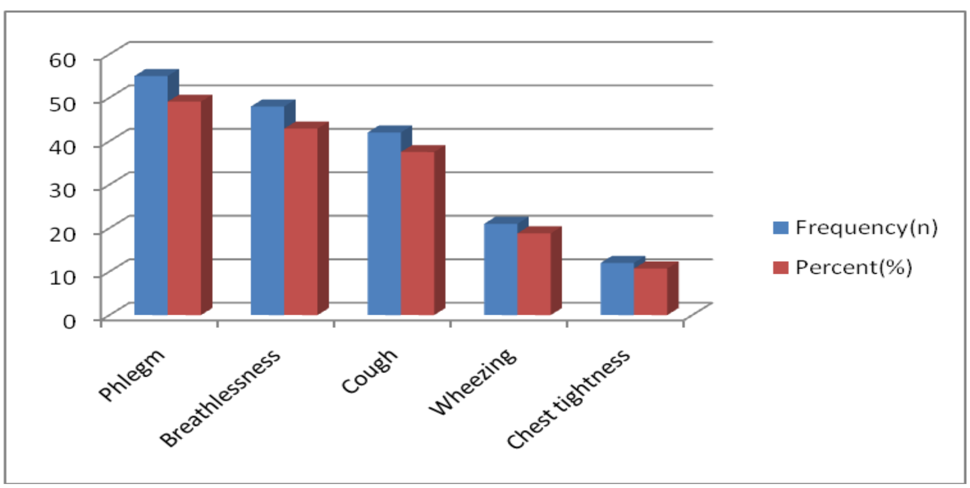

Figure 4.1: Prevalence of respiratory symptoms among Gold miners

4.3.2 Previous chest illnesses among gold miners

Previous chest illnesses among gold miners were elicited and observed that, 2.7% of the participants had ever been diagnosed with either emphysema or heart attack; none of the participants had ever been diagnosed with asthma, chronic bronchitis, lung cancer or tuberculosis.

4.3.3 Severity of respiratory symptoms

Among 42 workers who reported to have had cough; 52.4% reported to have had cough first thing in the morning, 88.1% reported to have had cough during the day or night, 71.4% reported to have had cough for four to six times in a day for four or more days in a week. 21.4% reported to have had cough for a period of three or more consecutive months in a year.
In addition to that, among 55 workers who reported to have had phlegm; 60% reported to bring up phlegm first thing in the morning, 72.7% reported to have phlegm during day or night, 70.9% had phlegm for four to six times in a day or four or more times in a week. 25.5% had phlegm for a period of three consecutive months in a year.

A total of 42.9% of study participants reported to experience shortness of breath while hurrying on a level ground or walking up a slight hill which is equivalent to MRC breathlessness grade 1, 34.8% had shortness of breath while walking with people of own age on a level ground or MRC breathlessness grade 2 while 44.6% reported to stop for breath when walking on their own pace on a level ground which is equivalent to MRC breathlessness grade 3.

4.3.3 Relationship between respiratory symptoms and other factors among gold mine workers

4.3.3.1 Working Section

Respondents who worked in an underground mine had high respiratory symptoms of phlegm (62.0%) and wheezing (26.0%). While respondents who worked in an open pit mine has high respiratory symptoms of cough (38.7%), MRC breathlessness grade 1 (45.2%) and chest tightness (12.9%). The difference for phlegm was statistically significant with $p<0.05$ (Table 4.6)

Table 4.6: Comparison of prevalence of respiratory symptoms between underground and open pit miners

Respiratory Symptom	Working Section			
	Underground	Open pit	*x2*	P value
Cough			0.010	0.922
Yes	18(36.0)	24(38.7)		
No	32(64.0)	38(61.3)		
Phlegm			5.112	0.024*
Yes	31(62.0)	24(38.7)		
No	19(38.0)	38(61.3)		
Breathlessness			0.127	0.721
Yes	20(40.0)	28(45.2)		
No	30(60.0)	34(54.8)		
Wheezing			2.316	0.128
Yes	13(26.0)	8(12.9)		
No	37(74.0)	54(87.1)		
Chest tightness			0.277	0.598
Yes	4(8.0)	8(12.9)		
No	46(92.0)	54(87.1)		

4.3.3.2 Duration of employment

As shown in table 4.7 below, there was no statistically significant association between prevalence of respiratory symptoms and duration of employment.

Table 4.7: Comparison of prevalence of respiratory symptoms by duration of employment at the current job

Respiratory Symptoms	**Duration of Employment**			**P**
	1-5years	**>5years**	***x2***	**value**
Cough			0.101	0.750
Yes	28(35.9%)	14(41.2%)		
No	50(64.1%)	50(58.8%)		
Phlegm			1.727	0.189
Yes	42(53.8%)	13(38.2%)		
No	36(46.2%)	21(61.8%)		
Breathlessness			0.000	1.000
Yes	33(42.3%)	15(44.1%)		
No	45(57.7%)	19(55.9%)		
Wheezing			0.212	
Yes	16(20.5%)	5(14.7%)		0.645
No	62(79.5%)	29(85.3%)		
Chest tightness			1.523	0.217
Yes	6(7.7%)	6(17.6%)		
No	72(92.3%)	28(82.4%)		

4.3.3.3 Education level

There was no significant association between prevalence of respiratory symptoms and education levels as shown in Table 4.8 below.

Table 4.8: Comparison of prevalence of respiratory symptoms between different levels of education

Respiratory Symptom	Levels of Education Primary Education	Secondary Education	Tertiary Education	***x2***	P value
Cough				1.761	0.415
Yes	11(40.7%)	30(38.5)	1(14.3)		
No	16(59.3%)	48(61.5%)	6(85.7%)		
Phlegm				1.196	0.907
Yes	13(48.1%)	38(48.7%)	4(57.1%)		
No	14(51.9%)	40(51.3%)	3(42.9%)		
Breathlessness				0.066	0.967
Yes	11(40.7%)	34(43.6%)	3(42.9%)		
No	16(59.3%)	44(56.4%)	4(57.1%)		
Wheezing				1.841	0.398
Yes	6(22.2%)	15(19.2%)	0(0%)		
No	21(77.8%)	63(80.8%)	7(100%)		
Chest tightness				0.900	0.638
Yes	3(11.1%)	9(11.5%)	0(0%)		
No	24(88.9%)	69(88.5%)	7(100%)		

4.3.4 Respiratory symptoms and associated predictors among gold miners

Multivariate logistic regression analysis showed that there is an association between current smoking and MRC breathlessness grade 1; participants who smoked were 6 times more likely to get breathlessness compared to those who did not. As shown in table 4.9 below.

