IMPACTS OF MARBLE INDUSTRY ON RESPIRATORY HEALTH OF WORKERS IN HATTAR INDUSTRY HARIPUR, PAKISTAN

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DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES,

BAHRIAUNIVERSITY, ISLAMABAD

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My beloved father & mother

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ABSTRACT

Pakistan having 297-billion-ton reserves of marble is one of those countries that are rich with raw marble. The study was carried out at Hattar sector Haripur, which is a manufacturing facility in the district of Haripur, Kpk province of Pakistan. The goal of this study was to assess occupational safety and respiratory health trends in the marble sector. The study concentrated specifically on the consequences marble dust may have on lung function and the environment. Lung function data were compared between a control group and a subject group made up of marble industry workers in order to evaluate respiratory health. Before and after bronchodilation, measurements were taken for forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio. The study also investigated the prevalence of obstructive and restrictive lung diseases using FVC and FEV1 measures. It was demonstrated that all groups, including the subject group of workers in the marble business, had more instances of obstructive and restrictive lung function patterns than did the control group. This suggests a potential link between occupational exposure to the marble industry and an increased risk of obstructive or restrictive lung conditions.

The study also provided a correlation matrix that examined the connection between lung function measurements and demographic factors. In the final analysis, this study emphasizes the detrimental effects on respiratory health brought on by exposure to marble dust in the marble business. The findings establish a platform for additional research and treatments aimed at boosting respiratory health among workers in this industry and offer insightful information about the association between occupational exposure in the marble industry and lung function. To protect the respiratory health and general wellbeing of marble industry workers, additional research projects and focused interventions are essential.

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CHAPTER 1

1 INTRODUCTION

The world population is increasing rapidly which is leading to the rise in anthropogenic activities. These anthropogenic activities due to the rapid population increase adversely affect the environment (Wang *et al.*, 2008). Such increase in population is one of the main reasons for global rise in pollution (Commoner *et al.*, 1971). Marble dust, which is produced during themanufacturing process of Marble, is also a pollutant. It is reported to cause several physiological problems in animals as well as plants (Iqbal *et al.*, 2022).

1.1 Increasing Urbanization: A Risk to Human Health

According to Alaloul and Musarat, (2020) and WHO, (2018b); 90% of human population around the world is at the risk of getting affected by air pollution due to the increasing urbanization. Rising industrialization, socioeconomic development, and population growth are immensely contributing to the increase in air pollution even though these are rarely quantifiedfactors (Dietz & Rosa, 1997).

1.2 Health Disorders Related to Air Pollution

In developing countries, increasing levels of air pollution are linked to industrial activities as well as the emissions from vehicles (B. Chen & Kan, 2008; Molina & Molina, 2004). Poor air quality has directly been associated with increasing number of illnesses and mortalities, specifically due to respiratory and cardiovascular problems. It is also responsible for causing various diseases like lung cancer, Alzheimer disease, autism, asthma, ventricular hypertrophy, retinopathy, low birth weight, Parkinson disease, and several psychological disorders (Ghorani-Azam *et al.*, 2016).

1.3 Marble and the Pollution Caused by Marble Dust

Since long, stones have been used for different purposes. Word “Marble” is derived from ancient Greek word “Marmaros”, meaning shining/crystalline rock. While in modern terms, word “Marble”, regardless of its origin, is used for all those rocks that are used for covering or pavement purpose by building industries. Marble being a metamorphic rock, is composed of recrystallized carbonate minerals (Ahmad & Khan, 2019; Royer-Carfagni, 1999).

Many of the health problems are also caused by the marble dust which is produced during the process of extraction and crushing of marble and act as an air pollutant (Iqbal *et al.,* 2022). For manufacturing, Marble is first obtained from the quarries, cut, and finished into specific dimensions. It is then prepared for different purposes in specialized mills that containpolishing machines, saws, and many other stuffs. Raw marble is passed through several steps and cut into smaller pieces for proper shaping. Almost 25% mass of the marble is lost during that process in dust form and particulate matter (PM). Beside PM, liquid (waste-water) is alsoreleased in slurry form (Ashraf *et al.*, 2014; El-Gammal *et al.*, 2011; Saini *et al.*, 2011). Around 70% resource of marble is wasted during processing, mining, and polishing techniques. 40% of marble waste is produced in the form of rocky fragments during quarrying, which is then dumped openly around riverbeds, roads, pits, landfills, agricultural fields, pasturelands, thus becoming one of the prominent reasons for environmental pollution around the world (Akbulut& Gürer, 2003; Khedr *et al.,* 2010).

