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Assessment of exposure to quarries and pulmonary function among quarry workers at BeitFajjar village

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Assessment of quarries and pulmonary function among quarry workers at Beit Fajjar village

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Dedication

I dedicate my dissertation work to my family and friends. First, to my parents' souls Ali andSara. Second, I dedicate this thesis for my lovely husband Khalid who encouraged my success and supported this attempt. Third, I dedicate this for my sweet children, Adam, Mohammad and Sarah. I hope they will understand one day why their mommy spent so much time working on the computer, and I plan to have more time with them now on**.**

Aya Ali Taqatqa

Declaration

I declare that this study is the result of my own work research, except where otherwise indicated. It has been not been submitted for Master degree or any higher degree to any other universities.

Signed: ....

Aya Ali Taqatqa

Date: 25.5.2021

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To complete this project, I need help and support from individuals and groups. So, I'd like to thank everyone who spent any effort to help in accomplishing this work. First of all, the words are not enough to express my thanks to Dr. Akram Amro for the valuable efforts in supervision and assistance in this study. Where he had an important role, which guided me to continue this study.

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I thank God for giving me the power, capability and potentiality to continue my educational level.

Abstract

Assessment of exposure to quarries and pulmonary function among quarry workers in Beit Fajjar village.

Background: Occupational health has been defined as "Promotion and maintenance of the highest degree of physical, mental and social well - being of workers in all occupations; (WHO, 2012). Workers in the quarry industry face numerous risks emerging from airborne particulate inhalation, and thisexposure mightpose a major health and safety concern. **Aim**: This study aims to identify theassessment of exposuretothe quarry industry and pulmonary function among quarry workers in BeitFajjar-Palestine.

Methodology: A descriptive cross-sectional study was conducted in 2020, with a sample of 200 quarry workersthat were conveniently recruited for this study. Data was collected by**a data collection sheet,** which included personal information of the workers;years of work for workers, and other personal variables, in addition to the "**questionnaire"**that is used for chronic respiratory illness assessmentin Epidemiological Research".**Spirometer** device was used in this study to measure the lung functions with main concentration on three parameters: Forced Vital Capacity (FVC), Forced expiratory volume in 1st second (FEV1), and FEV1% (FEV1/FVCV).

Results: All of the participants weremale at the worker site. Workers 'agewasbetween 20 to 50years. Most of participants (77%) did not use personal protective equipment (PPE). 92 percent of the study participants work in quarries for more than 35 hours a week, meaning that the majority of them are at risk of inhaling quarry dust. 77% of the study sample is a smoker, which is a high prevalence.

The most common reported respiratory symptoms by the participant were having cough and shortness of breath. Normal lung function test was among only 30% of respondents. Decreased pulmonary function was found among a significant percentage of the industry workers, 48% was found to have a moderate to a severe decrease in FCV, and 31% had a moderate to a severe decrease in FEV1, and 45% had moderate to severe decrease FEV1%.

By using independent sample t-test, there was no significant difference in mean FEV1 and FEV1% upon using protective equipment kit, smoking, family history of respiratory disease, worker's history of respiratory disease diagnosis, presence of shortness of breath, cough, nasal congestion, and educational level ($p > 0.05$), While there was a statistically significant difference of mean FEV1% for the favor of workers without wheezing (88.5 %) as compared to those who reported wheezing (81.1%)($P = 0.002$) .

In correlation demographic and work-related variables with FEV1 and FEV1% there was no statistically significant correlation between FEV1, FEV1% and Age, practical, and total working hours per week ($p > 0.05$). And there is a statistically significant difference of mean FEV1% upon the work place, with favor for the stone crushing industry workers (with FEV1% 89.4%) as compared to the stone pits (with FEV1% of 83.7%).

By using multivariate stepwise regression the model revealed that **practical experience** is the only predictor of FEV1, with very weak R2, justifying nearly 2% of the variation in the dependent variable (FEV1) which is considered a very weak explanation of the variation in the dependent variable and **working place represented in the stone pit or crushing** is the only **significant** predictor of FEV1%, in favor for stone crushing facility workers (89.41%, SD 10.47%) as compared to stone pits (83.76%, SD 16.73%), with a very weak explanation of the variation of the dependent variable R^2 (0,041).

Conclusion: This study showed chronic exposure to quarry dust was associated with deterioration of lung function indicated by reduced lung function indices among quarry workers. This finding reflects the need for periodic evaluation of lung function to help in preventing any deterioration in the respiratory health of these workers. Also, it emphasizes the need for advocacy that will drive the responsible body for this occupation to put clear legislations and enforce these workers to wear the proper PPEs.

ملخص الدراسة بالعربية

اسم البحث:تقييم التعرض لمصانع الحجر على وظائف الرئتين بين العمال في قرية بيت فجار.

الخلفية: تم تعريف الصحة المهنية على أنها الارتقاء والحفاظ على أعلى مستويات السلامة الجسدية والعقلية والاجتماعية للعاملين في جميع المهن حيث يتعرض العاملين في المحاجر للعديد من المخاطر الناجمة عن استنشاق الجزيئات المحمولة جوا التي تشكل مصدرا أساسيا للقلق على الصحة والسلامة العامة.

الهدف من الدراسة: تهدف هذه الدراسة إلى تقييم العلاقة بين وظائف الرئة لدى عمال المحاجر في بلدة بيت فجار وبيئة عملهم.

المنهجية: تم استخدام دراسة مقطعية وصفية ل 200 عامل في مصانع الحجروذلك من خلال جمع بيانات مناسبة للدراسة والتي شملت على البيانات الشخصية للعمال وعدد سنوات العمل في هذا المجال وعدد من المتغيرات الشخصية والأمراض التنفسية المزمنة واستبانة الدراسة التي تضمنت الأمراض التنفسية المزمنة في البحوث الوبائية كما وتم استخدام جهاز قياس التنفس لقياس وظائف الرئة وآثار التهوية. حيث يقوم هذا الجهاز بقياس ثلاثة مؤشرات ألا وهي: القدرة الحيوية القسرية (FVC)وحجم الزفير القسري في الثانية الأولى (FEV1)والنسبة بينهما (FEV1%).

النتائج:جميع المشاركين في الدراسة من الذكور العاملين في المحاجر وتتراوح أعمارهم بين 20 إلى 50 سنة. كما وأن النسبة الكبرى منهم 77% لا يستخدمون وسائل الحماية الشخصية. وجد في هذه الدراسة أن 92% من عينة البحث يقضون أكثر من 35 ساعة في العمل بالمحاجر في الأسبوع مما يدل على أن غالبيتهم معرضين لخطر التعرض لغبار المحاجر القابل للاستنشاق, و 77 % من عينة البحث من المدخنين .

أما عن أكثر المشكلات شيوعا بين المشتركين فقد تم رصد السعال في المرتبة الأولىو القصور في التنفس. حيث كان اختبار وظائف الرئة طبيعيا ل 30٪ فقط منهم.حيث تم إجراء فحص وظائف الرئة لدى المشتركين و تبين وجودانخفاض في وظائف الرئة بين نسبة كبيرة منهم في مصانع الحجر في هذه الدراسة ، حيث كان 48 ٪ لديهم انخفاضمعتدل إلى شديد في القدرة الحيوية القسرية FCV

، و 31 ٪ لديهم انخفاض معتدل إلى شديد في حجم الزفير القسري في الثانية الأولي FEV1 ، و 45 ٪ لديهم انخفاض متوسط إلى شديد النسبة بين حجم الزفير القسري في الثانية الاولي و القدرة الحيوية القسرية (FEV1 ٪) . كان الانسداد التنفسي المتمثل في انخفاض FEV1٪ مرتبطًا بشكل ثابت بالخبرة العملية ، وتاريخ التدخين ($p<0.05$). في حين أن العمر والتعليم، واستخدام معدات الوقاية الشخصية العامة، ومكان العمل (المحجر أو مصنع الحجر)، لم تكن عوامل ذات دلالة إحصائية مرتبطة بمستوى انسداد الجهاز التنفسي.

من خلال استخدام اختبار العينة المستقلة, لم يكن هناك فرق بين FEV و FEV1٪ عند استخدام معدات الحماية والتدخين و التاريخ العائلي لأمراض الجهاز التنفسي والتاريخ المرضي للعمال بما يتعلق بالجهاز التنفسي ,($p > 0.05$) بينما وجدفرق ذو دلالة إحصائية عند العمال الذين لا يعانون من صفير بنسبة 88.5% مقارنة باللذين يعانون من صفير بنسبة 81.1% ($p<0.02$).

في الترابط بين المتغيرات الديمغرافية والمتغيرات المرتبطة بالعمل مع FEV1و FEV1٪ لم يكن هناك ترابط ذو دلالة إحصائية بينFEV1و FEV1٪ مع العمر وساعات العمل ومجموع ساعات العمل في الأسبوع($P> 0.05$) .

باستخدام الانحدار المتعدد الخطوات الذي تضمن الخبرة العملية و مكان العمل و العمر و المستوي التعليمي و استخدام معدات الحماية والتدخين والتاريخ المرضي للجهاز التنفسي , كشف النموذج أن الخبرة العملية هي المتنبأ الوحيد , FEV1 وأن R^2 ضعيفة للغاية مما يبرر ما يقارب 2% من التباين في المتغير التابع والذي يعتبر تفسيرا ضعيفا جدا للتباين في المتغير التابع, ومكان العمل الذي يتمثل بالمحاجر أو بالمناشير هو المتنبأ الوحيد بالنسبة إلى FEV1 وذلك لصالح العمال الذين يعملون في مصانع الحجر بنسبة (89.41%, SD 10.47%)مقارنة بعمال المحاجر (83.76%, SD 16.73%), مع تفسير ضعيف للغاية لاختلاف المتغير التابع .R^2 (0,041)

الخلاصة: أظهرت هذه الدراسة أن التعرض المزمن لغبار المحاجر كان مرتبطًا بتدهور وظائف الرئة الذي أشار إليه انخفاض مؤشرات وظائف الرئة بين عمال المحاجر. وتعكس هذه النتيجة الحاجة إلى التقييم الدوري لوظيفة الرئة لدى العاملين وذلك للمساعدة في منع أي تدهور في صحة الجهاز التنفسي لديهم. كما أن النتائج تؤكد على الحاجة إلى الترافع والدعوة التي من شأنها أن تدفع الهيئات المسؤولة عن هذه الوظيفة لوضع تشريعات واضحة وفرض ارتداء معدات الوقاية الشخصية المناسبة بين هؤلاء العمال.

Table of content

Contents

List of tables

List of Figures

List of abbreviations

ATS: American Thoracic Society.
COPD: Chronic Obstructive Pulmonary Disorders.
CCOHS: Canadian Centre for Occupational Health and Safety.
CWP: Pneumoconiosis of Coal – Worker.
FEV: Forced expiratory volume.
FVC: Forced Vital Capacity.
HRW: Human Right Watch.
ILO: International Labor Organization.
MIAG: Mine Inspection Agency of Greece.
NAFTA: North American Free Trade Association.
NIOSH: National Institute for Safety and Protection in Health
NOHSAC: National Occupational Health and Safety Advisory Committee.
OEL: Occupational Exposure Limit.
OHS: Occupational Health and Safety.
OSHA: Occupational Safety and Health Administration.
OR: Odds Ratio.
PCBS: Palestinian Central Bureau of Statistics.
PEF: Peak Expiratory Flow.
PFT: Pulmonary Function Test.
PFI: Pulmonary Function Impairment.
PPE: Personal Protective Equipment.
SMI: Stone and Marble Industry.
SD: Standard deviation.
SPSS: Statistical Package for Social Sciences.
TB: Tuberculosis.
UNECD: United Nations Conference on Environing and Development.
VC: Vital Capacity
USA: United State of America.
WHO: World health organization.

Chapter 1

1.1 Introduction

Health was seen as the basic right of all in the constitution of the World Health Organization (WHO). At the workplace, WHO emphasized the importance of avoiding injuries and promoting workplace conditions. The first formulation of an official definition of 'working health' Initiatives of occupational health was in 1950s (WHO, 2012). Occupational health has therefore been defined as "Promotion and maintenance of the highest degree of physical, mental and social well - being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of workers in an occupational environment adopted to his physiological and psychological capabilities and to summarize: the adaption of work to man and of each man to his job ". In simple words, this definition was concerned with health problems related to the human social, biological, chemical & physical environment (ILO, 2016).

In the 70's and 80'sof the last century, the importance of workplace safety and right to health was emphasizedin many countries, therefore, the health agenda at workplacewas included inthe United States NIOSH/OSHA, CCOHS of Canada, and the Danish Working Environment Authority of Denmark, Health and Safety" atwork [HSE] (Hayhurst, 2011). In 1990-95, the WHO 8th General Job Initiative programmed recognized the imperative need in developed countries to resolve workplace health concerns. The target list for action listed agricultural, manufacturing, mining, home-based, and small-scale industries. A newer occupational well-being model was proposed as a discipline with the following components the basis of science, physical and chemical causes, ergonomics, psychology, occupational safety, and health (WHO, 2013). The CHE [Committee on Health and the Environment] has introduced the exposure assessment and protection mechanisms for workplaces over the same time through different bodies including the North American Free Trade Association NAFTA, the UNECD [United Nations Conference on Environing and Development]. The 1994 International Conference on Workers' Welfare took place in China in the context of the above activities over a half-hour - That already had a powerful national worker’s program. Then came the "National Policy on Occupational Wellness – The Way to Health" into being. It set out 12 recommendations for workplace and safety policies for each region. The Occupational Health Services (OHS), which comprises promotion and prevention, adaptation and work situation change, curative services, emergency services, and rehabilitative services, is among the values (Yang, et al., 2014).

It was widely felt that occupational health Issues were not necessarily workers' concerns, but that they were triggered by the interface between job and community, which depends on the influences of the regional, social-cultural, economic, and employment. The definition of safe environments, as laid out in the 1986 Ottawa Charter, states, "Health is developed and lived by those who are living and learning, working, playing and enjoying in the settings of their daily life. “The Jakarta Declaration of 1997 stressed the social background of the daily activities of the environment, organization, and personal sectors, which affect health and well-being (Udoh, 2013). It is evident from the above topic that 'workers' wellbeing' is a broader concept which includes 'health at work and safe workplace environments.' In 2007, 60th WHA adopted the "Economic Action Plan 2008-2017" for the wellbeing of working people worldwide. It developed a study for the 1994 Global Workplace Health Plan for Everyone (Ehrlich, et al., 2018).

The practice of quarrying is a long-term commercial operation of natural resources such as granite, lime, and gypsum. Staff in the quarry industry faces numerous risks emerging from airborne particulate inhalation, and these pose a major health and safety concern. Like gastrointestinal, dermal, ocular irritations, and injury to the skin, airborne contaminants pose a possible health risk to workers (Singh, et al., 2017). Lungs are affected by prolonged exposure to dust caused by granite rock grinding and by some respiratory and non-respiratory effects of cancer workers (Algophobe, et al., 2011). Some quarries have a special issue with inhaling silica-inhaling particles, which can lead to silicosis, a pulmonary irreversible disease contributing to lung inflammation and respiratory issues, even though the exposure ends (Nwachukwu, et al., 2013). Countries such as the United States and China have stated that millions of people exposed to silica dust grow silicosis that contributes to deaths among elderly people, in particular (Aliyu, et al. 2013).

Rock quarrying in global terms is very common but is also one of the riskiest sectors (Okafor, 2016), and the European Organization for Safety and Health at Arbeit (2008) reports that quarrying is double the risk of construction workers being killed in an industrial accident and 13 times higher than in the manufacturing sector at work. The World Health Office (ILO, 2015) has expressed its fear that 1.7 million people in the world die each year from accidents and diseases related to work. Between 1988 and 2002 a fatality rate for the entire quarry sector was registered by the Mine Inspection Agency of Greece (MIAG). About 44 percent of the incidents that happened in France in 2002 related to carriage, while 48 percent of the accidents recorded in Germany between 1999 and 2003 were in the carriage sector (ILO, 2015). Owing to the high rate of injuries, wounds, infections, and deaths worldwide, the carriers' sector has always been called an "unhealthy industry" (Chiocha, et al., 2011).