Table 4.9 Predictors of respiratory symptoms among gold cast miners

Respiratory Symptoms	B	SE	OR (95%CI)	P value
Cough				
Duration of Employment	0.048	0.061	0.953(0.0846-1.073)	0.425
Cigarette smoking	-0.122	0.61	0.885(0.268-2.922)	0.841
Previous dust exposure	-0.009	0.46	0.991(0.402-2.441)	0.984
Age	-0.043	0.036	0.958(0.892-1.029)	0.237
Phlegm				
Duration of Exposure	-0.120	0.062	0.877(0.785-1.001)	0.053
Cigarette smoking	0.554	0.611	1.740(0.525-5.766)	0.365
Previous dust exposure	0.101	0.455	1.106(0.453-2.700)	0.825
Age	0.056	0.036	1.057(0.986-1.134)	0.119
Breathlessness				
Duration of Exposure	-0.058	0.063	0.944(0.835-1.067)	0.358
Cigarette smoking	1.849	0.700	6.353(1.611-25.052)	0.008*
Previous dust exposure	-0.232	0.474	0.793(0.313-2.006)	0.624
Age	0.048	0.037	1.049(0.977-1.128)	0.189
Wheezing				
Duration of Exposure	-0.115	0.090	0.891(0.747-1.063)	0.199
Cigarette smoking	0.382	0.756	1.465(0.333-6.446)	0.614
Previous dust exposure	1.469	0.816	4.343(0.878-21.447)	0.072
Age	0.068	0.047	1.070(0.977-1.173)	0.145
Chest tightness				
Duration of Exposure	0.123	0.092	1.135(0.947-1.360)	0.171
Cigarette smoking	0.635	1.117	0.530(0.059-4.729)	0.570
Previous dust exposure	1.440	0.913	4.222(0.705-25.280)	0.115
Age	0.020	0.057	1.021(0.914-1.140)	0.718

** Categorized as 1-5years (short duration) and 6-15 years (long duration)

*Logistic regression, odds ratio, 95%CI, P-value<0.005

4.4 Lung Function Impairment

4.4.1 Prevalence of lung function impairment

A total of 104 out of 112 participants were able to achieve acceptable curves. The rest 8 (7.1%) could not produce any acceptable blows even after 8 consecutive maneuvers. Prevalence of airflow obstruction was 10.6% for FEV1/FVC<0.75 and 2(1.9%) for FEV1/FVC < 0.7 as shown in figure 4.2 and 4.3 below

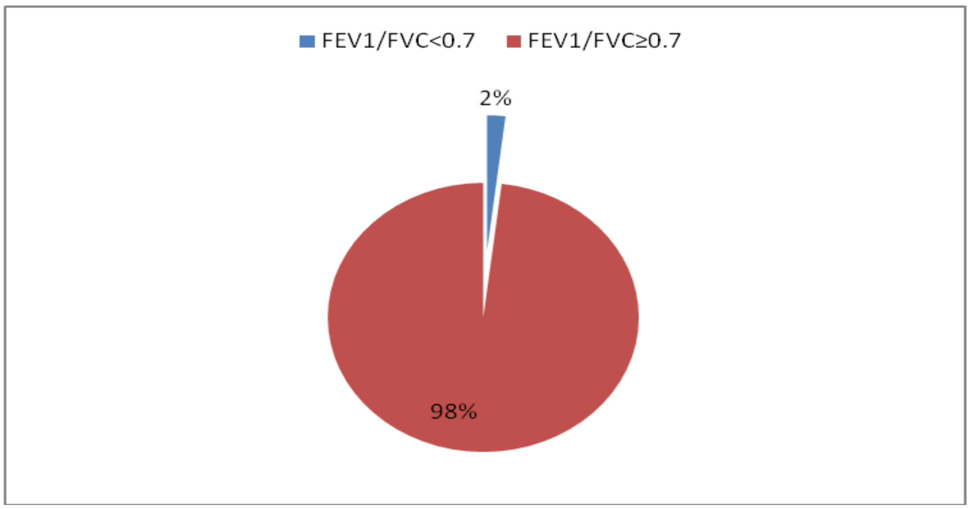

Figure 4.2: Prevalence of Airflow obstruction FEV1/FVC <0.7

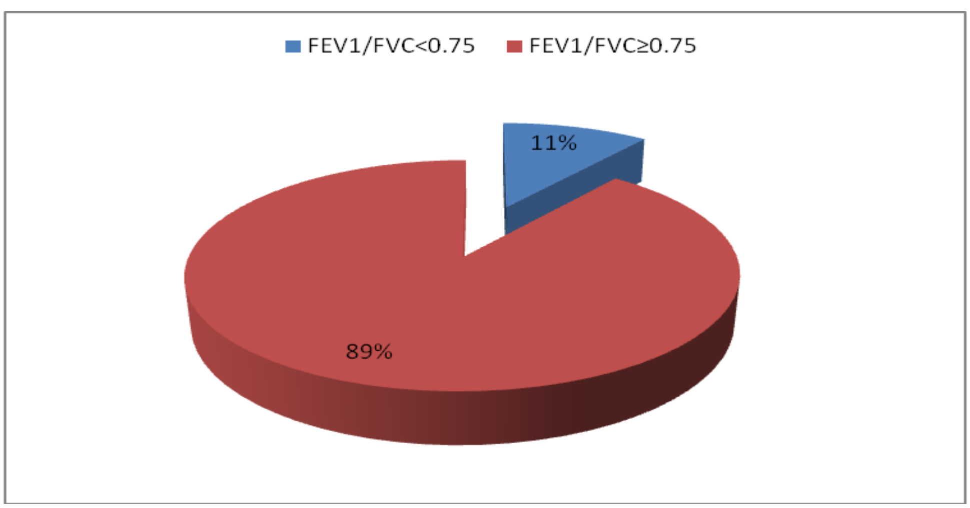

Figure 4.3: Prevalence of Airflow obstruction FEV1/FVC <0.75

4.4.2 Prevalence of restriction in lung

Among 98 participants that had FEV1/FVC≥0.7, nine (8.8%) had restriction (FVC<80%) as show in figure 4.4 below

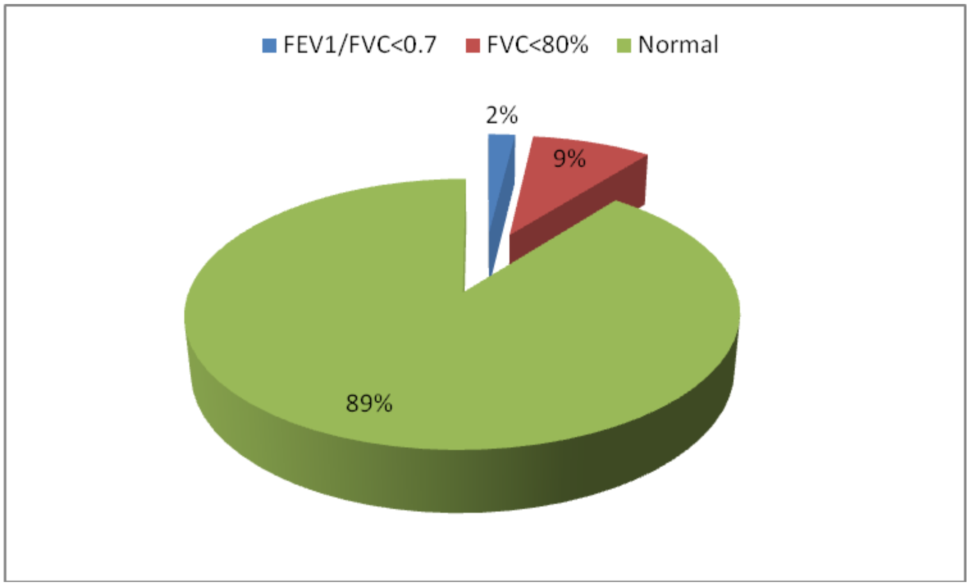

Figure 4.4: Prevalence of airflow obstruction (FEV1/FVC<0.7) and restriction (FVC<80%)

4.4.3 Lung function impairment and associated predictors among gold miners

Age, current cigarette smoking and previous dust exposure could not predict an outcome of lung function impairment.