1.4 Exposure of Marble Dust to the Workers

Workers that are working in such industries and marble quarries inhale suspended marble dust particles in the air which are formed during marble processing. As per epidemiological studies, workers that get exposed to marble dust are most likely to suffer from chronic bronchitis,asthma, impaired lung functioning, asthma, and nasal inflammation (Angotzi *et al.*, 2005; Camici *et al.*, 1978; Leikin *et al.*, 2009). Dagli *et al.*, (2008) also reported many problems like backache, stress, headache, and several other health disorders in affected workers. Many individuals reported with papilloma were also observed to have several problems such as fumes, dust, equipment maintenance issues, and intensive noise at workplace as well.

1.5 Marble Industries

Establishment of marble industries is expensive on both scales, i.e., a country needs to be richin natural resource of this precious stone along with modern technology of good quality for the manufacturing process with a quality worthy of trading locally and internationally. Marble today is traded Internationally and regarded as a differentiated product. It’s price and value arepurely dependent upon its quality, color, and type (natural characteristics) as well as its shape,size, thickness, and polishing (processing technology). That is why marble production is highly dependent upon the level of technology used (Kandil & Selim, 2006).

1.6 Pollution in Pakistan

According to world population review, (2022), Pakistan in 2022 lies just beyond the Bangladeshas 2nd most polluted country in the world with 59 concentration of $PM_{2.5}$ thus making it one of the most polluted countries in world. A striking impact was observed in socioeconomic, welfare, health, and environmental sectors due to a rapid increase in vehicles around Pakistan. Emissions from those vehicles along with some other sources resulted into an increase in air pollution (Ilyas, 2007).

1.7 Marble Industries in Pakistan

Pakistan having 297-billion-ton reserves of marble is one of those countries that are rich with raw marble. That marble produces large economic benefits through foreign buyers thus servingas one of the major sources for foreign revenue (Noor *et al.*, 2015). Around 30 different types of marbles are present in Pakistan. Marble reservoirs are mainly scattered across Kpk, Baluchistan, and tribal belt, generating 33M dollars last year (Tahir, 2015). As per Khan *et al.*,(2012), marble factory owners in Buner discharge huge amount of waste material that eventually harm aquatic life around the industry.

1.8 Hattar Industry

As we know, air pollution caused by anthropogenic activities is a rising environmental problem in world and one of the main reasons for increasing health problems. All those problems are reported in Hattar Industrial city located in Haripur, Pakistan as well due to the metallurgical, chemical, and mining industries (Fidaev *et al.*, 2021).

Hattar Industrial Estate is in Haripur near Kot Najibullah in Kpk province of Pakistan. It was established in 1985-1986 and with operating industrial units exceeding a number of 250 industries, it occupies a large area of 1063 acres. Those units mainly include textile, paper printing, food and beverages, chemicals, crockery, cement, pharmaceuticals, leather, publishing, and rubber products (Jadoon *et al.*, 2022; Wikipedia, n.a.).

1.8.1 Pollution Status of Hattar Industry

Hattar industrial estate waste is toxic and mainly causes pollution. Total toxic metals overall in all the effluents from industries was found to be 2.0 mg/L, which is above the safe limits. Different elements were found in different effluents of various industries. Cu in sewage and textile, Mn in ghee, and Iron in other effluents were higher than National Environmental Quality Standards (Sial *et al.*, 2006).

1.9 Problems in employs of hattar

Industrial Estate of Hattar has at least 2 lac poverty-stricken people employed with mediocre education. The air emission occurs continuously in Industrial Estate with almost equal to non-protective measures and little awareness regarding air pollution. This release of poisonous gas occurs due to the process of incomplete industrial combustion. Moreover, such gases are mainly responsible for putting worker's health and lives at stake. Besides, Industries also bear expensive healthcare charges of diseased workers suffering from acute diseases along with their badly affected working efficiency (Jadoon *et al.*, 2022). As per Rasheed, (2013), workers of Hattar industrial estate along with people living in near villages are exposed to toxic air pollution released directly in air due to industrial coal burning. Besides, food industries are built near steel industries which are badly affecting the food products. Jadoon *et al.*, (2022) analyzed the SPCO% (Carbon monoxide saturation) in the blood of workers from Hattar industrial estate and after comparing it with WHO's standard concentration i.e., 5%, he found out that 17% SPCO% was found in blood of workers in Steel industry. Besides, different diseases like dermatosis (35%), respiratory inflammation (29%), breathing issues (23.5%), asthma (16.7%), and eye inflammation (9%) were also observed in the workers as well. One of the main causes observed for all these problems was found to be the exposure of high carbon monoxide in air.