The stone industry, which has a role in satisfying local demand for the construction market, and conventional Palestinian exports and the local economies, is regarded as one of Palestine's major and important extractive industries. Stone is available in industrial volumes and is characterized by consistency, quality and multicolor, as a raw material for construction. These factories are scattered throughout the West Bank, and in the Governorates of Bethlehem and Hebron are most of the stein quarries and saws.In the West Bank, there are estimated to be about 700 saws and 250 quarry facilities with over 13,500 staff, investment capital of over 353 million dollars, and a manufacturing capacity of 30 million square meters. This industry accounts for approximately 5.4% of the Palestinian national product, 5.5% of the gross domestic product, and approximately 25% of the manufacturing sector income. The number of sales was almost 600 million. (Palestinian Industries General Union 2005, 2-6 a year.It started during the British Mandate with basic tools in historical mining and stein processing activities, followed by a second period from 1948 to 1973, with a quarry count of 111, including eight quarries.

The most sophisticated machines were introduced in the extracting and manufacturing processes in the Governorate of Hebron, while the third period, which lasted from 1974-1990, characterized the widespread use of modern technology and the substantial expansion of Hebron Governorship, the number of quarries in total Stone at the West Bank-level and second position in terms of the number of stone saws following Bethlehem came as a result of increased demand for stone, especially by the occupation, for building settlements, and also for the local building stone industry. The stone industry has ignored environmental factors, whether it's in the West Bank or Hebron, and whilst this is very important in the local economies and the employment of workers. And questions of fitness, both for workers or people adjacent to quarries and stone saws since this sector has worked to kill farm fields, transforming them into stone exploration areas and destroying natural-vegetation ground cover, as well as air and soil contamination.

The global health burden of respiratory diseases is enormous. An estimated 235 million asthma patients, over 200 million chronically obstructive pulmonary diseases (COPDs), 65 million moderate-to-severe COPDs, 1-6% of adults (more than 100 million), 8.7 million people with sleep disorders, tuberculosis (TB) living worldwide, millions with pulmonary elevated blood pressure and more are estimated to have been suffering from asthma, The environmental effects of biomass fuel consumption are exposed to at least 2 billion people, outdoor air emissions to 1 billion and cigarette smoke to 1 billion. Four million people die from chronic lung conditions prematurely last year (Ferkol and Schraufnagel, 2014).

Globally, the joint effects of residential and environmental air pollution resulted in seven million deaths. Chronic respiratory diseases (COPD) are highly vulnerable to harmful air quality effects of subjects such as chronic obstructive pulmonary disorders (COPD) and asthma. (Jiang, et al., 2016).

At least two billion people worldwide are exposed to poisonous smoke, usually ineffectively combusted in poorly-ventilated indoor stoves or fireplaces, from biomass wood. One billion people inhale toxic air and one billion people are addicted to smoking. While in all parts of the world and all social groups respiratory illness causes disease and mortality, poverty, crowding, climate exposures, and unhealthy working conditions in general increase the susceptibility to such a wide community of disorders. (International Air Societies Forum, 2017a).

Pulmonary disorders, obstructive and restrictive illnesses, may be divided into two main functional groups. The obstructive pattern is characterized by a partial or absolute blocking at either level of the airways increasing airflow resistance. In comparison, a decreasing degree of expansion of the lung parenchyma or chest wall as occurs in restrictive lung disease, such as idiopathic pulmonary fibrosis (Devos, et al., 2017).

Silicosis is one of the oldest working environments, and it kills tens of thousands a year in the world. It is an incurable and permanent lung disease caused by dust inhalation that includes breathable crystalline silica and is characterized by cauterization of the lung tissue by crystalline silica deposition. There is a significant global strain of silicosis. Indeed, it is estimated that in 2000, Silicosis was linked to 2000 to 8,800 deaths and 486,000 life-years adapted to disabilities4. (Pham, et al., 2020).

Owing to the risky nature of its operations the mining and quarrying sector is considered a risk industry worldwide. (Van den Honert and Vlok ,2015) noted that the injury mortality rate for South African mining and quarry industries approaches twice the worldwide fatality rate due to occupation hazards at one death per 300 workers. Virchow (2015) found the mine and quarry industry to be one of the world's most dangerous industries.

1.2Statement of problem

It was observed that the majority of people working in quarries have respiratory complaints. Exposure to dust of sand and rocks such as granite and sandstone are the main exposures for workers in this industry. Dust is typically caused by digging, drilling, or working on certain building materials, sandstones, or rocks in ways that generate fine silica in the air(OSHA, 2021).

In Palestine, studies on the health of workers, particularly the respiratory system health, have not been carried out to explain and analyze the effect of work in stone-crushing factories on workers' health. Workersin quarries suffer from many respiratory problems and symptoms that are often reported. There are information and evidence gaps regarding the relationship between quarries and respiratory diseases and this research attempts to establish and study this globally reported connection between quarry-related exposure to contamination and the likelihood that respiratory diseases may evolve.

1.3ResearchJustification

The quarrying and crushing industry plays a significant economic role in Palestine in terms of production, employment, and exports. With a total of 218 firms, it makes a combined contribution of 6% to the value-added of the industrial sector and employs 3.5% of all workers in the industrial sector. The stone industry is also a major economic player. Its value-added formed 3% of the gross domestic product and 17% of the value-added of the manufacturing sector. It employs 3,942 workers, constituting around 9% of manufacturing sector workers. Exports of stone products formed 20% of industrial exports to Jordan in 1994. The overall performance of the industry, measured by the value-added, was strong compared to the industrial sector. The productivity of the quarrying and crushing industry is 78% higher than the average productivity of the industrial sector while stone industry productivity is twice that of the manufacturing sector. Serious environmental damage is created by these industries, including solid and liquid waste, dust, and noise. These have a detrimental impact on the human population as well as on plants and natural resources but the damage can be minimized if proper production techniques are used and if firms are located on appropriate sites (Makhool& Al-Rob, 1999).

Disorders associated with work are the primary source of occupational complaints and disabilities (Habybabady, et al., 2018). Air pollution burden society and are one of the leading causes of death (WHO, 2012). The burden of chronic breathing conditions, some of them workplace exposures, smoking and lung infections, can be increased by multiple determinants (WHO, 2016). Global populations, particularly those in developed countries, are increasingly at risk of developing respiratory diseases as a result of smoke and dust production in various occupational and industrial sectors (Meo, et al., 2016).A substantial number of preventable diseases are account for environmental and work-related respiratory diseases and are the leading occupational diseases in America, based on the prevalence, seriousness, and preventiveness of conditions (American Lung Association, 2015). The development of Chronic Obstructive Pulmonary Disease (COPD), of which 19.2 percent are due to working exposure in the USA, is a significant contributing factor to exposure to various dust, toxic materials, vapor and gases (American Lung Association, 2017).Q uarry dust contamination harms the pulmonary system, as was seen in Libyan quarry workers before the revolution (Draid, et al., 2015).

In 2006, the World Health Organization (WHO) launched GARD in the hope of putting together national and international organizations, councils and agencies' shared expertise to enhance the lives of over a trillion people affected by chronic and acute respiratory illness (Forum of International Respiratory Societies, 2017a)

For example, an estimated 1.2 million employees annually could be exposed to silica dust alone and are likely to be exposed to harmful exposure. (Jonsson, et al., 2019). It is impossible to detect workplace lung diseases early since they are dormant for a lifetime of 15 years for silicosis and asbestos-related cancer 30 or more. Other factors like cigarette smoking can make a major contribution to the disease process and thereby obscure the link between illness and toxic exposure (Furlow, 2011).

Silicosis is one of the oldest working environments, and it kills tens of thousands a year in the world. It is an incurable lung disease caused by the inhalation of dust that contains free crystalline silica. Silicosis still afflicts tens of millions of workers in hazardous occupations and kills thousands of people every year, everywhere in the world. With its potential to cause progressive and permanent physical disability, silicosis continues to be one of the most important occupational health illnesses in the world. (IOL, 2009)

Large amounts of laryngeal cancer Survey has demonstrated that workers potentially exposed to silica dust, a well-known cause of silicosis are affected. Dust penetration is believed to lead to different kinds of dermatosis. (Ugbogu, et al, 2009)

Manual Stone’s exercise is interrelated to the incidence of symptoms of respiratory disease among quarry workers, the prevalence of dermatosis on the quarry in comparison with the control community, and the extent of employees' awareness about the health effects of dust inhalation. (Ahadzi, et al., 2020)

Agriculture and stone-cutting are the major economic industries. In BeitFajjar the major force of economics the stone industry, popular in the buildings in Israel and the Palestinian Territories, known as Jerusalem stone. In Beit Fajjar, out of 650 in the west Bank, there are 138 stone processing plants. Since 1998, there were problems for Palestinian quarry owners to extend their licenses. Under Human Rights Watch (RW) Israel denied permission for almost all 40 or almost all other Beit Fajjar quarries, or almost all of the Palestinian-owned quarries in the West Bank region under Israeli administration.

Stone and Marble Industry (SMI's) impacts on public health and the environment

SMI in Palestine has severely and adversely impacted public health, including the health of the workers involved directly in the industry itself, and health of the population living in SMI's neighborhoods, as well as the well-being of the surrounding environment and ecosystems. These impacts result from rock quarrying and crushing operations in open areas, cutting and polishing of massive rock blocks in stone-cutting plants, pulverization, chemical alteration, and transportation of rocks, as well as from building and construction's activities. The SMI's activities result in air, water, soil, and noise pollution, in addition to their negative impacts on the green cover (trees and vegetation). Furthermore, this industry, as largely being an uncontrolled industry, has certainly increased the amounts of waste generated from its operations, including the limestone waste (LSW) (Salem, 2021)

1.4Aim of the study

To identify the association between Quarry industry and pulmonary function among quarry workers in BeitFajjar-Palestine.

1.5Objectives of the study

- To identify the association between socio-demographic characteristics and pulmonary function among quarry workers in Beit Fajjar village.

- To identify the association between quarry industry exposures and pulmonary function among quarry workers in BeitFajjar village.
- To assess working conditions and safety measures use among quarry workers in BeitFajjar village.
- To develop hypothesis about the association between quarry workers ‘conditions and pulmonary functions.

1.6 Expected outcome

The study of the association between quarry and respiratory disease among workersin Beit Fajjar Village would increase the knowledge about these correlations and reveals the risk and protective factors in Beit Fajjar community. Thereafter, programs may be developed focusing directly on these groups at risk and working on a preventive campaign against specific contributing risks aiming to decrease both prevalence and incidence of this serious health challenge, through better occupational health and safety practices of this business.

Chapter 2

Literature review

In this chapter, the impact of stone dust on health, epidemiology of quarry industry on workers' health, and similar studies worldwide and in Palestine is presented.

2.1Impacts of Stone Dust on Health

Boiling, crushing, and road transport are the major sources of dust in a quarry operation. Employees are in danger of inhaling the emitted dust which is harmful. Dust inhalation can cause significant health issues, including respiratory and lung ailments while skin and eye diseases are caused by dust exposure (Sheikh, et al., 2018). Exposure levels in the New Zealand workplace are 8hour weighted average of 10mg/m3 for complete dust 5mg/m3 and breathable quartz dust 0.2 mg/m3 (Glass, et al., 2013).

Workers are prone to chronic disorders in quarry. Dust, vapor, and gas contamination put employees in danger of chronic diseases (Famiyeh, et al., 2017). Exposure to mining dust can cause several pathological effects depending on the composition, shape, size and length of exposure (Utembe et al., 2015). Long-term exposure to the population would potentially become silicosis, silicotuberculosis, (tuberculosis of the lung), obstructive airways disease, and occupational asthma, according to Akgün (2018) and Fritschi, et al (2016). Infuses of carbon dust often contribute to a high prevalence of many diseases in the mining and carriage manufacturing industry, which have little health at all (Basu et al., 2015). Long-term jobs in dust conditions, frequent smoking and an increased prevalence of respiratory diseases also degrade their immune workers in heavy industry and collieries (Ulmann, et al., 2015). Consequently, safety risk identification and management are important for monitoring and improving the safety of quarries.

2.2Diseases Associated with Dust pollution

Chronic dust pollution causes pulmonary disease and causes some respiratory and non-respiratory effects in the carriage workers, arising from the statement of granite rocks. In some quarries, a particular concern is the inhalation of Silicon-containing dust leading to silicosis, an irreversible pulmonary disease leading to pulmonary inflammation and respiratory problems which progress even at the stop of exposure (Isara, et al., 2016).

Pneumoconiosis Pneumonia (Cohen, et al. 2016) is a deadly respiratory disease caused by coal powder that can lead to progressive mass fibrosis and is also a significant worker's disease in developed economies globally. The latest awareness of quick progressive pneumoconiosis in young miners has reinforced the sense of urgency, vigilance and avoidance of exposure and medical study (Petsonk, Rose, & Cohen, 2013). Pneumoconiosis accounted for 89.7 % of the confirmed cases in China in 2014, of which 50.52 percent was pneumoconiosis of coal-workers (CWP) and 42.69 percent was silicosis (Q. Wu et al., 2016). The claimed silicoanthracosis of Jungraithmayr, et al. (2016) is also pneumoconiosis arising from carbon and silica accumulations in the pulmonary from inhaled carbon dust; the silicon content can create dangerous fibrous nodules in the entire body.

Fibrosis and cancer: Diffuse and persistent airway conditions, including emphysema and chronic bronchitis, may also be at risk for dust-related employees (Petsonk et al., 2013). Pulmonary fibrosis includes a category of lung scarring diseases, which result from known or unknown insults and which pose a substantial degree of morbidity and mortality, according to White et al. (2020). Low dust penetration also causes pulmonary disease (Leng, et al., 2016). Quarry function was related to an increased risk of lung cancer (Taeger et al., 2015). The incidence of multifarious infections, the prevalence of non-communicable diseases and the pervasive weaving of non-communicable and transmissible illnesses represent the double illness dilemma of interrogators in developed countries. Leaders must develop integrated care and control plans based on people to minimize risk. In the United States of America (USA), the National Institute for Safety and Protection in Health (NIOSH) conducts health inspection services for employees, including first-time and five-year chest radiography (Petsonk.et al., 2013). The approach to prevention must be the identification of work that contributes to over-exposure to silica and the elaboration of successful management strategies (Blanc & Seaton, 2016).

Silicosis and tuberculosis Silicosis and TB are associated with exposure to silica particles. Fortunately, the production and application of engineering management technology avoid over-exposure of respirable silica emissions (Yorio et al., 2015). Tuberculosis management requires a combining strategy according to Vynnycky et al. (2015), which would expand clinical services to reduce complications in care, boost diagnostics, enhance antiretroviral therapy coverage and successfully enhance preventive treatment.

2.3Epidemiology of occupational exposure to dust

Occupational exposure is one of the leading global causes of respiratory disease and in formal and informal jobs in both developed and developing countries (Naidoo and Muneku, 2015).

Air pollutions is one of the main health risks for workers exposed to dust and causes morbidity and mortality among these workers worldwide(Nwibo, et al., 2012). Work-related dust pollution in developed countries is a well-known phenomenon especially among stone carriage; (Nwibo et al., 2012). Many epidemiological studies, for instance, have found that respiratory disability and occupational exposure to dust are related. (Nwiboet al.2013).

Several studies showed that socio-demographic factors are risk factors for respiratory health. A cross-sectional study has shown that men are more at risk than women, and the level of schooling is a risk factor for respiratory disease in quarry workers in Edo State, Nigeria (Isara, et al., 2016), and in Iran (Rafeemanesh, et al., 2015).

A cross-sectional study at Ebonyi state, Nigeria (Nwibo, et al., 2012) found that the risk of respiratory disorders and compromised pulmonary function_cygar smokers are at higher risk that was demonstrated by prolonged exposure to stonecutting.

In 2015, a cross-sectional analysis in the peri-urban region of Bangalore, Ramesh, et al. found that people living close to a quarry with low economic status were more vulnerable to respiratory illness than people living well removed from the quarry. The duration of exposure to the quarry is another risk factor for respiratory disease, in a case-control study, in (Libya, Draid, et al., 2015), and In a case-control study in Palestine ,WS, 2018, showed that a reduction in lung function associated within years of exposure .

In a cross-sectional descriptive study in Nablus, Ramallah, Hebron and Jenin governorates, Tahhan, et al, (2017), another risk factor for pulmonary disease is the lack of preventive measures and the lack of safety interventions raises the risk of respiratory disease.