Table 4.10: Predictors of lung function impairment among gold miners

Lung function Impairment	β	SE	OR (95%CI)	P value
Age	0.000	0.053	1.000 (0.902-1.109)	0.995
Cigarette smoking	-0.495	0.850	0.61 (0.115-3.226)	0.561
Previous dust exposure	0.164	0.679	1.178 (0.311-4.455)	0.810

4.5 Available control measures

During a walk through survey, observed engineering control measures for open pit operations included heavy machine equipments with enclosed cab filtration systems and drill dust collection system for drilling machines. In addition to that, there was a water truck that moved around to spill water for controlling environmental dust all the time. On the other hand, observed engineering control measures for underground operations included availability of a ventilation system and the use of wetting agents for the roads that where just outside the underground mine and the surrounding area; inside the mine it was wet all the time due to water coming out from the drilled rocks. However, most of their heavy equipment machines did not have air conditioning hence the workers could not close the windows of their cabins.

Independent t-test comparing respirable dust exposure levels between those who were in vehicles that had air conditioning thus enabling closure of cabins and those who were in vehicles that had no A/C hence could not close the windows of their cabins showed that those whose vehicles had no A/C had statistically higher exposure levels (GM; 0.48±0.20) compared to those who had A/C(GM;0.17±0.29), t=1.77, p<0.001. Among study participants only 33.9% of underground workers were using vehicles that had A/C while 87.1% of open pit workers were using vehicles that had A/C.

Administrative control measures observed included the fact that they were registered by Occupational Health and Safety Authority (OSHA) which is government agency dealing with OHS issues and they also had a company OHS policy. In addition to that, they had written procedures for dust control, RPEs were adequately available and easily accessed at their PPE warehouse. OHS representatives were available in each department and trainings on OHS issues including dust were provided at least once a week for both underground and open pit operations.

On top of that, blasting was done by remote control at the specific time of the day after ensuring that all personnel have moved out of the mine. There was also a schedule for periodic medical examinations to be performed once a year to each miner. Dust masks were also provided to all workers at all the working period.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Introduction

This study aimed at determining personal respirable dust exposure levels, prevalence of respiratory symptoms and measured lung functions test so as to determine the prevalence of airway obstruction and restriction among gold miners working at both underground and open pit mines. A walk through survey was also conducted to determine the dust control measures available at the mine.

5.2 Personal respirable dust exposure levels

GM for underground and open pit were 0.41mg/m^3 (GSD=0.28) and 0.17mg/m^3 (GSD=0.23) respectively ranging from 0.08-2.11mg/m^3 over a mean sampling time of 8hours ranging between 8-11 hours. . This shows that both underground and open pit workers were exposed to respirable dust below TLV of the ACGIH for respirable dust of 3mg/m^3 (12). As expected, mean respirable dust exposure level of underground mining was higher compared to open pit mining(39). In addition to that, the respirable dust exposure level of underground mining operation matches the one that was found in an underground gold mine at the Anglogold Ashanti (Obuasi) limited of 0.4mg/m^3 (53). However another study done among underground gold miners in Obuasi- Ghana found that workers were exposed to mean respirable dust concentration of 0.83mg/m^3 which is twice as much compared to that which was found in this study(54). For open pit operations, geometric mean found in 2015 at the same mine was 1.23±1.82mg/m^3 which is low compared to what was found in this study(23). Even for similar exposure groups, the findings of this study were low compared to the findings of 2015; for excavator operators we found geometric mean respirable dust exposure level of 0.16±0.21mg/m^3 while in 2015 it was 0.82±0.20mg/m^3 and for dump truck operators, we found geometric mean of 0.13±0.15mg/m^3 while in 2015 it was 0.94±0.14mg/m^3. This can suggest that respirable dust exposure levels for open pit operations have substantially improved over time.

Differences in mean respirable exposure levels between underground and open pit could have been caused by the fact that an underground mine is contained hence workers require a local ventilation system compared to an open pit mine which is naturally well ventilated. In addition to that, this study found out that there was a significant association between respirable dust exposure levels and availability of an A/C as an engineering control measure in enclosed cabins heavy machine equipments (42). Personal respirable dust exposure levels of those who could not close their cabins due to lack of A/C was significantly higher (GM; $0.48 \pm 0.20 mg/m^3$) compared to those who had A/C in their cabins (GM;$0.17 \pm 0.29 mg/m^3$). And at the same time only 33.9% of underground workers were using vehicles that had A/C compared to 87.1% of open pit workers which might have also contributed to observed relatively higher respirable dust concentrations in underground miners when compared to open pit miners.

In order to obtain gold from earth, there are different activities that take place such as blasting, drilling, loading and unloading of materials. This means that, workers get exposed to different levels of personal respirable dust depending on their jobs(16). The findings were also the same in this study whereby a one way analysis of variance (ANOVA) showed that there was a significant difference in GM of personal respirable dust exposure concentrations between and within SEGs. A post-hoc comparison using bonferroni test showed that for underground operations, personal respirable dust exposure levels were significantly higher in offsiders who are basically dealing with drilling activities compared to truck operators who are dealing with haulage activities. Also the GM of personal respirable dust exposure concentration of bogger operators who are dealing with loading trucks with mined materials was significantly higher compared to truck operators who are dealing with haulage. All these findings are similar to the study done in Tanzania whereby respirable dust exposure measurements were significantly higher in those dealing with drilling activities compared to those dealing with loading and shoveling(16). For open pit operations, a one way analysis of variance also showed that there was a significant difference in GM of personal respirable dust exposure concentrations between and within SEGs. A post-hoc bonferroni test showed that GM of personal respirable dust exposure of quality controllers was significantly higher compared to truck, dozer and excavator operators. This is because all these operators were operating heavy machine equipments with enclosed cabins that have air conditioning (42)while quality controllers work in direct contact with dust and the only control measure they use is putting on dust masks which is a PPE and the last line of defense(14).

Although this study found that personal respirable dust exposure levels were relatively lower than TLV recommended by ACGIH, amount of silica contained in these rocks was beyond the scope of this study. Silica is known to cause silicosis, emphysema, chronic bronchitis, tuberculosis and renal disease(10). I addition to that, silica is a human carcinogen in IARC group 1(16) which means that it can also cause cancer.