1.10 Need of Addressing Environmental Protection Policies

Industries and industrial policies around the world should set new standards to meet the target of zero emission rate. For that, there is a need of addressing zero emission rate with industrial sector. Industrial policies must make zero emissions as their aim to tackle pollution. However, a significant transformation is required from current industrial policies which primarily protects industries to the policy measures that alter the sector. Sectors like steel, cement, and chemicals have so far been mostly shielded from the consequences of climate policy (Bourdrel *et al.*, 2021).

The purpose of this study is to investigate how the marble business in Pakistan's Hattar Industrial Area affects the respiratory health of its workforce. Despite its economic importance, concerns about the possible effects of marble mining and processing, which produce airborne pollutants and fine particulate matter, on respiratory health are growing. These pollutants can cause a range of respiratory problems, from mild illnesses like chronic bronchitis to serious ones like pneumoconiosis. It is crucial to create strict emission restrictions, regularly monitor the quality of the air, and require the use of air filtration equipment in order to lessen these impacts. Worker safety initiatives should also supply the required protective gear and educate workers about the risks. Governmental agencies, business stakeholders, medical practitioners, and research endeavors can work together to comprehensively address and relieve the respiratory health impacts on marble industry workers in Hattar, Haripur, Pakistan.

1.11 LITERATURE REVIEW

1.11.1 Increasing Air Pollution in World

The release of chemicals into the air that are harmful to both human health and the entire planet is referred to as "air pollution." (Mackenzie & Turrentine, 2021). It is a mixture of toxic materials that come from both natural and man-made sources (Fuzzi *et al.*, 2015; NIEHS, 2022). According to Ginoux *et al.*, (2012), 25% of the world's dust emissions are attributable to anthropogenic emissions, whereas 75% are of natural origin. These ratios differ significantly from location to location on Earth. The main causes of man-made air pollution include vehicle emissions, natural gas, and fuel oils used to heat homes, waste products from manufacturing and power generation, mainly from coal-fired power plants, and odors from chemical manufacturing. Hazardous compounds are released into the atmosphere by natural processes as well, such as methane, which is produced by the breakdown of organic materials in soils, smoke from wildfires, and, volcanic ash which are frequently started by people (NIEHS, 2022). The environment (Moraga & Hosseinabad, 2017). Despite being a global concern, the concentration of PM is significantly higher in developing countries because of the increasing amounts of dust brought on by transportation, building, and other industrial activity (Yang *et al.*, 2001). Additionally, air pollutants disrupt plant life by impairing stomata movement, photosynthesis, foliar geometry, nutrient transfer, and membrane permeability which results in low yield, premature senescence, and other negative impacts in highly vulnerable plants (Tripathi & Gautam, 2007).

Since the beginning of the Industrial Revolution, the impact of aerosol particles on the environment, the human body, the climate, and outdoor materials has substantially risen (Jimoda, 2012; Liang *et al.*, 2016; Yin *et al.*, 2011). Aerosols in particular have a considerable influence on atmospheric chemistry and climate change, which has repercussions for general air quality and human health (Anderson *et al.*, 2012; Dickerson *et al.*, 2017; Fajersztajn *et al.*,2017; Kampa & Castanas, 2008; Rajšić *et al.*, 2004).

Exposure to ambient air pollution (AAP), such as Ozone and $PM_{2.5}$, may have both chronic and acute negative impacts on human health, leading to an increase in ER visits and hospital admissions as well as early mortalities (R. Burnett *et al.*, 2018; R. T. Burnett *et al.*, 2014; Fann*et al.*, 2018; Kloog *et al.*, 2013). 11.65% of deaths worldwide in 2021 were caused by air pollution alone (Ritchie & Roser, 2021). With 6–7 million fatalities in 2019, air pollution (including home and ambient air pollution) continues to be one of the leading causes of mortalities (Parvez *et al.*, 2021). According to recent research conducted in developed countries, increased air pollution may worsen people's mental health, particularly their chance of developing depression (Chan & Yao, 2008; Kioumourtzoglou *et al.*, 2017; Xu *et al.*, 1994).