2.4 Pulmonary function testing in quarry industry workers

In a study conducted on pulmonary problems among quarry workers by Nwibo et al., (2012) the workers pointed out that they had numerous breathing issues, including chest pressure, tobacco, wheezing and shortness of breath. The study showed that no protective precautions were required for up to 98.3 percent of employees. The findings of this trial indicate that prolonged dust exposure from rock crushing might improve respiratory vulnerability and impairment of pulmonary function, including increased service duration as an added risk factor for tobacco or cigarette smoking.

In a detailed description of the prospective Cohort Study (2009) wasthe population (26–66 yrs. At baseline) consisted of 2,679 males and 3,026 females with an FEV1 measurement in at least one of the three rounds of follow-up and information on relevant co variables. High educational level was used as the reference class; the study showed FEV1 decline was faster in less-educated females, independent of smoking. In males, FEV1 decline did not differ between educational levels.

A cross-sectional study of 524 stone quarry workers in Ghana to assess the joint effect of work post and PPE usage on self reported disease symptoms while controlling for relevant compositional and contextual factors, the result was Stone quarry workers who work between 1- 100 m and beyond 100 m from the crusher with the required PPE were

90% and 87% respectively less likely to report eye irritation compared with their counterparts who work between 1 and 100 m from the crusher without the required PPE.

Ugbogu, et al., (2009) studied the occurrence of respiratory and skin problems among manual stone workers and found out that Respiratory signs were present in up to 85% of workers and skin infections in 77%. The study also showed that, while the effect of dust on their health is highly sensitive, the use of protective robes and equipment was not widespread. In a report by Ilyas et al. (2010) it was found that issues relating to dust have been compounded by instances where owners of crushed stone have not provided the necessary security for employees. The report further indicated that self-medication is the safest form of care and that staff should not have health benefits at all.

Compared with the developed world, developing countries are more likely to be detrimental to people and the atmosphere. This is because the climate and healthcare in developed nations are unsatisfactory (Ilyas&Rasheed, 2010). In addition, this study has shown that the effect of dust in bad work conditions is linked to a deteriorating trend in air quality as a result of different kinds of environmental emissions, given the privileged livelihood trends. Evidence suggests that children are involved in dangerous mining work and that these young workers are extremely likely to catch dust-related illnesses relatively quickly (ILO-IPEC, 2007).

Different experiments have found that rock contains crystalline silica in different concentrations based on the rock type. For example, granite rock containing crystalline silica is up to 71%, while calcareous and basalt rocks contain up to 40% and 1% respectively (HSE UK, 1992).The Kajiado Geology Study documents analyses of samples of calcareous rock suggesting varying silica content, which are the highest at 11.38 percent in the Kenya Marble Quarry samples collected (Demissew, et al.2016). There has nevertheless been little research on the effect on the health of 19 employees of the calcareous quarry dust and the nature of the problem is therefore not known.

Isara, et al., (2016) conducted study aimed to determine the prevalence of respiratory symptoms and assessed ventilatory functions among quarry workers in Nigeria. Workers were investigated by standardized questionnaire. Using a KoKo legend spirometer, FEV1, FVC, FEV1/FVC and PEFR were measured. The outcomes: A total of 113 quarry workers were examined (76 exposures and 37 controls). The chest pressure (35,5%) was considerably higher than 16,2% of controls ($p<0,05$). The category was substantially higher than 16,2%. In the control community, the prevalence is higher of cough (23.7% vs 13.5%), sputum (21.1% vs. 16.2%) and dyspnic disease (7.9% vs. 5.4%), wheeze (10.8% vs. 10.5%) and nasal inflammation (27.0% and 25.0%). In the control groups, exposure levels were greater.In comparison to the community of controls the mean (SD) FEV1 and FVC have been significantly lower; 2.77L (0.73) compared to 3.14L (0.78), $p < 0.05$, and 3.48L (0.84) compared to 3.89L (0.92), $p < 0.05$. Smokers in both groups were substantially lower in their FEV1 mean (SD) than non-smokers, with FVC and PEFR; 2,91L (0, 77) versus 3,39L (0, 69), p = 0, 01, 3,61L (0, 91), versus 4,26L (0.74). The study concluded that chronic quarry-dust exposure is related to respiratory symptoms and decreased indexes of lung function among quarry workers. The application of PPE and periodic assessment of the condition of the lungs of quarry workers are recommended.

Kumar, et al., (2014) conducted study aimed to study the deterioration of pulmonary function in quarry workers and its relation with duration of their exposure in India, on 75 male quarry workers and 75 healthy ages, gender, height, weight matched controls. Pulmonary function testing in quarry employees, lung function assessment using computerized spirometer pulmonary functions are performed (Spirowin 2.0). The results of unpaired t analysis were compared, and a correlation was made using Pearson correlation coefficient between work period and percent difference in lung function. The results showed a substantial decrease between the quarry staff and their corresponding controls in mean values of FVC, FEV 1, FVC/FEV1%, PEF and FEF25–75%. In addition, the decrease in percentage of pulmonary function values was positively associated with the period of employment. Comparing pulmonary functions between quarry workers and controls, it is inferred, and is associated with the durations of exposure, that exposure to dust containing silica in quarry workers is worsening pulmonary function. We recommend that workers be protected by wet working, adequate ventilation, and preventive measures details.

Aja and Chukwu (2018) investigated on the effect of stone crushing dust on the health of workers of quarry industry at Ebonyi State. The study was descriptive, 144 questionnaires were used. Finding shows that silica and other harmful chemicals contain stone crushing dust, and inhaling this dust can lead to infections such as silicosis, visual irritation, skin disease and bowel discomfort. To avoid these diseases recommendations including provision of personal protective equipment, the adequate training of competent staff, the use of non-humanly hazardous substances, the health education of the employees about dust effects and the steps aimed at preventing dust inhalation of the quarry industry.

PrasadandWagh (2019) conducted a study aimed to assess the pulmonary function test among the Stone Quarry industry workers in WardhaDistrict, India. It was a community-based Cross-sectional analysis carried out in the stone quarries situated in villages of 30 Wardha district. Standard Pulmonary Function Test (PFT) 56.60%, Obstructive lung disease found in 10.34%, Restrictive lung disease in 31.04 %, mixed lung disease in 2.02 %, Irregular PFT in all was (43.40%). (43.40%). It has been found that pulmonary function parameters among the quarry employees have been significantly reduced.

Draid, et al., (2015) conducted a study aimed to determine the lung impact from working within the Libyan quarry industry, and if the length of work impacted the degree of degradation. 83 workers in the Libya Nafusa Mountains chose to participate from eight silica quarries. The quarries worked on the strong geological structure of the cretaceous. 85 people without affiliation to quarry operations lived in Gharyan City and took part in controls. The evaluation vector spirometry was Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV1), FVC/FEV1 and Peak Expiratory Flow (PEF). No difference in height, weight, or smoking was made between the control and groups of people exposed ($p = 0.18, 0.20, 0.98$). FVC, FEV1 and PEF are considerably lower in exposed groups ($p = 0.003, 0.009, 0.03$, respectively) until adjustment for other variables. Significant differences between control and exposed groups for the FVC, FEV1, and PEF exist following adjustment for age, height, weight, and smoking status. This study shows the negative impact on the lung function of exposure to quarry dust and that Libyan quarry workers were exposed before the Revolution. This research demonstrates that exposure is damaging because the decline in lung function has not been significantly related to years.

Rusibamayila, et al., (2018) conducted a cross-sectional study aimed to determine respiratory impairment, personal respirable dust exposure levels and associated factors among miners in a gold mine in Tanzania. A questionnaire has been used for respiratory symptoms data collection. Spirometry analysis of lung functions. Personal exposure to breathable dust was obtained with air sampling pumps from related exposure categories. The 112 study participants were selected using a simple random sampling technique. The findings demonstrated that, over a mean sampling time of 8 hours (7–11 hours), the overall Geometric Medium (GM) of breathing dust was 0.26 mg/m3 (GSD = 0.32). Underground employees had a slightly higher GM of respirable dust (0.41 0.28 mg/m3) than open-pit workers (0.17 0.23 mg/m3), with a p-value of 0.01. Underground employees had the highest GM of respirable dust, 0.53 mg/m3 (GSD = 0.27), followed by boggier operators. The quality controllers had the highest GM of respirable dust among open-pit employees, at 0.39 mg/m3 (GSD = 0.18). Phlegm (49.1%), breathlessness (42.9%), cough (37.5%), wheezing (18.8%), and chest tightness were the most common respiratory symptoms (10.7 percent). Cigarette smokers were more likely than nonsmokers to report breathlessness. Airflow barrier prevalence (FEV1/FVC<0.7) was 1.9%, while lung restriction prevalence was 8.8%. The study found that age, smoking habits, and past dust exposure had no bearing on lung function disability. Despite levels of respirable dust exposure being below the recommended occupational exposure limits, the prevalence of respiratory symptoms among the gold miners surveyed was found to be high. This necessitates additional research into the quartz content of respirable dust.

Rachiotis, et al., (2018) conducted a cross-sectional study aimed to investigate the prevalence and risk factors of lung function impairment among Greek cement workers. 137 employees have been interested in this research. Moreover, the monitoring group included 110 workers not subjected to cement dust. At the workplace the concentration of total cement dust was 1,1 to 11,6 mg/m3. The threshold limit of 10 mg/m3 was exceeded in only one measurement. The prevalence of FEV1 was higher than controls (13.9% vs.

2.7%; Chi-Square Test; =.002) than that of cement workers. Multivariate analysis has shown that cement production workers have recorded an almost 5-fold risk of low lung function, as expressed by FEV1<80 percent, in comparison to the reference population OR=4.92; 95 percent C.I. =1.22–12.62). The risk of FEV1<80 percent (OR=4, 91; 95 percent C, i.e., =1, 32–11, 56) has been linked with the near-4-fold increased smoking. The study showed that, although the overall and inhalable dust levels were below industrial exposure limits, a high prevalence of compromised lung function among the Greek cement producers was found.

Shaik, et al., (2015) conducted a cross-sectional study aimed to study the Lung functions test in stone Quarry workers. The study was carried on 100 workers. 50 young males 20-35 yrs. old, nonsmoking workers without any preexisting cardio-pulmonary disorders, exposed to silica dust for a duration of 1-20yrs in a stone quarry worker in Rayachoty area, served as subjects. Another 50 males who were similar in all aspects to the study group, not exposed to silica dust professionally at any time, served as controls. Results: FVC, FEV1, PEFR &FVC % were highly significant and lower in stone quarry workers. FEV6 is significantly lower compared with controls Conclusion: Exposure to these substances, hitherto unaccustomed, led to the development of a new set of disorders which can now be classified under 'Occupational Diseases'. Occupational exposure to silica dust leads to the development of various pulmonary disorders, by sinuses begin most important of them.

Nwibo, et al., (2012) conducted cross-sectional study aimed to determine the prevalence of respiratory problems and lung function impairment among quarry workers in Ebonyi State, Nigeria. Respiratory problems and lung function were studied in 403 quarry workers aged 10–60 years. The finding showed that respiratory problems found were chest pain (47.6%), occasional cough (40.7%), occasional shortness of breath (6.5%) and wheezing (5.2%). The mean±SD FEV1 and FVC values were significantly decreased with length of exposure—respectively, 3.52±0.77 and 3.91±0.72 L for <5 years; 2.79±0.68 and 3.09±0.87 L for 5–10 years; and 2.03±0.92 and 2.86±0.83 L for >10 years of exposure. Moreover, the mean±SD FEV1 and FVC values of smoker (3.37±0.81 and 3.56±1.02 L, respectively) were significantly (p<0.05) lower than that of non-smokers

(3.68±1.02 and 3.89±0.99 L, respectively) working in the quarry site. The study concluded that chronic exposure to dust due to stone quarrying may increase the risk of respiratory problems and impaired lung function—cigarette smokers are at higher risk.

Kabir, et al., (2018) conducted a cross-sectional descriptive study aimed to investigate the respiratory health problems of stone crushing industry workers in Bangladesh. Data were collected by the use of a questionnaire survey, focus group discussions, in-depth interviews and spirometry examinations. Focus group discussions and questionnaire surveys were conducted among 240 workers. The results showed that there was a significant relation between respiratory problems and inhalation of dust and particulate matter and cigarette smoking. It also shows that coughing was the most common problem among the respondents. The majority of respondents suffered from obstructive types of respiratory problems. Also, the findings of the study reveals that chronic exposure to dust at stone crushing plants increases the risk of respiratory problems and the impaired lung function of workers. It also reveals that there is a significant relation between respiratory problems and inhalation of dust and cigarette smoking. Raising awareness about health risks amongst workers could reduce these health hazards. The government should make a national policy for the prevention, control, and elimination of silica exposure and silicosis. The results would help to raise awareness of the issue. Finally, it would raise awareness on respiratory health problems of workers at stone crushing industries in Bangladesh and help the government to make a policy for the prevention, control and elimination of silica exposure and silicosis, and thus enhancing public health policy and practices in the country.

Apenteng, et al., (2016) conducted cross-sectional descriptive study aimed to assess the occupational health-related problems of most quarry workers in Ghana. Simple random sampling was employed in the selection of the respondents from a population of adult quarry workers. Data on socio-demographic profiles and health-related conditions were obtained. The study sort to relate the duration of time spent in the quarry with the incidence of pulmonary problems and other health conditions. Results indicated that the frequency of carrying out the quarrying activities was between 4 to 6 days and majority of the respondents carried out activities on a 24 h schedule. Ninety percent of the respondents did not use protective clothing whilst at work. Respondents, 63.3%, 45% and 58% reported symptoms of persistent coughs, shortness of breath and chest pains respectively. Other health-related conditions reported included; muscle pain (91.7%), weight loss (83.3%), fatigue (96.7%), skin irritations (30%) and eye irritation (53.3%). X ray diffraction analysis of rock samples from the quarry site revealed the presence of crystalline silica, aluminum silicate hydroxide, potassium silicate hydroxide and quartz which are known to cause respiratory problems over prolonged exposure.

2.5 Studies in Palestine

Jaber, et al., (2015) conducted a study aimed to determine the prevalence of respiratory problems and lung function impairment (PFI) among Palestinian stone cutting workers, and to investigate its association with work conditions and other risk factors. During April-June 2012, 259 men worked in all stone-saw workshops (n = 42) in the north of the West Bank region, Palestine, located around the valley from Nablus to Tulkarm. Interview questionnaire, comprehensive history, clinical evaluation, and spirometry have been used to study respiratory disorders and lung function. Results showed, that between 28.2% and 17.8% and 3.8% of staff, chronic cough, chest pain and wheezes were present. The prevalence of pulmonary irregular function tests among the workforce was 21,6%; 20,1% of the workforce had restrictive lung diseases and 1,5% had obstructive pulmonary diseases. Multivariable regression, which has been shown to be more likely to cause irregular pulmonary function tests (OR 4.5; CI: 1,01-20.2; p = 0.049), (OR 2.1; CI: 1,03-4.5; p = 0.04) and (OR 2.1; CI: 1.04-4.5; p = 0.03), respectively. Conclusion: The industry may boost the risk of respiratory problems, impaired lung function, of a cigarette smoker, long work and non-use of PPE (Personal Protective Equipment) are more vulnerable to chronic exposure to stone cutting.(Jaber et al., 2015)

Rahhal, et al., (2015) conducted a study aimed at the effect of working in stones crushing factories on respiratory function, a cross-sectional descriptive study was used to describe the pulmonary function of all the 98 stone crushing workers in Nablus, Ramallah, Hebron and Jenin governorates. The first second of forced spirometry, the FEV1 forced vital power; the FEB1/FVC for breathing patterns was used to measure expiratory volume. Forced Spirometry was applied. It has been shown that 20 percent of employees complained of at least one symptom of respiration like cough, sputum and chest pain. The majority of employees showed a conservative trend, with 69% of all employees, with 67% displaying only moderate restraint. On the other hand, the obstructive pattern displayed only 11.2 percent and the remaining patterns were regular. The FEV1 values were not significantly lower ($p = 0.76$), but the FVC values were significantly less ($p < 0.001$). The values of FEV1/FVC were considerably high ($p < 0,001$). The findings were correlated with the mean of the predictive values measured. It was concluded that work in stone cutting plants has a detrimental impact on breathing and thus urgently needs intervention to avoid problems in health

2.6Conclusion

Respiratory diseases are an enormous challenge to life, health, and productive human activity. Prevention, control, and cure of these diseases and the promotion of respiratory health must be a top priority in global decision-making in the health sector. The control, prevention, and cure of respiratory diseases are among the most cost-effective health interventions available – a "best-buy" in the view of the WHO. Investment in respiratory health will pay manifold dividends in longevity, healthy living days, and national economies. Public awareness and control of the environment are important steps in preventing respiratory diseases. The key controllable factors are reduction in tobacco smoking and improvement in air quality, which includes a reduction in second-hand tobacco smoke, smoke from the indoor fire, and unhealthy public and workplace air. Strengthening childhood immunization programs and greater availability of the pneumococcal conjugate vaccine must be a priority in low-income countries. Prevention and timely treatment of HIV infection can have a major impact on reducing the burden of respiratory illness. Effective training of healthcare workers and making available medications and appropriate diagnostics are keys to better lung health.(Forum of International Respiratory Societies, 2017b) .