5.3 Respiratory symptoms among gold miners

Despite the fact that personal respirable dust exposure levels were below TLV recommended by ACGIH, prevalence of respiratory symptoms among gold miners were still high; phlegm (49.1%), breathlessness (42.9%), cough (37.5%), wheezing (18.8%) and chest tightness (10.7%). These findings were similar to the ones found in a study done in Anglo-gold Ashanti (Obuasi) limited where by the least reported respiratory symptom was cough (28.5%),almost half of the respondents reported phlegm while dyspnoea (67%) was the most reported despite the TWA of respirable dust being $0.4mg/m^3$.In a study done in a coal mine in Tanzania also the prevalence of respiratory symptoms among miners was high(9). Even the findings of the study done in 2015 at the open pit operations of the same mine, personal respirable dust exposure levels were below TLV recommended by ACGIH but prevalence of respiratory symptoms was high; cough 70%, phlegm 61%, chest tightness 37%, shortness of breath 21%, wheezing 12% (23). Just like the way mean respirable dust exposure levels have seem to have decreased over time, also prevalence of respiratory symptoms have decreased over time. This may explain the paradoxical findings of current symptoms being high while respirable dust exposure not particularly high because historical exposures were high. In addition to that, there is a possibility that the crystalline silica content was high hence supporting high prevalence of respiratory symptoms.

In this study, 2.7% reported to have ever been diagnosed with any of the stipulated chest illnesses. This is most likely because of the “survivor effect” hence the workers who have been highly affected by dust and suffered chronic chest illnesses might not be at work during the time of data collection(32). Also the presence of the clinic in the mine that performs periodic medical examination to the workers might have also contributed to the “survivor effect”. This was contrary to the findings of the study done among Basotho gold miners whereby almost 50% reported to have suffered from either silicosis, past tuberculosis, current tuberculosis or chronic productive cough(22). But also in the same study done in South Africa; they had high prevalence of current smokers 35%, ever smokers 61% while the one done in Ghana had 5.2% current smokers and 17.9% ever smokers (20) thus when compared to the findings of this study current smokers (12.5%), ever smokers (6.1%) , the likelihood of smoking to contribute to the observed findings in this study is very low.

There was no statistically significant difference in proportions of workers suffering from most respiratory symptoms between underground and open pit workers except for phlegm where by 62% of underground workers reported phlegm, this is similar to the findings of a study done in an underground mine in Anglo-gold Ashanti (Obuasi) limited where by almost half of the population reported to have phlegm while only 28.5% reported cough(53). Lack of the statistical difference in their proportions could be explained by the fact that a large proportion (65.2%) of participants had dust exposures from previous jobs and among them 89% had worked in a mining job before which means they might have been previously working in an open pit mine and currently working in an underground mine or vice versa. But since their previous dust exposure levels were not quantified in this study, these assumptions remain speculations until confirmed by further studies.

In this study, we found out that there was no statistically significant association between duration of employment and respiratory symptoms. While in a study done in Ghana there was no association between duration of underground service and chronic bronchitis but there was an association between breathlessness grade and duration of underground service (20). In our study only 30.4% of workers had been employed for a duration of more than 5 years, this is because North Mara gold mine started underground operations 3 years ago and gave underground mining task to a subcontractor, so for underground operations the maximum duration of employment would be 3years which is inclusive in the category of short duration. Hence even though underground miners seem to be more exposed compared to open pit workers, they have a short duration of employment so far which gives room for further prospective studies to be conducted since they also give the best relationship between an exposure and an outcome. Furthermore, “health workers effect”(32), nature of dusts that workers had been previously exposed to and high proportion of respondents who reported to have had previous exposure to dust might have also affected the relationship between duration of employment and respiratory symptoms.

Smoking was found to be the most predictor of MRC breathlessness grade 1 in this study OR=6.353 (1.611-25.052). These findings were similar to the ones found in Ghana and South Africa(20)(36) whereby in Ghana, smoking was significantly associated with breathlessness grade 2 while in a study done in South Africa it was found that smoking exacerbates effects of dust on respiratory symptoms.

5.4 Lung function impairment among gold miners

In this study, we found that prevalence of airflow obstruction was 1.9% for FEV1/FVC<0.7 and 10.6% for FEV1/FVC<0.75. These results were low compared to the ones found in Basotho gold mines in South Africa which were 13.4% and 26.3% for FEV1/FVC<0.7 and FEV1/FVC<0.75 respectively (22). Also when compared to the findings of the study done among coal miners in Tanzania which was 17.1% for FEV1/FVC<0.7 still the prevalence of airflow obstruction was low. Prevalence of lung restriction in this study was found to be 8.8%. These results could be explained by “survivor effect” which is a common limitation in occupational studies whereby the workers found at work during sample collection are usually the “healthy” ones. In addition to that, the mine owns a clinic that conducts pre-entry, periodic and exit medical examination therefore it was unlikely to find workers with lung function impairment at work thus the sick workers might have been screened out during medical examination.

Age, cigarette smoking and previous exposure to dust could not predict an outcome of lung function impairment in this study. These results were contrary to the ones found in Ghana, South Africa,(20) (25)(27)(36)(37). In this study mean age of participants was 37.4±6.4 years with only 2 people aged above 50 years and 30.4% aged between 41-50 years. These results could be supported by "health worker effect"(32) whereby most likely those affected by mining hazards might have already left the job premises by the time this study was conducted. Similar reason could support lack of prediction of lung function impairment by cigarette smoking as those whose respiratory systems are affected by either respirable dust, cigarette smoking or both would have been screened out during periodic medical examinations. 65.2% of workers have history of being exposed to dust in their previous jobs with a duration ranging from 1-18 years of previous exposure, however at North Mara gold mine, pre-entry medical examination is a mandatory procedure during recruiting employees hence the sick ones are most likely screened out during this process thus affecting the relationship between previous exposure and lung function impairment.

5.5 Available Control measures

In large scale mines, operators of heavy machines are the ones who are most frequently exposed to dust(42). These operators were captured among similar exposure groups included in this study but engineering controls such as enclosed cabins, having enclosed cab filtration system, drill dust collection system were in place(42). In addition to that, there was a vehicle that moved around spraying water in open pit mine and around both mines, for underground operations, the area was wet because of water coming from drilled rocks and also jumbo machines that deal with drilling were using water pump systems. This could explain the relatively low respirable dust exposure levels that we obtained in this study since using air and water systems alone has shown to reduce dust concentrations up to 80%(43). These results were similar to the ones found in a comparative study among Chinese and Australian underground mines whereby the commonly found practices where the using of water during various mining activities(44) .There is also a possibility of "Hawthorne effect" to have contributed to our findings because the administration knew that we were around and what we were studying which might have also led them to put stringent control measures during our study period.

Administrative control measures such as having Standard Operating Procedures (SOPs), provision of training, removal of personnel, periodic medical surveillance, and availability of RPEs were also found in place. This showed commitment of an employer towards protecting the health of employees(46). RPEs are the last line of defense as a dust controlling measure(14), there was a PPE warehouse at the mine whereby workers could access them using their identity cards. Trainings on proper use of PPE were provided as one of the topics among those provided by OHS department. However utilization of RPE was covered in our study.

5.6 Limitations of the study

i. The study design is cross sectional hence just gives a snapshot of the current situation but cannot establish exposure-disease relationship.
ii. The results of the study may not be generalized because it was limited to the specific sample of workers in the gold mine. The sample selected was the representative of the study population
iii. "Survivor effect" which is common in most occupational studies whereby the workers found at work are usually the "healthier" ones.(32)

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In this study we found high prevalence of respiratory symptoms despite levels of personal respirable dust exposure for both underground and open pit operations being below recommended TLV recommended by ACGIH. For open pit operations, respirable dust exposure levels and respiratory symptoms were decreasing over time compared to a study done in 2015 (23). However silica content of respirable dust was not measured which its TLV value is less than 0.025 mg/m^3(12). The differences in mean respirable dust exposure levels between and within SEGs were significant. Current smokers were 6 times more likely to suffer from MRC breathlessness grade 1. There was no association between respiratory symptoms and duration of employment or education level. Prevalence of airflow obstruction and restriction found in this was also low compared to other studies which could have most likely be attributed by “survivor effect”. Available control measures included ventilation system, enclosed cabins, removal of personnel during blasting, provision of OHS trainings and RPE.

6.2 Recommendations

From the findings of this study, we recommend the following:

Recommendations towards science

i. Cohort prospective studies be conducted so that close follow up can be done to establish a causal-effect relationship and also remove “Hawthorne effect”.

ii. Studies on ex-miners be conducted so that health effects from various hazards including dust be established without ’’health worker effect”.

Recommendations to the Gold mine

i. All heavy machine equipments should have Air conditioning system working so that operators can work while closing their cabin windows thus reducing dust.

ii. Conduct awareness campaigns to workers regarding the effects of cigarette smoking on respiratory system.

iii. Miners should have a rotation schedule so that those with relatively higher exposure do not quickly get health effects, work for a shorter duration and die. On job training can be conducted so that workers are equipped with skills on how to perform different activities, hence get exposed differently instead of one group getting higher exposure for a long time.

Recommendations towards policy makers

i. OSHA should make a close follow up and ensure that OHS standards are observed.

ii. Ministry responsible for health and the ministry responsible for labor should financially support prospective studies on occupational health.

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APPENDICES

Appendix 1: Informed Consent Form (English Version)

INFORMED CONSENT FORM FOR A PARTICIPANT (ENGLISH)

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DEPARTMENT OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH

FORM NO:…………

Title of the Research: Respiratory Impairment and Personal Respirable Dust Exposure Among Underground and Open Cast Gold Miners.

Principal Investigator: Matilda G. Rusibamayila
Institution and address: MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES (MUHAS)
P.O Box 65001,
DAR ES SALAAM – TANZANIA

Introduction

This consent form contains information of the above named research. In order to be sure that you are informed about participating in the research, we are asking you to read (or we read to you) this consent form and understand it. You will also be asked to sign it (or make your mark in front of the witness). You will retain a copy of this form. This form might contain words that are unfamiliar to you, please ask us to explain anything you may not understand.

Before contacting you, we have obtained permission to conduct this study from the Mining authority, The Acacia Gold Mine, here at North Mara.

Purpose of this study

To determine respiratory impairment, personal respirable dust exposure levels and associated factors among miners in a gold mine in Tanzania.

Participation

We will ask you some questions related to respiratory symptoms in regard to your occupation. After that we will also take some measurements on lung function before and after your working shift. Those found with severely lung dysfunction will be referred to the district hospital. Some of you will be asked to wear personal respirable dust equipments for the whole entire shift. Feel free to participate.

Confidentiality

All issues concerning your participation will be treated as confidential; no any authorized person will have access to this information. We will be compiling a report, which will contain responses from several participants without any reference to individuals. We will not put your name or any identifying information on the records of the information you provide.

Risks

No harm or risk will be involved for those who will voluntarily participate in this study.

Right to Withdraw and Alternatives

Taking part in this study is completely your choice. If you choose not to participate in the study or if you decide to stop participating in the study, you will not get harm. You can stop participating in this study at any time, even if you have already given your consent.

Benefits

Participating in this study will give us an opportunity to establish the magnitude of respiratory impairment due to occupational dust exposure among open pit and underground gold miners. This information will help create awareness to policy and decision makers on various efforts for prevention of health of workers in their work places.

Contact

The research has been reviewed and approved by Ethical Research Committee of Muhimbili University of Health and Allied Sciences, MUHAS. Please if you have any question about your rights as a participant, you may contact **Dr. Joyce Masalu ,** Chairman of the Senate Research and Publications Committee, **P.O Box 65001, Dar es Salaam (Tel 022-21503002-**

06, 2152489) or **Dr. Simon Mamuya; MUHAS: P.O Box 65001, Dar-es Salaam. (Tel. 0787 721 377)** who is the supervisor of this research.

Agreement Part

I therefore request your participation in this study; participation in this study will involve asking some questions and you will be required to respond according to what you know on the given options, take lung function tests and you will be required to wear sampling devices for the whole working shift.

DO YOU AGREE? YES:…… NO……. (Tick for appropriate response)

If you agree, sign below

Participant's sign…………………….. Date………………….

Investigator's sign…………………… Date………………….

Appendix 2: Informed Consent (Swahili Version)

FOMU YA RIDHAA YA KUSHIRIKI KWENYE UTAFITI (SWAHILI)

CHUO KIKUU CHA AFYA NA SAYANSI SHIRIKISHI MUHIMBILI

IDARA YA MAZINGIRA NA AFYA KAZINI

NAMBA YA FOMU: ………………….

Utafiti juu ya : Matatizo ya Mfumo Wa Upumuaji na Kiwango cha Vumbi Laini Linaloweza Kufika Ndani ya Ufizi wa Mapafu Miongoni Mwa Wafanyakazi wa Migodi ya Dhahabu Iliyo Wazi na Iliyo Chini ya Ardhi .

Jina la Mtafiti: Matilda G. Rusibamayila
Jina na Anwani ya Taasisi: CHUO KIKUU CHA AFYA NA SAYANSI SHIRIKISHI MUHIMBILI (MUHAS)
S.L.P 65001,
DAR ES SALAAM – TANZANIA

Utangulizi

Fomu hii ina maelezo juu ya utafiti tajwa hapo juu. Ili uweze kujua habari muhimu zinazohusu huu utafiti na kushiriki inakubidi uisome hii fomu kwa umakini (au tukusomee kwa sauti) na kuielewa . Utaombwa kutia saini baada ya kuisoma (au kuweka alama ya dole gumba mbele ya shahidi). Utabaki na nakala yako. Hii fomu inaweza kuwa na maneno usiyoyafahamu, tafadhali tuulize ili tukueleweshe. Kabla ya kukufikia, tumepata ridhaa ya kufanya utafiti huu kutoka kwa uongozi wa mgodi huu wa Acacia.