Chapter 3

Conceptual framework:

3.1 Pulmonary function testing

Spirometry is carried out with a deepest inhalation and a strong exhalation into a spirometer (the device that records the various measurements of lung function). The analysis of Spirometry findings is based on two dimensions: The first is the forced vital capacity (FVC). The ratio of FEV1 and FVC.(Gholami, et al., 2018). This figure corresponds in one second to the percentage of the lung size (FVC). For instance, when the FEV1 is 4 and the FVC is 5, it will be 4/5 * % or 80% of the FVC. This means that 80% of the air inhaled in the lungs can be exhaled in the 1^{st} second. The reference values for a given person are compared to the three main Spirometry measures (the FVC, FEV1 and FEV1/FVC ratios). The comparison figure is focused on stable people with normal lung function. The value for a person of the same sex, age and height is provided in the spirometer testing (Gholami, et al., 2018).

Interpretation of the effects of Spirometry involves comparing the calculated value of the participant to the reference value. The findings shall be considered natural if the FVC and the FEV1 are within 80% of the reference value. The FEV1/FVC ratio standard value is 70% (and 65 % in persons older than age 65). (Gholami, et al., 2018).

Table 3.1 Pulmonary Function Test Interpretation

SPIROMETRY TEST	**NORMAL**		
FVC and FEV1	Equal to or greater than 80%	Mild Moderate Severe	70-79% 60-69% less than 60%
FEV1/FVC	Equal to or greater than 70%	Mild Moderate Severe	60-69% 50-59% less than 50%

Table 3.2: Interpretation of spirometry device based on age

TEST RESULTS BASED ON AGE		SUGGESTED DIAGNOSIS
FVC	FEV_1/FVC RATIO*	
		Normal
Adults: ≥ LLN	Adults: ≥ LLN or ≥ 70%	
		Obstructive defect
Adults: ≥ LLN	Adults: < LLN or < 70%	
		Restrictive pattern
Adults: < LLN	Adults: ≥ LLN or ≥ 70%	

FEV_1 = forced expiratory volume in one second; FVC = forced vital capacity; LLN = lower limit of normal (defined as below the fifth percentile of spirometry data obtained from the Third National Health and Nutrition Examination Survey).

3.2 Defense mechanism of the human body to deal with any dust

The following mechanisms help to manage the entry of dust into the body and airway. Air passages are short (nose, pharynx, glottis, bronchi act as filter). In the nose, only 35 to 42% of fine powder enters the lungs and 80% of the mouth respires. Capture and penetration of hard mucus and submucosal tissues, from which poisoning, cough, and sneezing and the action of the ciliated epithelium is eliminated. Phagocyte activity consists of leukocytes, endothelial blood, cells and plasma cells. The more quickly eliminated pigmentation of colorless poles in the lung tissues. The lymphatic regions are gradually drained into the bronchial walls with their valve arrangements and the filtering of the lymph nodes and discharge the sections into the bronchial secretions. The species' antibodies. The persistent changes in dust reaction include proliferations of tissue cells, fibrosis and calcification including diaphragm fixation and adherent pleurisy. (Schumacher, 2012).

3.3 Factors affecting pathogenesis

Four main factors that control the pathogenesis associated with dust include a) exposure b) routes of dosage c) Exposure thresholds and d) dosage effect.

Exposure is the concentration or volume of a particular agent achieved at a specific frequency for a specified time to a target organism, device or subpopulation. Exposure evaluation is an estimation of the exposure of an agent (and its derivatives) by an individual, mechanism, or subspecies (WHO, 2014). The primary entrance route for dust into the nasal or oral cavity is inhalation.

This depends on the aerodynamic particle diameter, air circulation around the body, and respiratory function. Based upon a number of biochemical and particulate causes, the inhaled particles will then either be deposited or expired again. The 5 modes of deposition are sedimentation, impaction of inertia, propagation, and electrostatic deposition (significant only for very small particles < 0.5 mm). The most important processes are sedimentation and impaction. Skin touch and mucus contact are the next typical way in which dust [caustic] is ingested in the systemic circulation from dermal and mucosal and enters the lungs because it has a chemical property. Wet dust is highly ingested [when it is interspersed with sweat or water on workers' skin]. Additional causes include local skin reactions. The joint absorption also results in conjunctivitis and ulcerations due to lack of safe eye wear during the job. Where poor hygiene encourages polluted or filthy workplaces to feed, drink or fume several inhaled contaminants are often swallowed and absorbed, but these are typically included in the inhalation direction for monitoring and measuring purposes (Demeke and Haile, 2018).

3.4 Dose Response effect:

The higher exposure to dust particles has greater impact on the health. The curve for dust resembles a standard S-shaped curve. In the respiratory tract, the gastrointestinal and skin effects are profoundly adverse. Chronicity or cumulative toxicity are therefore essential (Mohammadien, et al,.2013). Different industrial hygiene authorities set minimum allowable exposure levels for dust to the minimum results to mitigate the effect. The OELs are an important factor of risk assessment and are also used in ethical codes (Ghosh, 2020).

3.5Conceptual framework

According to a literature review and after reviewing all models suggested for risk factors for respiratory disease and its association with quarry, the risk factors are summarized as follows:

- Socio-demographic and economic factors.
- Smokingexposure.
- Using protection equipment and exposure protection measurements in the quarry.
- Duration of exposure.

The conceptual framework for this study:

- Socio-demographic factors: (age, sex, Educational level).
- Economic factors.
- Occupational Safety and Personal Protective Equipment's
- Duration of exposure.
- Past and Family History of respiratory disease
- Occupational and Exposure History
- Personal Habits (Smoking).

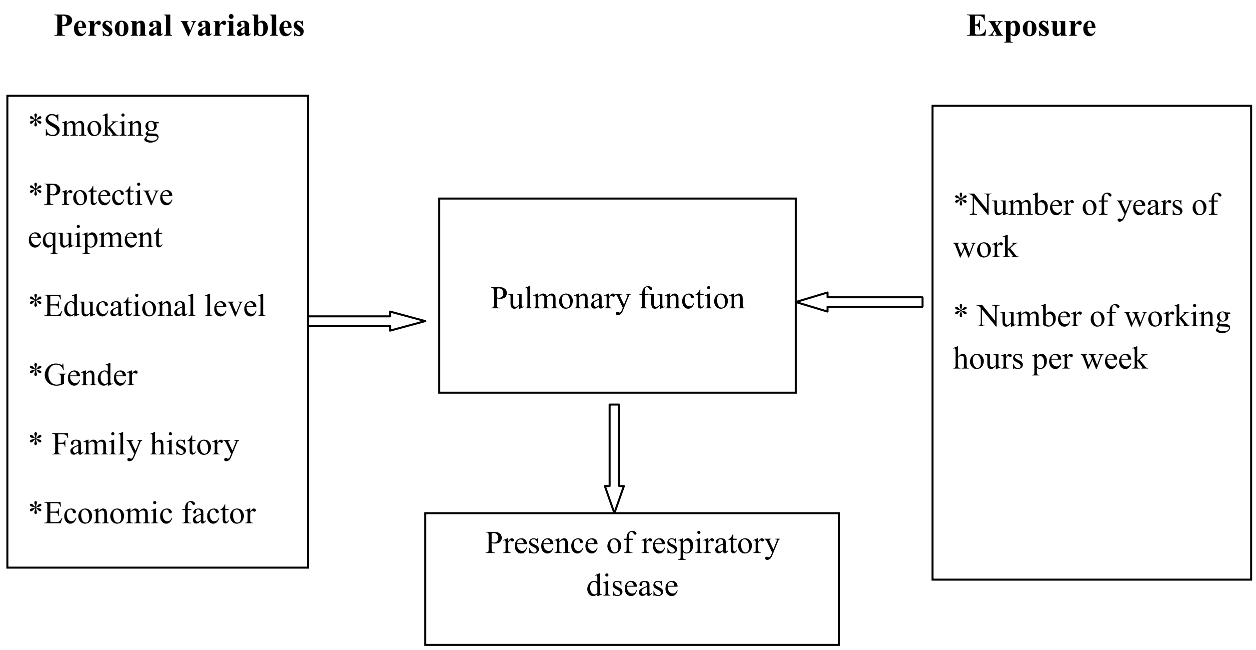

Figure 3.1: Study Conceptual Framework

Chapter 4

Methodology

4.1 Introduction

This chapter will be summarizing the setting, sampling method, sampling frame work, inclusion and exclusion criteria and ethical consideration of the research.

This study will adopt a quantitative cross sectional, descriptive, analytical study to determine the pulmonary function among quarry worker in Bait Fajjar - Palestine.

4.2 Research setting

The study conducted at BeitFajjar Village, Bethlehem city, which is located eight Kilometers south of Bethlehem governorate, in the central west bank. The primary economic sectors are agriculture and stone cutting. BeitFajjar is a major player in stone industry, which is used in the construction of buildings in Palestine and Israel, and this is which make many workers there complaining of signs and symptoms of respiratory disease. According to the Palestinian Central Bureau of Statistics (PCBS, 2020), the total population of BeitFajjar in 2020 was 14,296. There are 1,808 households living in 2,042 housing units.(ARI, 2010). (Figure 4.1)

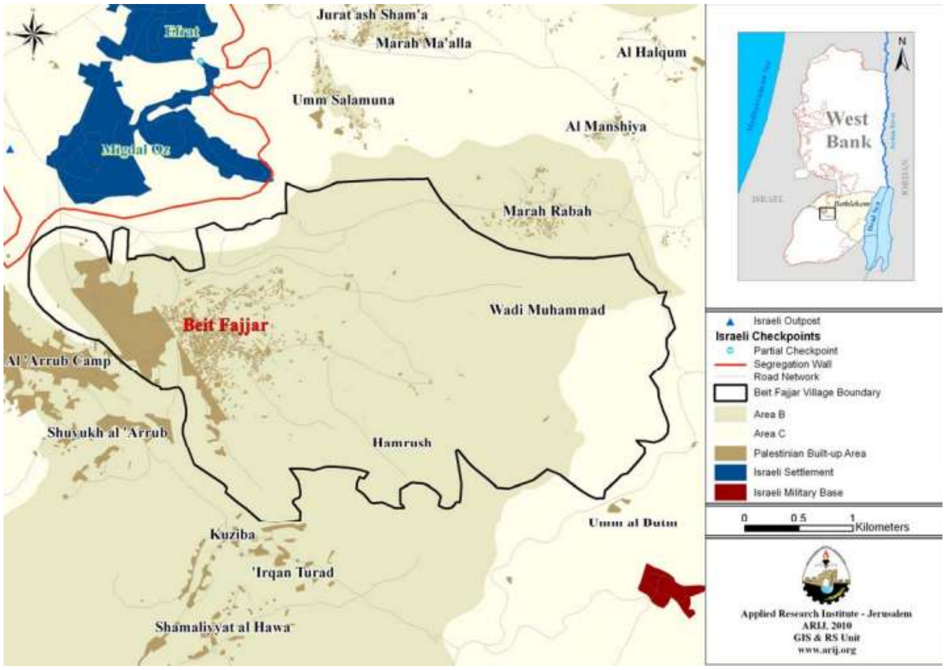

Figure 4.1 BeitFajjar locations and border(ARI, 2010)

The economy in BeitFajjar is dependent mainly on industry; marble and stone, which absorbs 80 percent of the town workforce. The results of a field survey for the distribution of labor by economic activity in BeitFajjar are the following: Industry (80%), Trade Sector (7%), Government or Other Employees Sector (5%) ,Services Sector (5%) , Agriculture Sector (3%)(ARI, 2010).As show below in the (Figure 4.2).

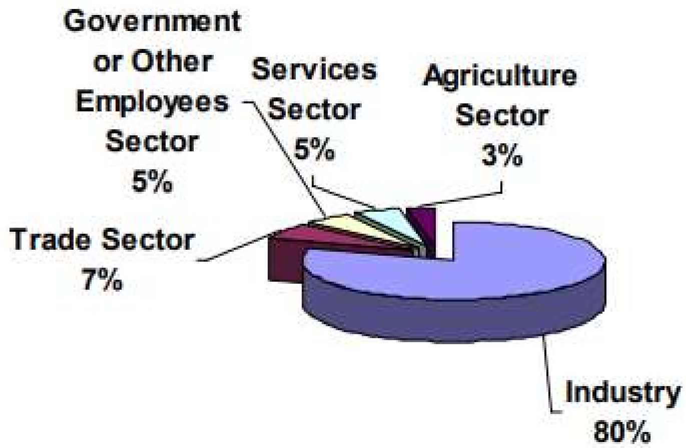

Figure 4.2 Economic Activity in Bait Fajjar Town(ARI, 2010)

4.3 Sample and Population

The study population was obtained from the workers who work at the quarry in BeitFajjar village.

4.3.1 Sample size

Sample size was calculated using sample size online calculator, the calculated sample size was revealed as 200 participants. Based on the P=0.05, confidence interval 95% and according to Beit Fajjar Municipality the number of quarry workers is around 1200, and the study took a sample of 200 participants.

4.3.2 Sampling Method

None probability connivance sampling method was used in this study, researcher doesn’t have a list of patients to obtain a random sample of the workers. The village was distributed to 10 radiuses of equal distances; the population sample distributed among those 10 radiuses.

4.3.3Inclusion- Criteria

The inclusion criterion was as following:

- Workers aged more than 18 years.
- Male who living in BeitFajjar village.
- Acceptance to sign a consent form.

4.3.4 Exclusion criteria:

- Any participant who had been diagnosed with any chronic respiratory disease before the start of work in quarry (including Asthma, COPD, etc.…).
- Workers in the quarry field who had been working less than one year.

4.4 Methodology

4.4.1 Research Design

A descriptive cross-sectional design was used for answering the questions of this research. This methodology was adopted as it is the best design to answer the current questions, and because it is both fast and feasible.

4.4.2 Data collection tools

The researcher used the following data collection tools

1. **Data collection sheet,** (App. 1) which included personal information of the workers, years of work for workers and other personal variables.
2. **Spirometer**. The Spirometer tests are gold standard when it comes to measuring the lung functions or ventilation effects specifically the measurement of the amount (volume) and/or speed (flow) of inhaled and exhaled air. It measures three parameters:

   1] Vital capacity (FVC)

   2] Forced vital capacity (FEV1)

3] Forced expiratory volume ratio (FEV1%)

3. **Modified version of "American Thoracic Society Questionnaire** (Aapen. 2) For Chronic Respiratory Illness in Epidemiological Research" (ATS, 1978). It is time tested and has been extensively used in studies, having the same utility value even now. It also allows flexibility by allowing modifications to it. It can be done as structured-self filling questionnaire or interviewer administered tool depending on the discretion of the researcher and the knowledge levels of the respondents for any study. It has 7 sections that are named as: Socio Demographic Factors, Personal Habits, Past and Family History, Occupational and exposure History, Occupational Safety andPersonal. Respiratory Morbidity Assessment and Rhino-Sinusitis Assessment.

   Validity and reliability of American Thoracic Society Questionnaire

   The questionnaire used in this study is valid and reliable scale for respiratory symptoms and lung diseases according to Jamali and Nafees (2017) American Thoracic Society Questionnaire were significantly associated with decrements in lung function and should be strongly emphasized in clinical or occupational history for assessment of respiratory health. The use of standardized respiratory questionnaires is an effective tool for assessing the burden of respiratory symptoms in occupational setting.

4.4.3Data collection procedure

After getting approval from the ethical committee at Al-Quds University, approval for study was taken from Quarry administrators to conduct the study. Then the workers were invited to participate if they are fitting the inclusion criteria and if they are not within the exclusion criteria. Those who fit were asked to singe consent form, and a written description of the research was given to them. Then data collection sheet was filled, and the American thoracic Society questionnaire was administered, and at the end spirometer tests were conducted.

4.4.4 Statistical analysis

All data was captured and the statistical analysis was performed using SPSS version 24.Descriptive statistics of Frequency and percentages, cross tabulationswereused to summarize socio demographic, and work safety related variables.Correlationperson r test was used to test the correlation between FEV1 and FEV1% with scale level socio demographic variables. Independent sample t test was used to test the difference of mean percentage of FEV1 and FEV1% upon nominal socio demographic, respiratory symptoms, and work related variables. Stepwise Multivariate regression analysis was used to analyze the predictors of variation of the dependent variables (FEV1 and FEV1%)

4.5 Ethical considerations

This study was submitted to Al-Quds University- School of public health research committee for discussion and approval (App. 4) to Al-Quds University graduate studies committee approval. Ethical clearance was granted from Al-Quds university central ethics committee.

All participants were informed about the study aims and objectives and were asked to sign a written consent form (App.3) before participating. A special form was prepared by the researcher. The researcher guaranteed commitment for the anonymity of the participants and confidentiality of the data. The researcher committed to that the data will be used for scientific purposes only.

Chapter 5:

Results

5.1 Characteristics of the participants.

A total of 225 workers were approached, the data analysis showed that 200 respondents filled the questionnaires and were subjected to the spirometer testing, which makes the total response rate to be 88%. The other 25 either did not fill the questionnaire or refused to be subjected to the spirometer testing.

5.1.1 Socio-demographic and other characteristics of the participants:

Table 5.1 shows participants demographic characteristics frequency and distribution. 43% of participants were working at stone-pits and57% in stone crushing industry. Workers mean age (Years) was 33.53 ± standard deviation 9.55 years. The study population was relatively young, about 65% below the age 30 years.

In terms of theireducational level, 53% had primary education and 44% had high school or university education. Their income level was relatively low; i.e., 94% of the workers reported that their income is between 1000 - 3000 Nis. 39% of the participants were single, and 59% were married.

Table 5.1: The Demographic characteristics of participant'sfrequency and distribution:

Variable	Category	Percentage%	Frequency
Workplace	stone-pit	43%	86
	Stone crushing industry	57%	114
Age by years	20 or less	6.0%	12
	20 – 29	32.0%	64
	30 – 39	29.0%	58
	40 –49	25.5%	51
	50 years and above	7.5%	15
Educational level	Illiterate	2%	4
	Primary	53%	107
	Secondary	41%	83
	University	3%	6
Income by shekel	Less than 1000 Nis	1%	2
	1000 - 3000 Nis	94%	188
	3001 - 5000 Nis	4%	8
	More than 5000	1%	2
Marital status	Single	39%	78
	Married	59%	118
	Divorced	1%	2
	Widower	1%	2

5.1.2 History of exposure

Table 5.2 presents the mean practical experience (Years) was 14.92 ±standard deviation 9.10 years and the meantotal working hours per week was 42.04 ± standard deviation 10.74 hours/week.

Table 5.2:Duration of exposures in years.

Variable	Mean	Standard deviation
Practical experience (Years)	14.92	9.10
Total working hours per week	42.04	10.74

5.1.3 Health history

Ass presented in table 5.3, the participants reported that 7% of their families had respiratory diseases. 3% reported that that 4 of their families suffered from chronic bronchitis and 2 workers have sinusitis.

Table 5.3: Health status of participants and their families.

Variable	Category	Percentage%	Frequency
Parents' history of respiratory diseases.	Yes	7%	14
	No	93%	186
Parents' history diagnosis	Chronic bronchitis	42.9%	6
	Emphysema	28.6%	4
	Lung Cancer	28.6%	4
You have ever suffered from a respiratory disease	Yes	3%	6
	No	97%	194
If yes, the diagnosis was:	Chronic bronchitis	66.7%	4
	Sinusitis	33.3%	2

5.1.4 Smoking history

In terms of smoking 77% of participants reported being a smoker as seen in figure 5.1

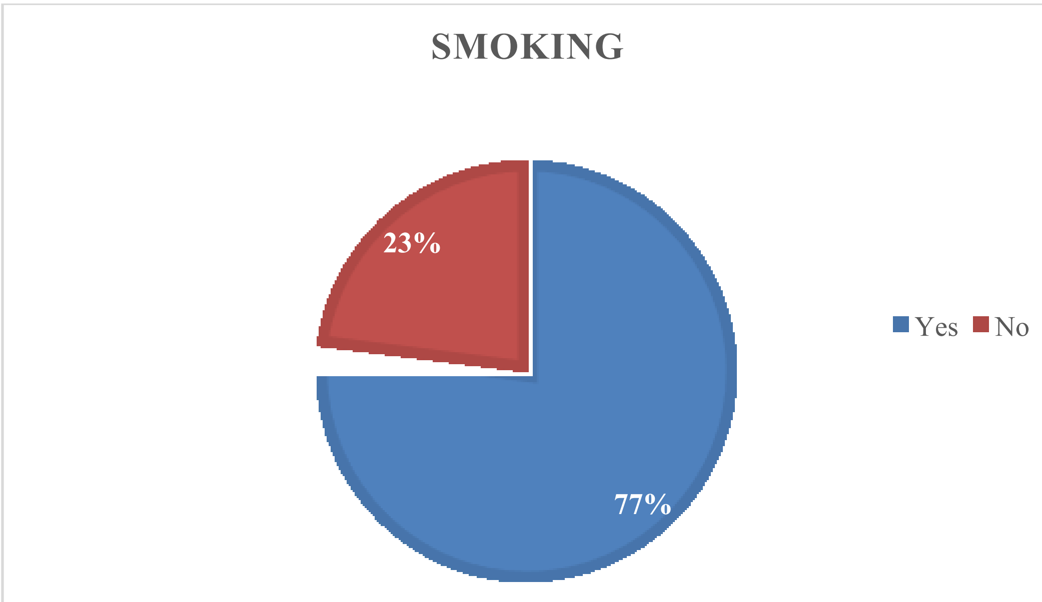

Figure 5.1: Smoking history

As showed in table 5.4 mean of duration of smoking for a smoker was 12.96 ±SD 8.33 years, and the mean number of smoked cigarettes per day is 25 ±SD 12cigarettes.

Table 5.4:Intensity and duration of smoking

Variable	**Mean**	**Standard deviation**
If you are a smoker, how long have you smoked (Years)?	12.96**(years)**	±8.33**(years)**
If you are a smoker, how many cigarettes did you smoke per day?	25.2 (cigarettes)	±12.4 (cigarettes)

5.2 Participants use of preventive measures.

5.2.1 Responses regarding personal protective equipment use

Figure 5.2 down below shows the detailed percentage of each question according to responses from participants. 96% knowsabout personalprotection equipment for workers. 22.5%uses personal protective equipment and a face mask. 97%washes their hands and face before consuming food or drinks in the workplace. All workers reportedchangingtheirclothes after daily work.

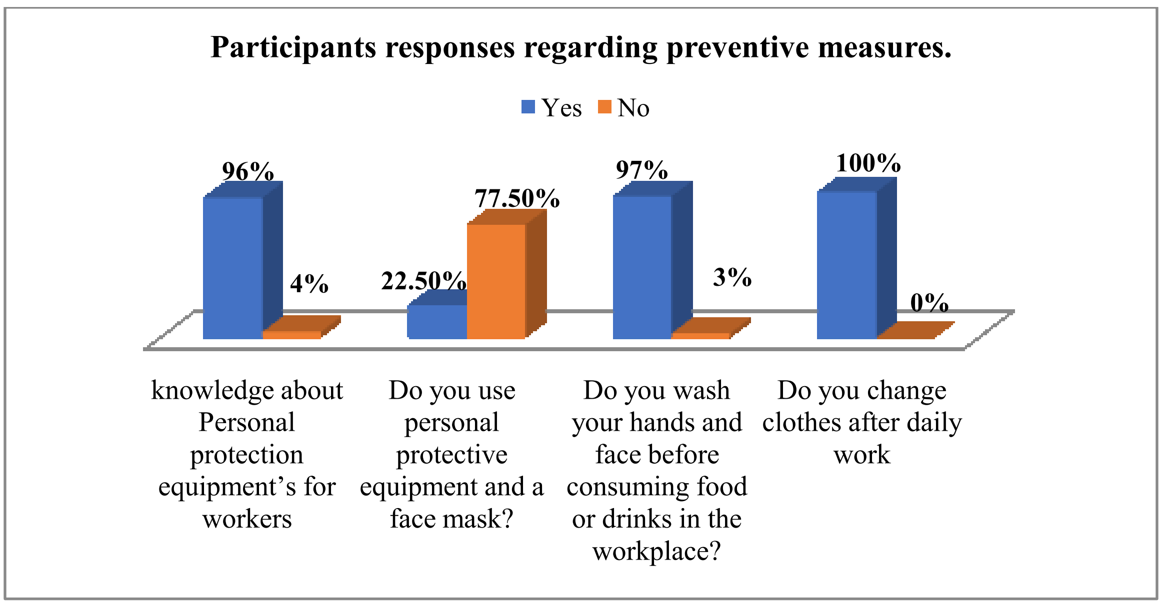

Figure 5.2: Participants responses regarding preventive measures.

5.2.2Reasons behind not using protective personal equipment

The figure5.3 below shows the reason why they don't use personal protective equipment and a face mask: 29% said that it's not available. 48%reported that it was uncomfortable for them and 17% thought it is unnecessary. 5% reported other causes.

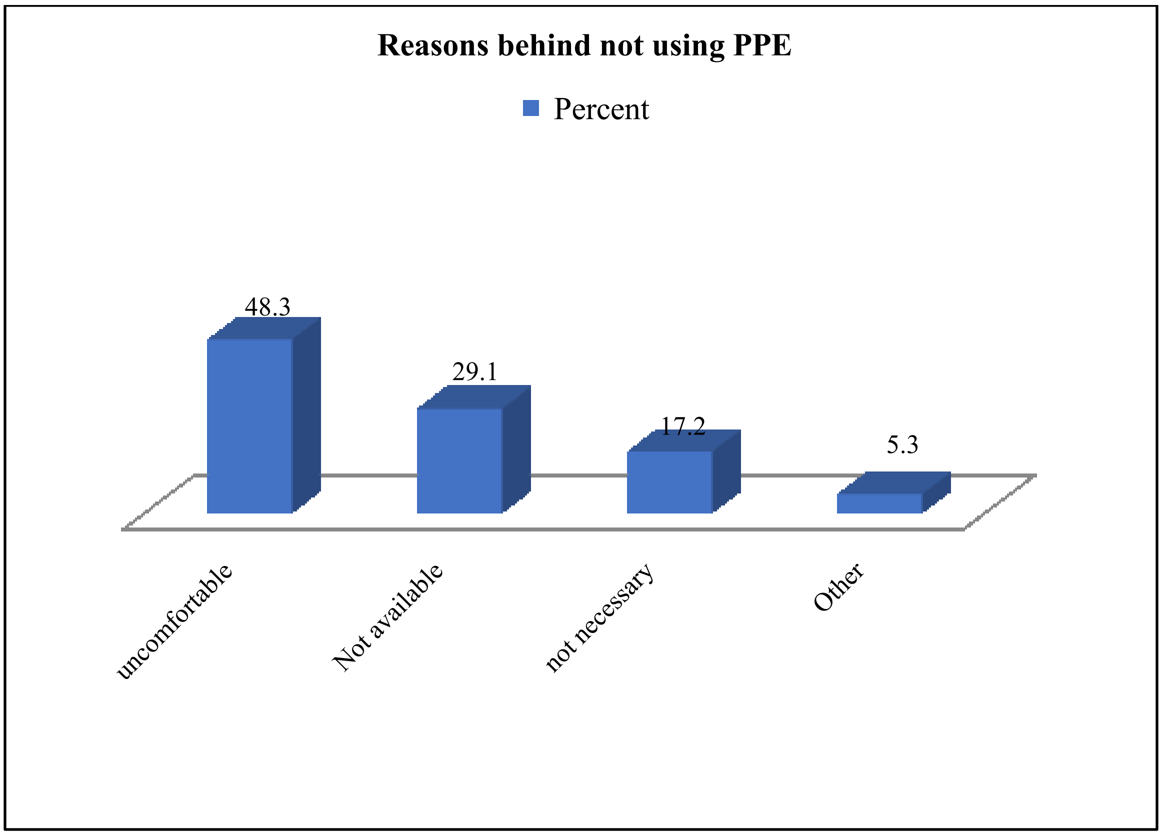

Figure 5.3 Reasons behind not using PPE

5.3Respiratory symptoms among participantsaccording the American respiratory

5.3.1 Cough

Figure5.4 illustrates the percentages of each question according to responses from participants. As for the cough symptom, 60.5%had a cough in the last 12 months and 44.5%had the cough happen 4 or more times a day. 30% suffered from coughing 4 or more days a week while 25.0%sufferedfrom a cough in the morning and 8%suffered from cough in most days.

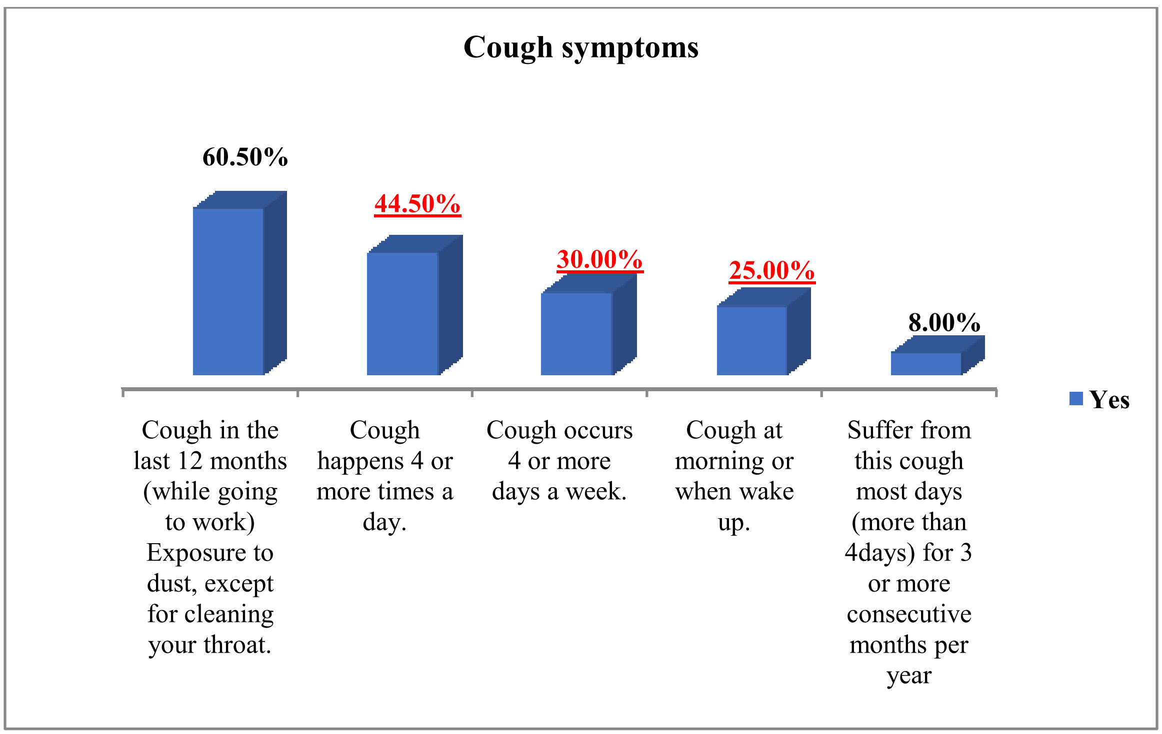

Figure 5.4: Cough symptoms

5.3.2 Sputum

Figure5.5belowillustrates the detailed percentages of each question according to responses from participants, as for sputum symptoms, 42%had sputum in the last 12 months while going to work and being exposed to dust. 32%had sputum happen two or more times every day. 29% had it occur 4 or more times a week. 26%had sputum usually come out first thing in the morning or when they wake up. 23% had sputum come out during the rest of the day or at night as well. 5%had bouts of coughing and sputum that lasted 3 or more weeks per year.