Dhumuni la utafiti huu

Utafiti huu una lengo la kupata taarifa juu ya matatizo ya mfumo wa upumuaji na kiwango cha vumbi laini linaloweza kufika ndani ya ufizi wa mapafu miongoni mwa wafanyakazi wa migodi ya dhahabu iliyo wazi na iliyo chini ya ardhi.

Ushiriki

Tutakuuliza maswali kadhaa yanayohusiana na matatizo ya mfumo wa upumuaji kutokana na kazi unayoifanya. Baada ya hapo tutachukua vipimo vya uwezo wa mapafu yako kufanya kazi kabla na baada ya muda wa kazi. Wale wataokutwa na matatizo kwenye mapafu yao watapewa rufaa ya kwenda hospitali ya wilaya. Baadhi yenu tutawaomba wavae vifaa maalum kwa ajili ya kupima kiwango cha vumbi laini linaloweza kufika ndani ya ufizi wa mapafu kwa kipindi chote cha kazi. Tafadhali kuwa huru kushiriki.

Usiri

Unahakikishiwa kwamba taarifa zote juu ya ushiriki wako kwenye utafiti huu zitakua siri. Tutaandaa taarifa moja kutokana na maelezo na vipimo vya washiriki mbalimbali hapa mgodini. Hatutaandika jina lako wala hatutainesha utambulisho wowote kutokana na taarifa utakazotupatia.

Madhara

Utafiti huu hautakuwa na madhara yoyoye kwa mshiriki.

Haki ya kujitoa kwenye utafiti

Kushiriki katika utafiti huu ni uchaguzi wako. Endapo utachagua kutoshiriki au utaamua kusimamisha ushiriki wako, hutapata madhara yoyote. Unaweza kusimamisha ushiriki katika tafiti huu muda wowote hata kama ulisharidhia kushiriki.

Faida

Ushiriki wako katika utafiti huu utasaidia kutambua ukubwa wa tatizo la magonjwa ya mfumo wa upumuaji yatokanayo na madhara ya vumbi laini linaloweza kufika ndani ya ufizi wa mapafu kwa wafanyakazi wa migodi ya dhahabu iliyo wazi na iliyo chini ya ardhi. Hii itasaidia kujenga uelewa kwa watunga sera na watoa maamuzi juu ya namba nzuri ya kulinda afya za wafanyakazi wawapo makazini.

Mawasiliano: Utafiti huu ulipitiwa na kukubaliwa na kamati ya mapitisho ya utafiti ya chuo kikuu cha cha afya na sayansi shirikishi Muhimbili. Iwapo una maswali kuhusu utafiti huu, unaweza kuwasiliana na **Dr. Joyce Masalu** ambaye ni Mwenyekiti wa kamati ya chuo ya utafiti na machapisho, **P.O Box 65001, Dar es Salaam (Tel 022-21503002-06, 2152489)**, au Dr. Simon Mamuya; **MUHAS: P.O Box 65001, Dar-es Salaam. (Tel. 0787 721 377)** ambaye ni msimamizi wa utafiti huu.

Makubaliano

Hivyo basi, unaombwa kushiriki katika utafiti huu; utauliza maswali ambayo yatahitaji kupata maelezo kutoka kwako,pia tutachukua vipimo vya uwezo wa mapafu yako kufanya kazi. Baadhi yenu tutawaomba wavae vifaa maalum vya kupimia kiwango cha vumbi laini linaloweza kufika ndani ya ufizi wa mapafu kwa kipindi chote cha cha muda wa kazi siku nzima.

JE WAKUBALI? NDIYO:…… HAPANA……. (Weka alama ya vema panapohusika)

Endapo umekubali, tia saini hapa chini:

Saini ya mshiriki …………………….. Tarehe………………….

Saini ya mtafiti…………………… Tarehe ………………….

Appendix 3: Questionnaire (English Version)

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES (MUHAS)

SCHOOL OF PUBLIC HEALTH AND SOCIAL SCIENCES (SPHSS)

P.O Box 65015 DAR ES SALAAM- TANZANIA

A STUDY ON: Respiratory Impairment and Personal Respirable Dust Exposure among Open pit and Underground miners.

Date of Interview: …………………….Questionnaire number: ……………….

Name of interviewer: ………………………………..

INSTRUCTIONS

1. Please cycle the correct number in given options
2. Write a correct number in space provided (for example age in years)

SECTION A: DEMOGRAPHICS

Qn.No	**Question**	**Response**
1	Age (in years)	
2	Sex	1= Male 2= Female
3	Level of education	1= No formal education 2= Primary education 3= Secondary education 4= Tertiary
4	Working section ***(If 1 proceed to question no.5, if 2 proceed to question no.6)***	1= Underground 2= Open cast

5	Occupational Group/ Job category for underground pit	1= Bogger operators 2= Jumbo operators 3= Truck operators 4= offsider 5= Any other
6	Occupational Group/ job category for open pit	1= Dump truck operator 2= Excavator operator 3= Dozer operator 4= Quality controller 5= Any other
7	Duration of employment (years)	
8	Working shift/ hours per day	
9	Working hours/week	

SECTION B; RESPIRATORY SYMPTOMS

I am going to ask you some questions mainly about your chest. I would like you to answer **YES or NO** whenever possible.

Cough		
Qn.No	**Question**	**Response**
10	Do you usually have a cough? ***If no skip to question no.16***	1= Yes 2= No
11	Do you usually cough first thing in the morning?	1= Yes 2= NO
12	Do you usually cough during the day or at night?	1= Yes 2= No
13	Do you usually cough as much as four to six times a day for four or more days in a week?	1= Yes 2= No

14	Do you cough like this on most of the days for as much as 3 consecutive months or more in a year?	1= Yes 2= No
15	For how long have you had this cough?	
Phlegm		
Qn.No	**Question**	**Response**
16	Do you usually bring up phlegm from your chest? ***If no skip to question no.22***	1= Yes 2= No
17	Do you usually bring up phlegm at all on getting up, or first thing in the morning?	1= Yes 2= No
18	Do you usually bring up phlegm at all during the rest of the day or night?	1= Yes 2= No
19	Do you usually bring up phlegm as much as four to six times a day, or four or more days in a week?	1= Yes 2= No
20	Do you bring phlegm on most of days for as much as three consecutive months or more in a year?	1= Yes 2= No
21	For how long have you had phlegm	
Breathlessness		
Qn.No	**Question**	**Response**
22	Are you troubled by shortness of breath when hurrying on level, ground or walking up slight hill?	1= Yes 2= No
23	Do you get shortness of breath walking with other people of your own age on lever ground?	1= Yes 2= No
24	Do you have to stop for breath when walking on your own pace on lever ground?	1= Yes 2= No
25	***If Yes to any of the above;*** For how long have you had trouble for shortness of breath?	