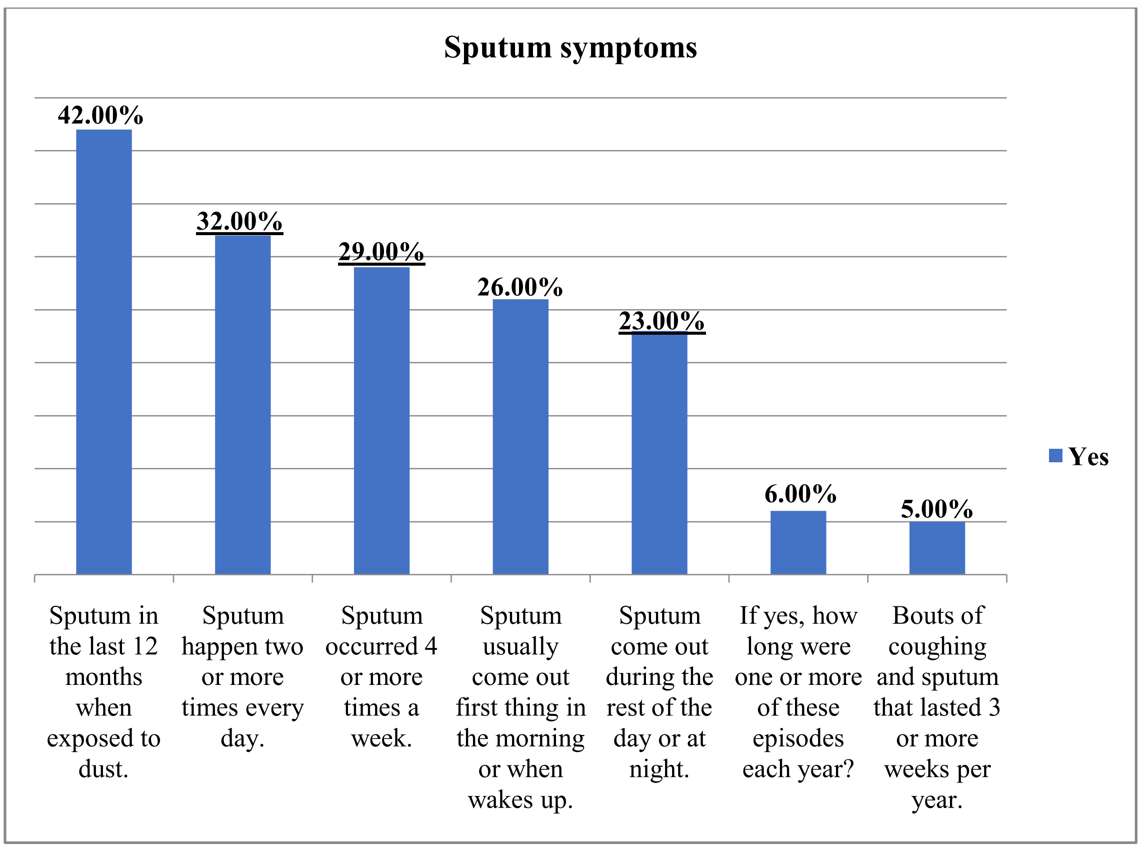

Figure 5.5: Sputum Symptoms

5.3.3 Shortness of Breath

Figure 5.6illustrates the detailed percentages of each question according to responses from participants to the questions related to the shortness of breath symptom. 40% had shortness of breath or difficulty breathing in the last 12 months. 34%suffered from shortness of breath while doing strenuous work. 33%suffered from shortness of breath while climbing stairs or while running. 25%experienced shortness of breath when walking for 15 minutes or at the same level compared to those of the same age. 26%stopped to take their breath after a few minutes (walking for nearly a hundred meters on flat ground). 22%suffered from shortness of breath when the simplest work such as getting dressed and not being able to leave the house.

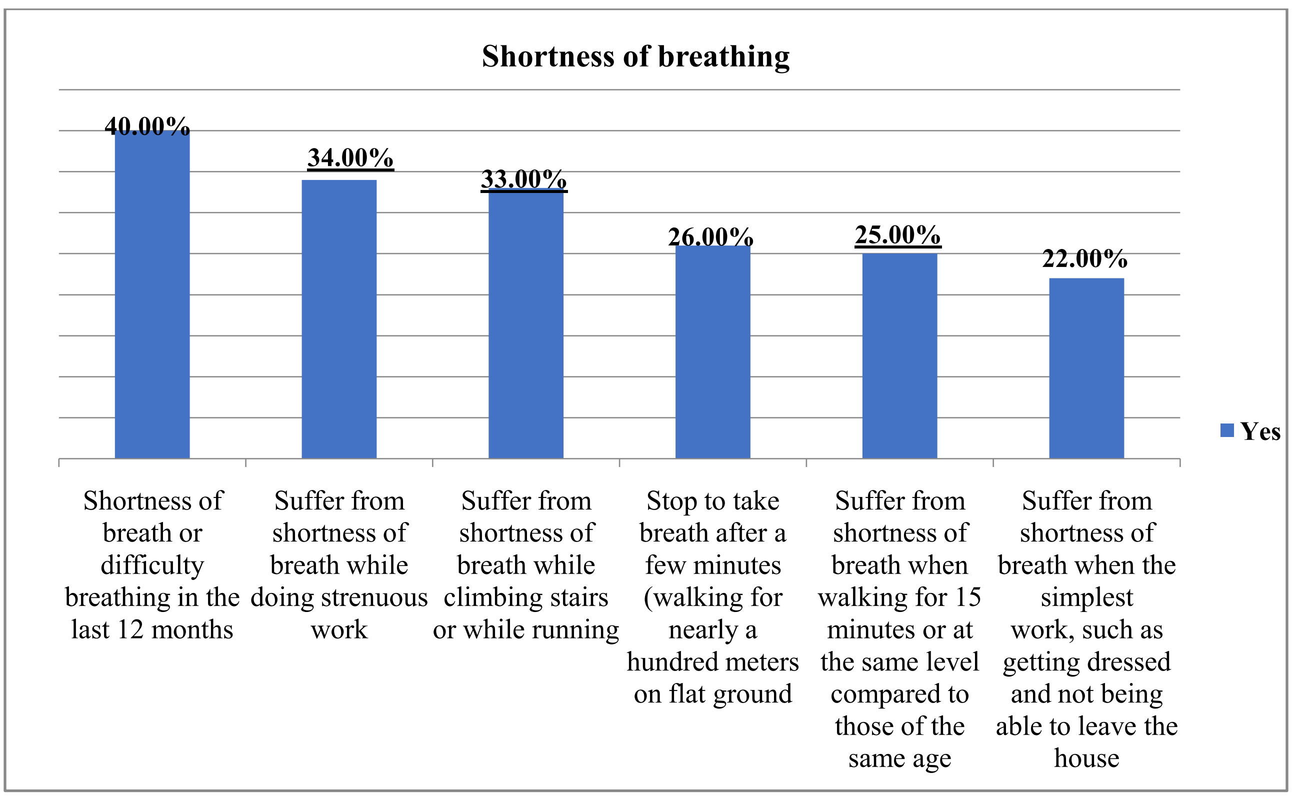

Figure 5.6: Shortness of breath symptom

5.3.4 Wheeze

Figure 5.7 illustrates the detailed percentages of each question according to responds from participants to Wheezes accompanied by a cough symptom 26% heard wheezes from the chest in the last year except for snoring. 18% were wheezes accompanied by a cough. 21% were wheezes last most of the day and night. 16% were wheezes accompanied by chest tightness. 11% suffered from a repentance of wheezing in the chest with shortness of breath in the past year. 10% had one or more seizures in the past year. 8% agreed that a solution is medication and 6% took medications (inhaler. Pills,etc.).

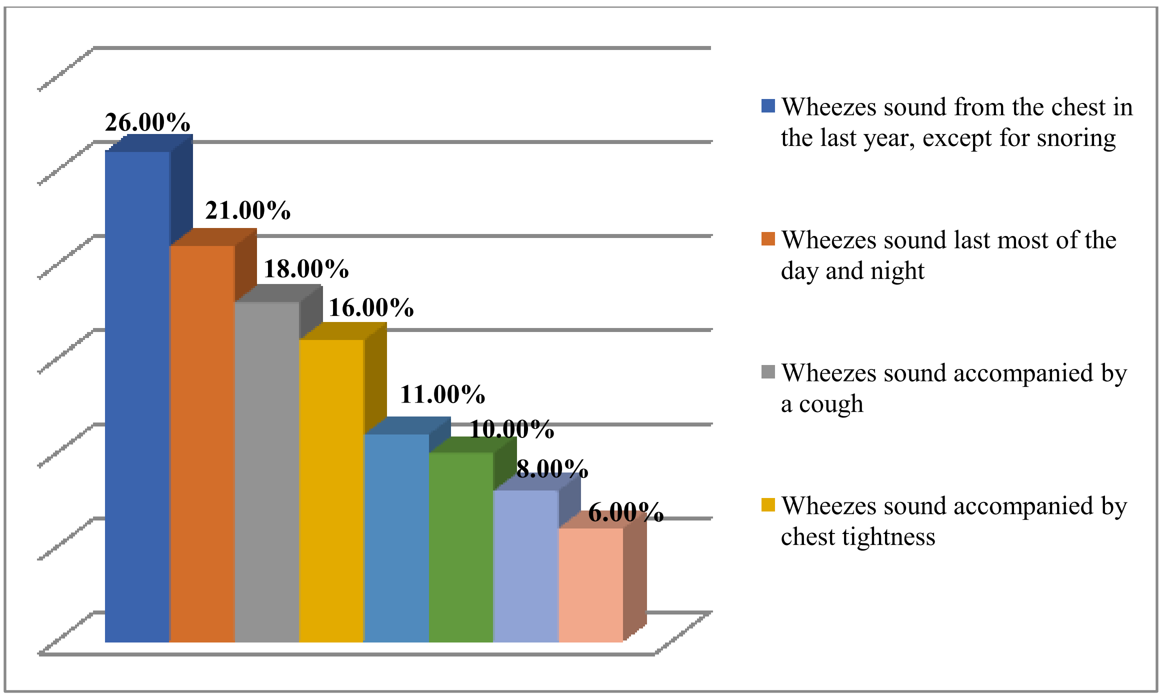

Figure 5.7: Wheezes accompanied by a cough

5.3.5 Nasal symptoms

Based on a Likert scale from 1-5 where 1 means never and 5 means always, as shown in table 5.5 that the majority of participants did not complain from nasal congestion (average of responses below 3)

Table 5.5: Nasal and other symptoms

Statement	MEAN	SD
Suffer from a congested or blocked nose during the past year	2.25	1.35
Weakness, boredom, or mood changes associated with the above symptoms	2.16	1.28
The above symptoms accompanied by coughing or wheezing in the chest	1.82	1.12
Pain or pressure in the ear during the past year	1.77	1.17
Sneezing or runny nose during the past year	1.76	1.15
Sore throat during the past year	1.75	0.99
Discolored nasal discharge in the last year	1.46	0.89
Suffer from nasal discharge during the past year	1.45	0.88
Have you had a headache, pains, or a feeling of pressure in the facial area during the past year	1.44	0.91
Strange smell or taste during the past year	1.38	0.89

5.4 pulmonary tests:

5.4.1 Forced vital capacity (FVC).

Figure 5.8 below illustrates the participants' FVC. It shows that 30 percent of them are normal, on the other hand 21 percent of them are severe, 27 percent are moderate, and 22 percent are tested as mild decrease in vital capacity.

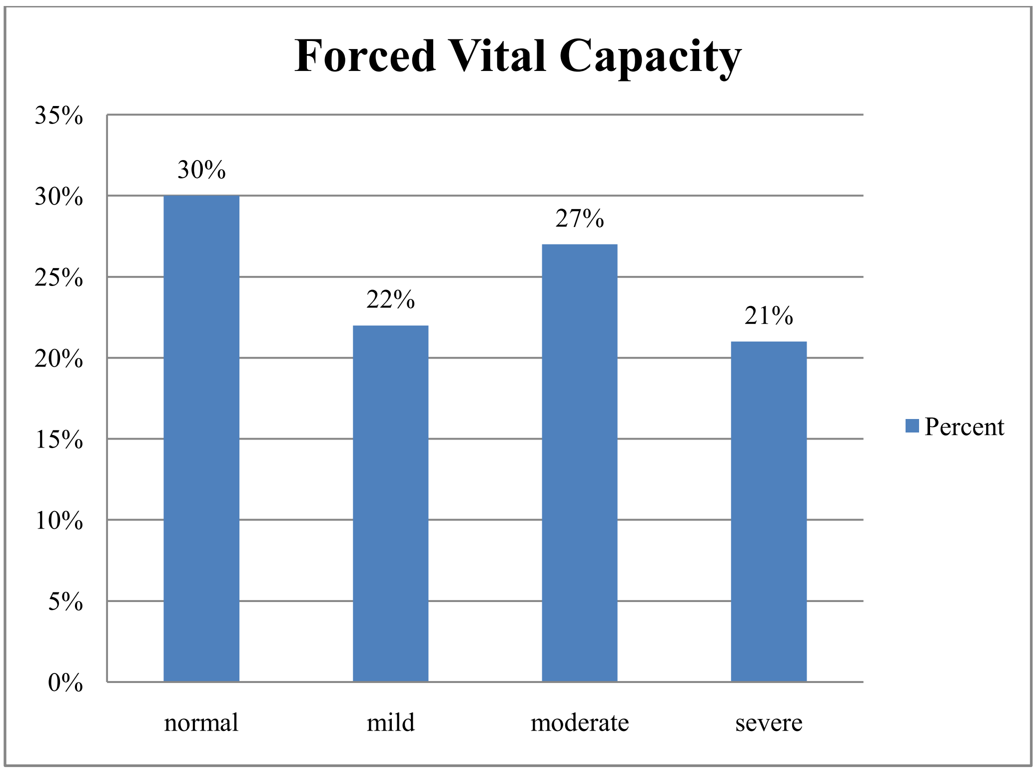

Figure 5.8: Forced vital capacity (FVC %)

5.4.2 Forced expiratory volume (FEV1)

Figure 5.9 below illustrates the forced expiratory volume of the participants, where based on the classification of related percentages of FEV1 explained above, 35% of participants were normal, 24%have a mild decrease in FEV1, 20% were moderate and 21% were severe decrease in FEV1 percentage.