Wheezing		
Qn.No	**Question**	**Response**
26	Have you had attacks of wheezing or whistling in your chest at any time in the last twelve months? ***If no skip to question no.28***	1= Yes 2= No
27	How long do you have wheezing in your chest?	
Chest tightness		
Qn.No	**Question**	**Response**
28	Does your chest ever feel tight or your breathing becomes difficult? ***If no skip to question no.31***	1= Yes 2= No
29	Do you usually experience chest tightness while at work or just after work?	1= Yes 2= No
30	For how long do you have this problem?	
Chronic bronchitis		
Qn.No	**Question**	**Response**
31	During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? ***If No, skip to question no 34***	1= Yes 2= No
32	Did you bring up more phlegm than usual in any of these illnesses?	1= Yes 2= No
33	Have had more than one illness like this in past three years?	1= Yes 2= No

SECTION C; HISTORY TAKING

Occupational History		
Qn.No	**Question**	**Response**
34	Have you ever worked for any dust job before? ***If no skip to question no.37***	1= Yes 2= No
35	***If yes, specify;-*** What is the job/ industry/ factory/ mining…………………. Where is it located/ area………………….	
36	For how long did you work?…………………..	
37	Have you ever been exposed to gas or chemical fumes in any other work? ***If no skip to question no.40***	1= Yes 2= No
38	***If yes,*** specify job ……………………………………. Industry/ area …………………………….	
39	For how long did you work?	
History of PastRespiratory diseases		
40	In your past life, have you ever been informed by a doctor that you had any chronic lung condition? ***If No, skip to question no.41***	1= Yes 2= No
	Tick all applicable i. Emphysema ii. Asthma iii. Chronic bronchitis iv. Lung cancer v. Heart attack vi. Tuberculosis	

Smoking		
Qn.No	**Question**	**Response**
41	Do you smoke? ***If yes, skip to question no.44***	1= Yes 2= No
42	Have ever smoked as much as one cigarette a day for as long as a year?	1= Yes 2= No
43	If yes, How long ago did you give up cigarette smoking? ***If no to above questions omit remaining question on smoking***	
44	For how long have you been smoking?	
45	How many cigarettes a day have you been smoking?	

SECTION D; PHYSICAL MEASUREMENTS

46	Weight	
47	Standing height	
48	Pre shift PEFR	
49	FEV1	
50	FVC	
51	FEV1/ FVC	

THANK YOU FOR YOUR COOPERATION

Appendix 4: Questionnaire (Swahili Version)

CHUO KIKUU CHA AFYA NA SAYANSI SHIRIKISHI MUHIMBILI

(MUHAS)

SLP 65001 DAR ES SALAAM – TANZANIA

DODOSO LA : Utafiti juu ya;- matatizo ya mfumo wa upimuaji na kiwango cha vumbi laini linaloweza kufika ndani ya ufizi wa mapafu miongoni mwa wafanyakazi wa migodi ya dhahabu iliyo wazi na iliyochini ya ardhi.

Tarehe ya usaili………………………Namba ya dodoso…………………..

Jina la mhojaji……………………

MAELEKEZO

1. Zungushia namba ya chaguo sahihi
2. Andika maelezo au Namba katika sehemu iliyoachwa wazi (mfano umri katika miaka)

A:UTAMBULISHO

Na.	**Swali**	**Jibu**
1	Umri (miaka)	
2	Jinsia	1= Me 2= Ke
3	Kiwango cha elimu	1= Sikusoma 2= Elimu ya msingi 3= Elimu ya sekondari 4= Elimu ya juu/ Ufundi/ Chuo

4	Kitengo ***(Kama 1, nenda swali na. 5. Kama 2, nedna swali na.6)***	1= Chini ya aridhi 2= Mgodi wa wazi
5	Kikundi cha kazi/aina ya kazi kwa mgodi ulio chini ya ardhi	1= Opareta wa Bogger 2= Opareta ya Jumbo 3= Opareta wa Truck 4= offsider 5= Kwingine
6	Kikundi cha kazi/ aina ya kazi kwa mgodi ulio wazi	1= Opareta wa Dump truck 2= Opareta wa Excavator 3= Opareta wa Dozer 4= Quality controller 5= Kwingine
7	Una miaka mingapi kazini?	
8	Unafanya kazi masaa mangapi kwa siku?	
9	Unafanya kazi masaa mangapi kwa wiki?	

B; DALILI ZA MARADHI YA MFUMO WA UPUMUAJI

Nitakuuliza maswali kuhusu kifua chako. Ningependa ujibu NDIYO au HAPANA pale inapobidi.

Kukohoa		
Na.	**Swali**	**Jibu**
10	Je, huwa unakua na kikohozi cha mara kwa mara? ***Kama HAPANA, nenda swali namba.16***	1= Ndiyo 2= Hapana
11	Je, huwa unakua na kikohozi kila uamkapo asubuhi?	1= Ndiyo 2= Hapana
12	Je, huwa unakua na kikohozi mda wa mchana na usiku?	1= Ndiyo 2= Hapana
13	Je, huwa unakohoa mara tano adi sita kwa siku au zaidi	1= Ndiyo

	ya siku nne kwa wiki?	2= Hapana
14	Je, huwa unakohoa kwa namana hii kwa miezi mitatu mfululizo kwa mwaka?	1= Ndiyo 2= Hapana
15	Je, nikwa miaka mingapi umekua ukikohoa naman hii?	
Kutoa makoozi		
Na.	**Swali**	**Jibu**
16	Je, huwa unatoa makohozi kutoka ndani ya kifua? ***Kama jibu ni HAPANA, nenda swali namba.22***	1= Ndiyo 2= Hapana
17	Je huwa unatoa makohozi mara unapoamka, au asubuhi uamkapo?	1= Ndiyo 2= Hapana
18	Je, huwa unatoa makohozi kwa muda wowote wa siku nzima au usiku?	1= Ndiyo 2= Hapana
19	Je, unapokohoa huwa unatoa makohozi mara mbili kwa siku au siku nne na zaidi kwa wiki?	1= Ndoyo 2= Hapana
20	Je, huwa unatoa makohozi kwa namna hii mara nyingi ndaini ya miezi mitatu mflulizo au zaidi ndani ya mwaka?	1= Ndiyo 2= Hapana
21	Ni kwa muda wa miaka mingapi umekua na tatizo la kutoa makohozi?	
Kupumua kwa shida		
Na.	**Swali**	**Jibu**
22	Je, unakua na tatizo la upumuaji unapotembea haraka au kwenye muinuko/ mpando?	1= Ndiyo 2= Hapana
23	Je, huwa inakulazimu kutembea taratibu zaidi ya watu wa umri wako unapotembea kwenye muinuko au mpando kwa sababu ya kupumua kwa shida?	1= Ndiyo 2= Hapana
24	Je, iliwahi kukulazimu kusimama kidogo wakati	1= Ndiyo

	ukitembea mwenyewe kwenye muinuko au mpando?	2= Hapana
25	Je, umekua na tatizo hili kwa muda wa miaka mingapi?	
Kupumua kwa kukorokota		
Na.	**Swali**	**Jibu**
26	Je, umewahi kupata shida ya kupumua kwa kukorokota muda wowote ndani ya miezi 12 iliyopita? ***Kama HAPANA, nenda swali namba. 28***	1= Ndiyo 2= Hapana
27	Kwa muda gani umekua ukipumua kwa kukorokota?	
Kubanwa kifua		
Na.	**Swali**	**Jibu**
28	Je, umewahi kubanwa na kifua au kushindwa kupumua? ***Kama jibu ni HAPANA, nenda swali namba.31***	1= Ndiyo 2= Hapana
29	Je, huwa unabanwa kifua au kushindwa kupua uwapokazini au mara baada ya kazi?	1= Ndiyo 2= Hapana
30	Umekua na shida hii kwa muda gani?	
Kukohoa wa Kukorokota		
31	Ndani ya miaka 3 iliyopita je, umewahikupata ugonjwa wowote wa kifua kiasi cha kushindwa kufanya shughuli zako za kila siku kwa muda wa wiki 1? ***Kama HAPANA, nenda swali namba.34***	1= Ndiyo 2= Hapana
32	Ndani ya kipindi hicho je ulipata makohozi kuliko kawaida?	1= Ndiyo 2= Hapana
33	Je, umewahi kuugua ugonjwa huu zaidi ya mara 1 ndani ya kipindi cha miaka 3?	1= Ndiyo 2= Hapana