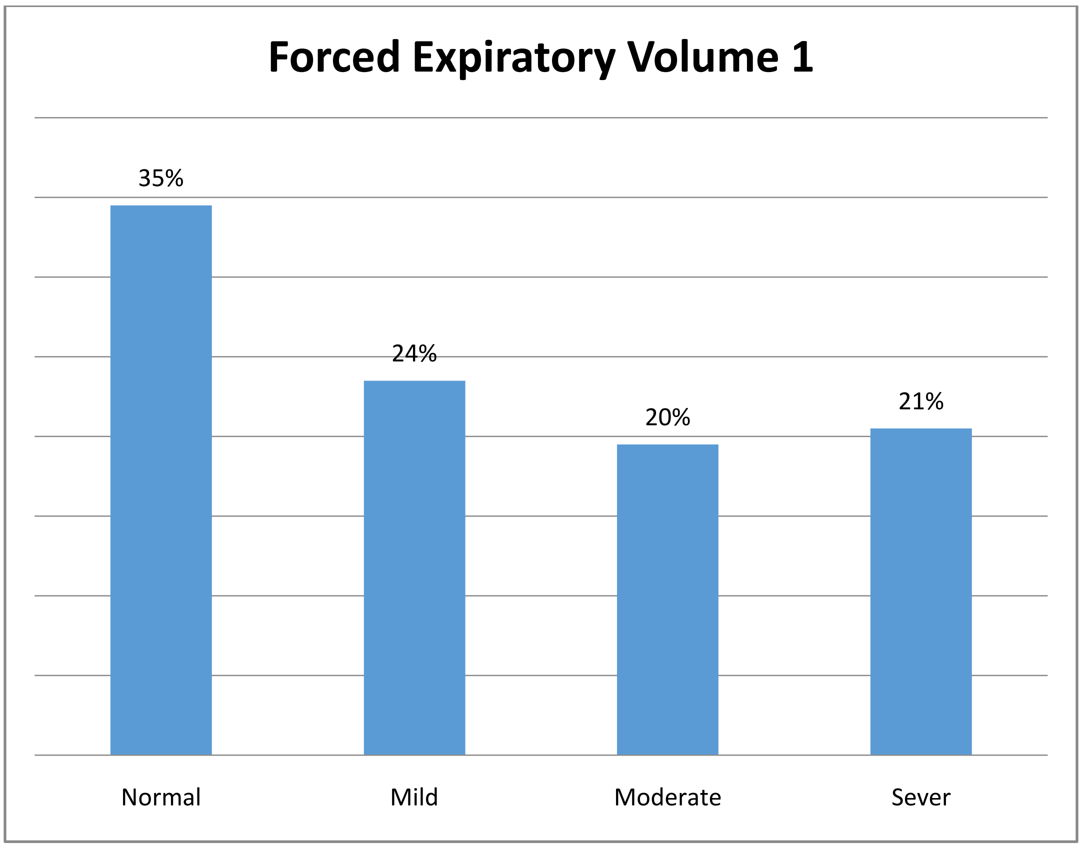

Figure 5.9: Forced expiratory volume (FEV1)

5.4.3 FEV1/FVC Ratio (FEV1%)

Figure 5.10 below illustrates the FEV1% among participants (FEV1/FVC), 36% of them were normal, 17%showed mildobstruction, 25% wherewith moderate obstructionand 22% had severe obstruction, according to the classification of the FEV1% mentioned previously in table 3.1

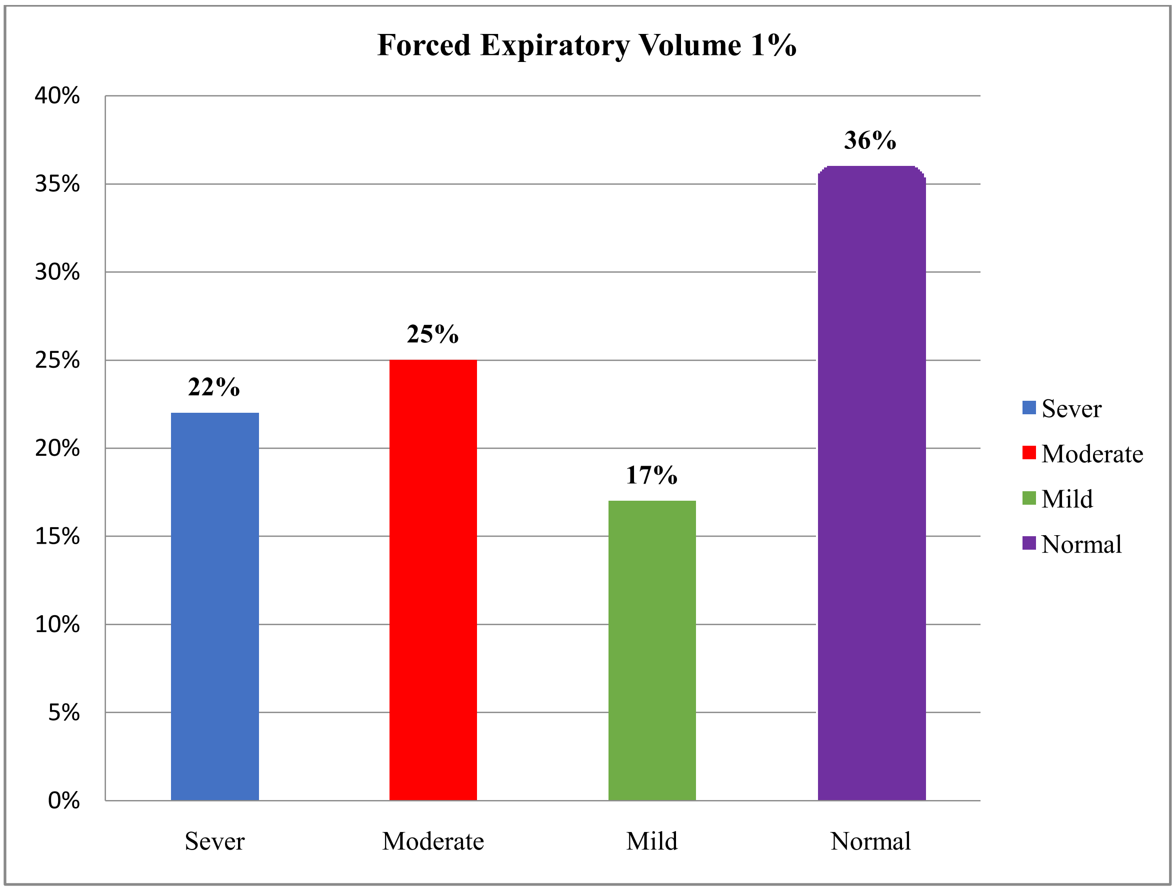

Figure 5.10: Forced Expiratory Volume 1%

5.6 correlation demographic and work related variables with FEV1

As shown in table 5.6 that there was no statistically significant correlation between FEV1 and Age, practical and total working hours per week ($p > 0.05$).

Table 5.6: correlation socio demographic and work related variables with FEV1 percentage

		EFV1 %
EFV1 %	Pearson Correlation	1
	Sig. (2-tailed)	
	N	199
Age	Pearson Correlation	-.080
	Sig. (2-tailed)	.261
	N	199
Practical experience	Pearson Correlation	-.055
	Sig. (2-tailed)	.439
	N	199
Total working hours per week	Pearson Correlation	.038
	Sig. (2-tailed)	.597
	N	199

5.7 Correlation between demographic and work related variables and FEV1%. (FEV1/FVC)

As shown in table 5.7 there was no statistically significant correlation with any of the independent variables (age, working hours and practical experience in years. (P- > 0.05).

Table 5.7: Correlation between independent variables and FEV1%.

		FEV1%
FEV1%	Pearson Correlation	1
	Sig. (2-tailed)	
	N	200
Age	Pearson Correlation	-.079
	Sig. (2-tailed)	.269
	N	200
Practical experience	Pearson Correlation	-.071
	Sig. (2-tailed)	.319
	N	200
Total working hours per week	Pearson Correlation	.021
	Sig. (2-tailed)	.768
	N	200

5.8 Difference of mean percentage of FEV1 and FEV1% in between categorical independent variables

Usingindependent sample t test, there was no significant difference in mean FEV1 and FEV1% upon using protective equipment kit, smoking, family history of respiratory disease, worker's history of respiratory disease diagnosis,presence of shortness of breath, cough, nasal congestion, and educational level (P> 0.05).

5.8.1 Wheezing

As presented in table 5.8there was statistically significant difference of mean FEV1% for the favor of workers without wheezing (88.5%) as compared to those who reported wheezing (81.1%) ,(P = 0.002) .

Table 5.8: FEV1 and FEV1% upon reporting wheezing with breath

	Wheezes most of the day and night?	**N**	**Mean %**	**Std. Deviation**	**Sig.**
EFV1	**Yes**	42	68.61	18.78	**0.101**
	No	158	73.29	17.73	
FEV1/FVC ratio	**Yes**	42	**81.1429**	15.30275	**.002**
	No	158	88.5373	12.95377	

5.8.2 Work place

As shown in table 5.9 there is a statistically significant difference of mean FEV1% upon work place, with favor for the workers working in stone crushing industry (with FEV1% 89.4%) as compared to the stone bits (with FEV1% of 83.7%).

Table 5.9: FEV1 and FEV1% upon workplace.

	Workplace	N	Mean%	Std. Deviation	Sig.
EFV1	stone-pit	86	72.31	20.54	
	stone crushing industry	114	74.37	16.33	0.190
FEV1/FVC ratio	stone-pit	86	83.7674	16.73297	
	Stone crushing industry	114	89.4114	10.47507	**0.07**

5.9 multivariate analyses of factors associated with FEV1.

As shown in table 5.10 and byusing multivariate stepwise regression that included the practical experience, work place, age, educational level, the use of protective equipment, smoking, and history of respiratory disease, the model revealed that **practical experience** is the only predictor of FEV1, with very weak R2, justifying nearly 2% of the variation in the dependent variable (FEV1) which is considered a very weak explanation of the variation in the dependent variable.

Table 5.10: Model summary of regression FEV1

Model Summary[b]									
Model	R	**R Square**	Adjusted R Square	Std. Error of the estimate	Change Statistics				
					R Square Change	F Change	df1	df2	**Sig. F Change**
1	.170[a]	**.029**	.024	4.71684	.029	5.894	1	198	**.016**

a. Predictors: (Constant), Practical experience

b. Dependent Variable: EFV1

Table 5.11: Anova table for FEV1 regression

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	**Sig.**
1	Regression	131.127	1	131.127	5.894	**.016[b]**
	Residual	4405.220	198	22.249		
	Total	4536.348	199			

a. Dependent Variable: EFV1

b. Predictors: (Constant), Practical experience

Table 5.12: coefficients of regression

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	5.187	.793		6.538	**.000**
	Practical experience	**-.565**	.233	-.170	-2.428	**.016**
a. Dependent Variable: FEV1						

5.10 Multivariate analysis of factors associated with FEV1%

As presented in the below table 5.13, using the stepwise regression, that included the practical experience, work place, age, educational level, the use of protective equipment, smoking, and history of respiratory disease, the model revealed that working place represented in stone Pit or crushing , is the only significant predictor of FEV1%, in favor for workers working in stone crushing facility (89.41%,SD 10.47%) as compared to stone pits (83.76% , SD 16.73%), with a very weak explanation of the variation of the dependent variable R^2 (0,041).

Table 5.13: Model summary of regression FEV1%

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.203[a]	**.041**	.037	13.52112	.041	8.541	1	198	**.004**
a. Predictors: (Constant), Workplace									
b. Dependent Variable: FEV1/FVC ratio									

Table 5.14: Anova table for FEV1% regression

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	**Sig.**
1	Regression	1561.498	1	1561.498	8.541	**.004[b]**
	Residual	36198.504	198	182.821		
	Total	37760.002	199			
a. Dependent Variable: FEV1/FVC ratio b. Predictors: (Constant), Workplace						

Table 5.15: Coefficients of regression.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.123	3.179		24.574	**.000**
	Workplace	**5.644**	1.931	.203	2.923	**.004**
a. Dependent Variable: FEV1/FVC ratio						

Chapter 6

6.1 Discussion

All of our participants were between the age of 20 to 50 years old, which means that whatever respiratory complications that they may complain of, it is less likely that it would be related to age, and that it may be associated with other factors (including the nature of their work), which makes it more difficult to highlight any association when the sample is composed of more than 65 years old participants, this supports the conclusion of (Laney &Weissman, 2014).

Only 3% of our samples were educated, which means that such a group of workers may be in more need for further and continuous education related to their health priorities in terms of preventive public health measures and safety. Almost 55% of the respondents were illiterate or had only a primary level of education, suggesting a low level of awareness of the respondents about the health implications of the respirable quarry dust.

As for the participant's income, with the majority of them being a moderate to low income (less than 3000 ILS), 1% of the participants get the minimum income which is less than 1000 NIS while the majority of them (94%) get a medium income 1000-3000 NIS. The percentages of the participants who get the highest income (3001-5000 NIS) are only 4%. The researcher noticed that the most of the workers gain a medium income.

The marital status of the participants of this study varies. The majority of them are married (59%), 39% of them were single while divorced and widower workers were 1 % for each.

This study found that more than 92% of the participants were working more than 35 hours per week in quarry site, indicating that majority of them are at a high risk of exposure to the respirable quarry dust. Average years of exposure is around 15 years which is a sufficient period for developing potential respiratory diseases (CDC,2018) in stone industries, specially that the average working hours is a round normal average worldwide which is 45 hours per week (workers- law, 2000) . This amount of working hour's exposure is indicating that the majority of them are exposed to the repairable quarry dust for prolonged period, with intensive exposure per week.

Reporting of 7% prevalence of chronic pulmonary diseases among parents of participants is well justified by the expected age of those parents, since we have a participants group with an average of about 33 years old, so their parents would fall within the category of people with higher prevalence of respiratory disease. Only 3 % of our sample reported respiratory disease complains themselves.

The majority (77%) of our participants were smokers and this is considered a high prevalence of smoking compared to literature in Palestine by Abu Seir, et al., (2019) that showed the prevalence of tobacco smoking was found to be 61.8% among Male quarry workers in Palestine. this presents another major risk factor for respiratory diseases, when we combine it with the extra hazard of inhalation of dust from stone industry, this may augment the risk of developing respiratory diseases (Chen, et al., 2013).

Most of respondents (77%) were not using personal protective equipment (PPE) -despite that 96% of them are aware of the importance of using protective equipment- because most of them consider it uncomfortable, this is consistent with the study of Haliru, et al., (2018), that has reported Poor awareness and poor understanding of occupational hazards are very common among staff and very few personal protection equipment has been documented to use. Furthermore, our results are shows better use of the Ugbogu study (2009), who stated that 98.3% of the quarry staff did not use PPEs in the Ebonyi State Report (Ugbogu, 2009). This finding highlights a poor safety measures and working conditions in our stone related industry, and this answers the 3rd question of this study

In this study the most eyes catching finding related to coughwas that 44.5% of our participants, reported cough 4 or more times a day. which is an indicator of irritation to the respiratory system, as cough is a defensive mechanism, that is triggered by allergen or obstruction of airways, and this may be an early symptom, of a future potential implication, that the researcher is recommending a cohort prospective study to investigate the accumulative effect of dust exposure, on respiratory symptoms, and further potential respiratory disease. This result is consistent with Ayaaba *et al*, (2017) which investigated respiratory disorders among gold miners in Ghana, in which cough was the most observed respiratory symptom. also, the results of this study support the findings of other Studies regarding cough among quarry workers, who also found that a prevalence of cough was 57.1 percent in Brazil while, the prevalence of cough in Iran was 31.9 percent. (Aghilinejad, et al., 2013),

sputum as a respiratory manifestation of different repository complications, was obvious in reporting that nearly third of our participants have sputum expelled 2 or 3 times a day, and even nearly quarter of them , reported sputum expelling during rest and at night, this is again , another indicator of potential dust exposure manifestation, as getting dust out with sputum is a common defense mechanism of the respiratory system, the question here is how much of the inhaled workers had been expelled out compared to the dust that remained in the lung and could be a potential risk factor of respiratory complication or obstructive disease in the future, sputum produced by the mucus they produce catches most of the dust particles. Tiny hairs called cilia, covering the walls of the air tubes, move the mucus upward and out into the throat, where it is either coughed up and spat out, or swallowed (Kakooei, et al., 2012).

Around 40% of our participants had reported shortness of breath; this finding is consistent with study of Nwibo et al, (2012), who reported a higher incidence of shortness of breath among quarry workers insoutheasternNigeria (47.6%). Shortness of breath is another indicator of a potential failure to initiate and fulfill a full deep breath, and it is an indicator of functionality of respiration, especially when performing a physical activity with more breathing, the issue of the cutoff point of shortness of breath and its relation to the pulmonary functional tests, is another area of investigation that the researcher is recommending for further studies

Wheezes are one of the symptoms of different respiratory system diseases (Nwibo, et al., 2012.). In our study it seems that the problem is not as much prevalent, this consistent with study of Isara, et al., (2016) who found that prevalence of wheezes is 10.8% among quarry workers in Nigeria.

Nasal congestion or nasal signs were not prevalent as it was expected among participants, since the average of answers by the respondents, were mainly between rarely (2) and sometimes (3), which is not a strong indicator or prevalence of nasal signs, though it is still average that may hide the fact that with some of the participants , the problem was prevalent and that the mean in this case does not represent the fact in all participants, even if they were few, they are the target participants that may develop further respiratory complications in the future, specially that in a previous question about the protective equipment kit use and face mask, only 22.5 % reported regular use of protective kit . It is also clear that those who use PPE had the double percentage of people reported never on the statement of having nasal congestion, which indicates the importance of using PPE in preventing such a respiratory complication such as nasal congestion. This association of the use of PPE with nasal congestion indicates the role of the nasal cavity as at the 1st defense mechanism against dust, preventing it from continuing its way to the lungs and deep parts of the respiratory system. the other symptoms of wheezing, coughing, and shortness of breath, may appear more clear in more severe cases of workers with respiratory disease, taking into consideration that the average age of our workers were 33 years old, may mean 2 things in fact, 1st that either the work life of quarry workers is short, in a way that people leave this earlier in older ages (40s.) or workers may leave when they start to develop diseases of more severe symptoms , this may be answered in a further study investigation etiology of workers turnover , and possible cross sectional study investigating current health status, of previous workers in quarry and stone cutting industry, among previous workers in their fifty's and sixty's

There were 30% of participants with normal FVC, on the other hand 70% of other participant ranged between sever, moderate and mild restriction. The highlight of this result is represented in the fact that around 50% of the participants had either moderate of severe restriction, while only 3% had answered positive regarding the presence of respiratory disease, which indicates a high percentage of undiagnosed respiratory restriction among our sample, this study indicates a great importance for the need of deep screening by further investigations, to identify different undiagnosed respiratory dysfunctions among workers in this sector, FVC alone does not explain changes in lung functions because they may be marginally disabled in the stable or the minimum obstructive pulmonary disease and mainly representing restrictive disease with less lung parenchyma elasticity and ability to expand (Gildea& McCarthy, 2015). This is why in this study we also used FEV1 and FEV1/FVC ratio, since we are interested in the potential prevalence of obstructive dysfunction. FEV1 (forced expiratory volume in 1st second) was abnormal andreduced among64% of respondents, this is consistent with study of Malenberg et al (2013) where they have observed that FEV1 in granite crushers reduced forced expiratory volume. Also,this result supports the same findings found by have observed, Mohammed Hussain Khan et al. (2009) who performed a multi-sectional analysis in the dust granite industry on the relationship between exposure to silica dust and COPD, and reported reduced FEV1 among workers in this industry

FEV1 is an indicator of presence of obstructive pulmonary disease, which is hindering the movement of air in the respiratory air ways while the participantswere doing forced expiration. if we look at the results in figure 5.9, around half of the participants have in between moderate and severe obstruction, taking into consideration again that only 3% reported diagnosed pulmonary dysfunction, this finding indicates a potential serious percentage of undiagnosed obstructive pulmonary dysfunction among workers in stones industry, which in turn opens the chance for further studies investigating the prevalence of accurate diagnosis of potential COPDs in this working sector.

Results showed in figure 5.10 that around half of our participants had complained from undiagnosed respiratory obstruction, based on the results of FVE1% results (< 0. 70%). This result is consistent with the findings of Gomes et al. (2011), Where considerable decrease in FEV1% was apparent among exposed workers, which suggests obstructive damage that may represent mechanical stimulation caused by dust (Hassen, et al., 2014). further investigations are need to assess those participants, to evaluate their respiratory function in other tests, that may increase the percentage of reported respiratory diseases among those stone industry workers, as the continuation of such hazard exposure, with such a minimal use of PPE, that may lead to further complications, represented in more workers moving from the status of normal and mild obstruction to more moderate and severe obstruction, which will affect workers health and threats further their life in near future. This finding also implicates the importance of further health promotion and occupational safety awareness among workers in this sector

PPE use wasn't associated with neither FEV1 nor FEV1%, the reason behind this finding may be associated with the fact that the workers responded with yes for this question, regardless of they were using a mask, or a protective boots, which may have affected the association between pulmonary function and the use of protective equipment. the thing that may oppose other findings of the role of PPE in decreasing respiratory symptoms (Ahadzi, Afitiri, Ekumah, Kanatey, & Afedzi, 2020)

there was no associated between age, working hours, working hours per week and any of the pulmonary test applied in this study. as working hours alone may not be enough to predict the variation in pulmonary tests, as it is related to the daily intensity of work, rather than the duration of exposure, the same with age, as older workers may have joined the work recently, and that people may join this industry in different ages of their life, where older workers may not necessarily have been working in this field since the beginning of their lives, which may justify why old age may not affect the duration of exposure , while the practical experience by years could be a legitimate variable reflecting the duration of exposure, which may be the strongest factor related to accumulative susceptibility to hazardous inhalation of dust . This finding may be partially justified that it is possible that this is time where more sever workers leave the work due to potential exaggerated severity of obstruction and respiratory symptoms, which is a topic that was not included in this study, and open a new possibility for further studies, analyzing the etiologies behind the potential turnover and leave of work in stone industry, and identifying if health reasons were behind this phenomena

Educational level, was not significantly associated with the level of obstruction in this study, this finding is contradicting with the finding of Tabak, et al.2009, which showed that Low educational level was associated with a lower baseline FEV_1. Compared to those with a high educational level, this may be justified by that the only potentialcontribution of education to level of obstruction may be related to the awareness of risk, and compliance with the protective measures, and in this study only around 3% of the workers were university graduates, which may suggest a very few representations in this work sector, that may affect its contribution to decreasing hazard, and further decreasing pulmonary complication.

In continuation to the results analysis, the 1st and 2nd question of this study were related to the possible associationof quarry working and socio demographic characteristics with pulmonary function. As shown insection 5.7 that practical experience which represents years of exposure in this study was significantly predicting pulmonary obstruction. With more obstructionrepresented in less FEV1%, amongstone pits workers. And practical experience predicted the variation of FEV1, where workers with more years of experience had less FEV1. This finding of association is consistent with findings of Kumar, et al., (2014 who suggested that more exposure is associated with more severe respiratory obstruction. also, this result confirms the findings of Nwibo, et al., (2012) who concluded that FEV1 had a significant inverse association with workers exposure time.Despite the fact that the Pits (quarry) are an open environment, workers there do not use water that increases humidity, which in turn may decrease the risk of dust inhalation, as they do in the stone cutting and crushing industry, that even if it is performed in closed environment, but the water decreases the chance of inhaling further dust, which is the luxury that the stone pits workers do not enjoy. The results of the study contradicts with findings of Rachiotis, et al., (2018), who found that workers in closed environment were more at risk compared to open environment, his study was conducted on cement dust exposure,.

6.2 Limitations of study

This study is relied on information from the participants to estimate the respiratory symptoms which make this study limited and may be prone to recall and information bias. Also, for this study is that the participants were not gender matched because all of them are male.

This study relied on FEV1 as a predictor for the pulmonary function while there are other diagnostic measurements can be used.

Another limitation of this study is that the sample is convenient; therefore, the number of the participant didn't include all quarry workers in Beit Fajjar (a group of 200 workers out of 1200).

Since that the participant reside in Beit Fajjar, which is a polluted area because the high number of stone pits, it can't be said that the decrease in pulmonary function is only because of working in quarries and we didn't exclude the confounding factors.

Chapter 7

7.1 Conclusion

This cross-sectional study was conducted to assess the association between pulmonary function, with socio-demographic, exposure, and working variables, among quarry workers at BeitFajjar village.

The results of this study have indicated the presence of respiratory symptoms, parallel to the fact that there were no reported respiratory diseases by the workers themselves, and at the same time, the results of this study have indicated a prevalent undiagnosed decrease in pulmonary functions.

This study showed chronic exposure to quarry dust was associated with deterioration of lung function indicated by reduced lung function indices among quarry workers. This finding reflects the need for periodic evaluation of lung function to help in preventing any deterioration in the respiratory health of these workers. Also, it emphasizes the need for an advocacy that will drive the responsible body for this occupation to put clear legislations and enforce these workers to wear the proper PPEs.

7.2 Recommendations

Based on the results and conclusion of this study, the researcher recommends the following

- For further researchers and future studies
    - Investigating pulmonary diseases among stone industry workers using other diagnostic tools like chest X-ray.

- Conducting further diagnosis for workers to be sure that they don't have chronic respiratory disease like Asthma, COPD, etc…) that could be connected with the exposure of quarry dust and refer them to the pulmonologist.
- Investigating the exposure through further analysis of air contamination with dust, using further scientific tools.
- Investigating the effect of using masks in particular, as a special PPE tool related to pulmonary function.
- Investigating the health status and reasons behind stone industry workers leaving this work sector.
- Investigating the total exposure impacts on the area residents including the total exposure effect.

- Advocating for the decreasing the lifetime, of work in such a hazardous job, to decrease the length of exposure
- Initiating an awareness campaign that educates about the importance of using masks in particular as a preventive measure of pulmonary dysfunction
- Advocating in front of stone industry owners, to use tools and equipment that may decrease dust and contamination in the working environment
- The quarry workers should provide adequate PPE which are applicable and suitable for the purpose intended for workers of quarries to protect their health.
- Demanding the ministry of Labour to activate the role of the Committee on Health and Public Safety in stone pits by putting strict regulations on the use of PPE.
- Conducting a case control study to measure the total exposure effect and it association with pulmonary functions between the workers residents (case) and the workers from other areas (control).

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Appendixes

Appendix 1 data collection sheet

Al – Quds University

Faculty of health professions

Public health department

Association between exposure to quarries and pulmonary function among quarry workers at Bait Fajjar village

أثر التعرض لمصانع الحجر علىوظائف الرئتين بين العمال في قرية بيت فجار.

الدراسة تخص رسالة ماجستير للطالبة آية علي طقاطقة من دائرة الصحة العامة في جامعة القدس

Participant Name:	
Date of Signature:	
Participant Code:	

Section I: Personal Data

Please circle the answer as it relates to you:

Work Section:

a. ☐ stone-pit b.☐ Stone factory

Age …………………….. years

Education

☐No schooling☐Primary☐ preparatory ☐secondary☐graduate

Marital status

☐single ☐ married ☐widowed ☐divorced

Income

☐1000- 3000 ☐3001- 5000☐ 5001- 7000 ☐>70000

Work Experience -------------------------

Total hours of exposure per week. ------------------------------ hours

Are you smoker:

☐ Yes ☐ No

If yes, for how long you smoker ………………. years

. If yes, how many cigarettes you smoke daily ……………….

. Were either of your parents have chronic lung conditions [as told by them or doctor or were on medications?

☐ Yes ☐ No

. If yes, what is the condition?

☐chronic bronchitis ☐emphysema ☐asthma ☐ lung cancer ☐Tuberculosis

. Did you ever have lung ailments before joining job?

☐ Yes ☐ No

. If yes, what is the condition?

☐chronic bronchitis ☐emphysema ☐asthma ☐Tuberculosis☐Sinusitis

. Are you aware of personal protective equipment's for the workers?

☐ Yes ☐ No

. Are you using of personal protective equipment's especially mask?

☐ Yes ☐ No

. If no, you can describe why?

☐non availability ☐uncomfortable ☐unnecessary ☐others specify

18 Do you wash hands and face before taking food or drinks at work place?

☐ Yes ☐ No

19. Do you change clothes after daily work?

☐ Yes ☐ No

Section III: Outcome Measures

No	Volume/test	Results
1.	Vital capacity (FVC)	
2.	Forced vital capacity (FEV1)	
3.	(FEV1/FVC) or FEV1%	

Appendix 2 American Thoracic Society Questionnaire

American Thoracic Society Questionnaire

اسم البحث: أثر التعرض لمصانع الحجر على وظائف الرئتين بين العمال في قرية بيت فجار.

اسم الباحث: آية علي طقطقة

Worker name:

Evaluator name: ____

Date of evaluation and signature: ____________________________

Participant's code : ____________________________

Cough	**No**	**Yes**
Did you have cough in the last 12 months [on going to work, exposure to dust, exclude throat clearance]?		
Does it occur 4 times or more per day?		
Does it occur 4 or more days in a week?		
Do you cough on getting up or as first thing in the morning?		
Do you cough rest of the day or at night also?		
If any of A-E above is yes, do you have such cough for most days [>=4 days] for 3 or more consecutive months per year		
Sputum		
Did you have phlegm in the last 12 months [on going to work, exposure to dust, exclude post nasal dripping] - it has to be brought up from chest?		
Does it occur twice or more every day?		

Does it occur 4 days or more every week?		
Do you usually bring up phlegm on getting up or as first thing in the morning?		
Do you bring up phlegm rest of the day or at night also?		
Cough and Sputum [Exacerbations]		
Have you had episodes of cough and Sputum lasting for 3 weeks or more, per year [noted by increase in amount of sputum, Fever and greenish yellow sputum]?		
If yes, for how long you had at least 1 or more such episode every year?	Years____	
Breathlessness		
Have you been disabled by shortness of breath or difficulty in breathing, other than due to heart or lung disease [TB, Cancer, Pneumonia] in the last 12 months?		
Do you have breathlessness on any strenuous work		
Do you have breathlessness when walking upstairs/slope or hurrying on level ground		
Do you have breathlessness when walking for 15 minutes or at the same level compared to people of your age		
Do you stop for breath after every few minutes [walking 100 yards] on level ground		
Do you have breathlessness with minimal work like dressing and not able to even leave the house		
Wheezing and chest tightness		
In the past 1 year have you ever heard wheeze or whistling sound from chest [exclude snoring/ gurgling abdominal sounds		
Was it associated with cough?		
Was it present most of the day and night?		
Was it associated with chest tightness?		
for how	Years ____	

many years this has been present?		
Exacerbations		
Has any attack of wheezing made you feel short of breath in the past 1 year?		
If yes to above, did you have 1 or more-episode last year?		
Did you require medicines or treatment for these attacks?		
Are you currently taking medicines for asthma [Inhaler/ tablets/ others]?		

Rhino-sinusitis assessment	**Never**	**Almost**	**Sometimes**	**Almost always**
Did you have 1 or more-episode or blockage in the last 1year?				
Did you have discolored nasal discharge in the last 1 year?				
Did you have postnasal discharge/dripping in the last 1 year?				
Did you have abnormal smell or taste sensations in the last 1 year?				
Did you have headache or facial pain/ pressure in the last 1 year?				
Did you have sneezing / watery				

nasaldischarge in the last 1 year?						
Did you have paining your teeth last 1 year?						
Did you have paining the ear/ on pressure in the last1 year?						
Did you have throat pain in the last 1 year?						
Did you have associated cough, wheezewith any of above symptoms?						
Did you have fatigue/irritability/ill feeling/ mood changes with any of above symptoms?						

Thank you for participation

Appendix 3 consent form

Informed consent to participate in Research

نموذج الموافقة على المشاركة في البحث

اسم البحث: أثر التعرض لمصانع الحجر على وظائف الرئتين بين العمال في قرية بيت فجار.

اسم الباحث: آية علي طقطقة

Worker name:

Evaluator name: ____

Date of evaluation and signature: ____________________________

Participant's code : _____________________________

عزيزي المشارك /المشاركة:

توقيعك ادناه على نموذج الموافقة هذا هو بموجب موافقة مكتوبة وموقعة على المشاركة في دراسة بحثية التي تقوم بها الباحثة أ. آية علي طقطقة بعنوان " أثر التعرض لمصانع الحجر على وظائف الرئتين بين العمال في قرية بيت فجار.". وهو إقرار بإنه قد تم شرح أهداف البحث وطريقة الفحص للبحث، وانه قد تم شرح حقوقك المتضمنة:

- سرية المعلومات التي تصرح بها وعدم إطلاع اي شخص عليها وتخزينها في مكان امن لا يصل اليه سوى الباحث.
- إخفاء هوية المشارك في تحليل البحث والنتائج.
- استخدام المعلومات للأغراض العلمية فقط.
- حرية انسحابك في اي وقت من الدراسة ومن دون الحاجة لإبداء الأسباب ودون اية عواقب شخصية او مالية.

- حقك في الاطلاع على نتيجة فحوصاتك ونتائج البحث النهائية.

وأنه في حال كان لديك أسئلة حول الدراسة او حول اي معلومة متعلقة بها، يرجى الاتصال بالباحثة: آيۃ علي حسن طقطقة على ***رقم التلفون:***0569083085

موافقة المشارك

لقد تم وصف الدراسة البحثية لي شفهيا، وبما فيه المعلومات المدرجة أعلاه، وأوافق على المشاركة بهذه الدراسة البحثية. سوف أحصل على نسخة موقعة من هذا النموذج للاحتفاظ بها في سجلاتي، أوافق على المشاركة بهذه الدراسة.

اسم المشارك الرباعي:____

توقيع بهذه: ___________________________

اسم وتوقيع بهذه: _:________________________

Appendix 4 ethical approval letter

Al-Quds University
Jerusalem
Deanship of Scientific Research

بسم الله الرحمن الرحيم

جامعة القدس
القدس
عمادة البحث العلمي

Research Ethics Committee
Committee's Decision Letter

Date: 4 May 2020
Ref No: 125/REC/2020

Dears Dr. Akram Amro and Mrs. Aya Taqatqa

Thank you for submitting your application for research ethics approval. After reviewing your application entitled ***"Association Between Exposure to Quarries and Pulmonary function Among Quarry Workers at Bait Fajjar Village"***. The Research Ethics Committee confirms that your application is in accordance with the research ethics guidelines at Al-Quds University.

We would appreciate receiving a copy of your final research report/ publication. Thank you again and wish you a productive research that serves the best interests of your subjects.

PS: This letter will be valid for two years.

Nuha El Sharif, PhD
Research Ethics Committee Chair

Cc. Prof. Imad Abu Kishek - President
Cc. Members of the committee
Cc. file

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