C; HISTORIA YA KAZI ALIZOKWISHA KUFANYA AWALI

34	Je, ulikwisha fanya kazi nyingine zenye mazingira ya vumbi? ***Kama HAPANA, nenda swali namba.37***	1= Ndiyo 2= Hapana
35	Kama jibu ni ndiyo, Itaje;-……………….	
36	Taja miaka ulifanya kazi hiyo…………..	
37	Je, ulisha fanya kazi katika mazingira ya uzalishaji gesi au kemikali yoyote inayotoa harufu? ***Kama HAPANA, nenda swali namba.40***	1= Ndiyo 2= Hapana
38	Kama jibu ni ndiyo,Itaje;-……………….. Kazi/ mahali…………………………..	
39	Taja miaka ulifanya kazi hio………………….	
40	Je, ulisha wahi kuambiwa na daktari kua una mojawapo au zaidi kati ya magonjwa ya mfumo wa upumuaji yaliyoolodheshwa apa chini? ***Kama HAPANA, nenda swali namba.41***	1= Ndiyo 2= Hapana
	(weka alama ya vema kila panapo husika) i. Kikohozi cha kupaliwa/ kuvimba mapafu ii. Pumu iii. Kikohozi sugu/ kisichokoma iv. Kansa ya mapafu v. Mshituko wa moyo vi. Kifua kikuu	
Uvutaji sigara		
41	Je, unavuta sigara? ***Kama ndiyo nenda swali namba.44***	1= Ndiyo 2= Hapana

42	Je, umewahi kua ukivuta sigara moja kwa siku kwa muda usiopungua mwaka mmoja	1= Ndiyo 2= Hapana
43	Kama ndiyo, umepita muda gani tangu umeacha kuvuta sigara?............................ **Kama umejibu HAPANA kwa maswali yote hapo juu, tafadhali usijibu maswali yanayofuata kuhusu uvutaji sigara.**	
44	Kwa muda gani umekua ukivuta sigara?..................................	
45	Je, umekua ukivuta sigara ngapi kwa kila siku?...	

ASANTE KWA USHIRIKIANO WAKO;

D; VIPIMO

46	Uzito	
47	Urefu	
48	Pre shift PEFR	
49	FEV1	
50	FVC	
51	FEV1/ FVC	

Appendix 5: Observation Checklist (Control Measures)

Engineering control measures

Underground (Tick where appropriate)		
1	Ventilation system	1=Yes 2=No
2	Enclosed cabins for heavy equipments	1=Yes 2=No
3	Use of wetting agents	1=Yes 2=No
4	Any other	………
Open pit (Tick where appropriate)		
5	Drill dust collection system	1=Yes 2=No
6	Enclosed cab filtration system	1=Yes 2=No
7	Controlling dust on unpaved haulage roads	1=Yes 2=No
8	Controlling dust at the primary hopper dump	1=Yes 2=No
9	Any other	………..

Administrative control measures (Tick where appropriate)

10	OSHA registered	1=Yes 2=No
11	Witten procedures for dust control	1=Yes 2=No
12	Removal of personnel during blasting	1=Yes 2=No
13	Availability of RPE	1=Yes 2=No
14	Providing training on dust health effects and prevention	1=Yes 2=No
15	Periodic medical surveillance	1=Yes 2=No
16	Any other	………..

Respiratory Protective Equipments

17	RPE appropriate for the task performed	
18	RPE comfortable to wear	
19	Any other	

Appendix 6: Respirable Dust Collection Form

ID	Section	Job type/ category	Activity	Equipment No	Eng. Control Meas.	Sampling Date	Pump No.	Filter No	Pre-CAL (cc/ min)	Post-CAL (cc/ min)	Average flow (cc/ min)	Start (min)	Finish (min)	Total time (min)	Pre Wt (mg)	Post Wt (mg)	Respirable dust wt (mg)	Volume of air (m^3)	Respirable dust (mg/m^3)

Appendix 7: Introduction Letter

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

OFFICE OF THE DIRECTOR, POSTGRADUATE STUDIES

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Ref. No. HD/MUH/T.344/2015

21st April, 2017

North Mara,
Acacia Gold Mine
P.O Box 422
TARIME.

RE: INTRODUCTION LETTER

The bearer of this letter Ms. Matilda Rusibamayila is a student at Muhimbili University of Heath and Allied Sciences (MUHAS) who is pursuing MSc. Environmental and Occupational Health.

She is conducting a research titled ***"Respiratory impairment and personal respirable dust Exposure among underground and open cast gold miners in North-Mara, Tanzania".***

Kindly provide her the necessary assistance to facilitate the conduct of her study.

Thank you for your cooperation,

Sincerely,

Ms. A. Ndyeikiza
For, Director of Postgraduate Studies

c.c Dean, School of Public Health and Social Sciences
c.c Ms. Matilda Rusibamayila

Appendix 8: Approval Letter

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

OFFICE OF THE DIRECTOR OF POSTGRADUATE STUDIES

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Ref. No. MU/ PGS/SAEC/Vol. XVI/

20th April, 2017

Ms. Matilda Rusibamayila
MSc. Environmental and Occupational Health
MUHAS.

RE: APPROVAL OF ETHICAL CLEARANCE FOR A STUDY TITLED: "RESPIRATORY IMPAIREMENT AND PERSONAL RESPIRABLE DUST EXPOSURE AMONG UNDERGROUND AND OPEN CAST GOLD MINERS IN NORTH-MARA, TANZANIA"

Reference is made to the above heading.

I am pleased to inform you that, the Chairman has, on behalf of the Senate, approved ethical clearance for the above-mentioned study. Hence you may proceed with the planned study.

The ethical clearance is valid for one year only, from 20th April, 2017 to 19th April, 2018. In case you do not complete data analysis and dissertation report writing by 19th April, 2018, you will have to apply for renewal of ethical clearance prior to the expiry date.

Dr. E. Balandya
DEPUTY DIRECTOR OF POSTGRADUATE STUDIES

cc: Director of Research and Publications
cc: Dean, School of Public Health and Social Sciences