1.11.2 Respiratory Problems due to Air Pollution

Asthma, Emphysema, and various other respiratory illnesses including chronic obstructive pulmonary disease are all linked to air pollution, which can influence the development of the lungs (COPD). Chronic bronchitis has been associated with PM and nitrogen oxide as well. Asignificant public health issue in 2020 was the co-occurrence of the wildfires in the western United States and the COVID-19 pandemic. A study connected wildfire smoke with more COVID-19 cases and fatalities, strengthening the relationship between respiratory-tract infections and air pollution that has long been known to exist (NIEHS, 2022). Despite widespread recognition of the effects of air pollution on respiratory diseases, cardiovascular diseases are thought to be the primary cause of half of the deaths in 2019 (6.7 million estimated) linked to air pollution (Murray *et al.*, 2020).

1.11.2 Workers at Risk of Fatal Diseases and Injuries

Since workers and employees are a company's most precious assets, it is the owner's or employer's legal duty to safeguard their health and safety at work. Workplaces that are safe and healthy have lower chances of accidents, property damage, and worker disabilities. Rapid technological and societal development needs greater flexibility in Safety regulations, Occupational Health, and Hygiene at all workplaces (Leamon, 2001). Recent estimates from the International Labor Organization (ILO) indicate that between 160 and 270 million workers have occupational illnesses or accidents each year. A multitude of reasons, including poor medical facilities, an illiterate workforce, and a lack of accurate accident data, contribute to theappalling state of OH&S in developing nations like Pakistan. Productivity and economic growth depend on a healthy and engaged workforce (Pasha, 2003).

Like many developing nations worldwide, Pakistan lacks thorough Occupational

Health & Safety Laws as well. The incidence of injuries and illnesses is very high in Pakistan, as thousands of workers are exposed to dangerous chemicals and gases in industries including chemical, construction, agricultural, brick kilns, and many more. Illiterate workers are recruited by the sizable brick kiln and construction sectors, where occupational health and safety issues are present. Workplace practices in brick kilns, such as increased bonded labor, etc., are cruel and inhumane to employees (Zia-ur-Rahman *et al.*, 1923).

1.11.3 Historical Prospect of Marble

The word "marble" is derived from the Greek word "marmaros," which means crystallized rock or brilliant stone. Since a very long time ago, stones have been used for various purposes. Marble is a metamorphic rock that is made up of re-crystallized carbonate minerals (new world encyclopedia, 2007). When constructing the pyramids and other long-lasting structures that still stand today, the ancient Egyptians employed stones as a permanent framework for their civilization. Stones were also utilized by the Greek and Roman empires to build theatres and columns, which are still popular tourist destinations in most Mediterranean nations. These countries now use marble and stones for both interior and exterior decoration in both public and private structures. This expresses the idea that stones are the most durable and long-lasting building material (Maponga & Munyanduri, 2001).

For thousands of years, marble has been the material of choice for monuments, temples, and structures. Marble has represented heritage, luxury, and an excellent choice for a very long time. Marble buildings still exist in Europe, the Mediterranean, and the far east. Some of the most famous structures in the world were constructed by the Ancient Greeks using beautiful white marble. Throughout history, architects, sculptors, and craftspeople have utilized marble to make stunning structures. The Parthenon in Athens, the Colosseum in Rome, the Taj Mahal in India, and even the White House are excellent examples (Ahmad, 2019). Following the ancient Greeks, the Romans adopted the practice of covering brick-and-mortar structures with marble slabs. This invention gave them the ability to quickly build interminable cities. Quarrying techniques and equipment significantly improved as demand for marble grew, enabling a greater amount of natural marble to be harvested (Ali, 2010).

1.11.4 Marble Queries and Marble Processing

The extraction of Marble is carried out from open quarries on the earth's surface in addition to underground mines. Before any marble is extracted from the quarry once mining has started, there may be several months of excavation. Before extracting marble blocks, the overburden, or dirt sitting on top of the desired ore, must first be removed. The quarries determine the extraction techniques and dimensions of the final marble blocks. Depending on how the regionis shaped, the cutting procedure may be carried out vertically or horizontally. In terms of color,size, and cleanliness, the extracted blocks are divided into groups (Haider, 2020; Happho, 2021). Blocks of marble are sawed into slabs. Simple disc saws will be used to cut small marbleblocks into slabs for use in construction. To create conventional 2-cm thick, one-sided polishedmarble slabs, medium and large marble blocks will normally be cut with gang saws as shown in **Figure 1.2** (Kingstone, 2022).

To improve the marble's resistance, it is reinforced and treated. Then, all cut marks are eliminated,and the surface is polished and sharpened to give it a smooth, glossy finish. Marble slabs will be prepared for packaging and delivery after the material has been shaped and polished. It maybe bundled in wood for later transport in containers (Haider, 2020).

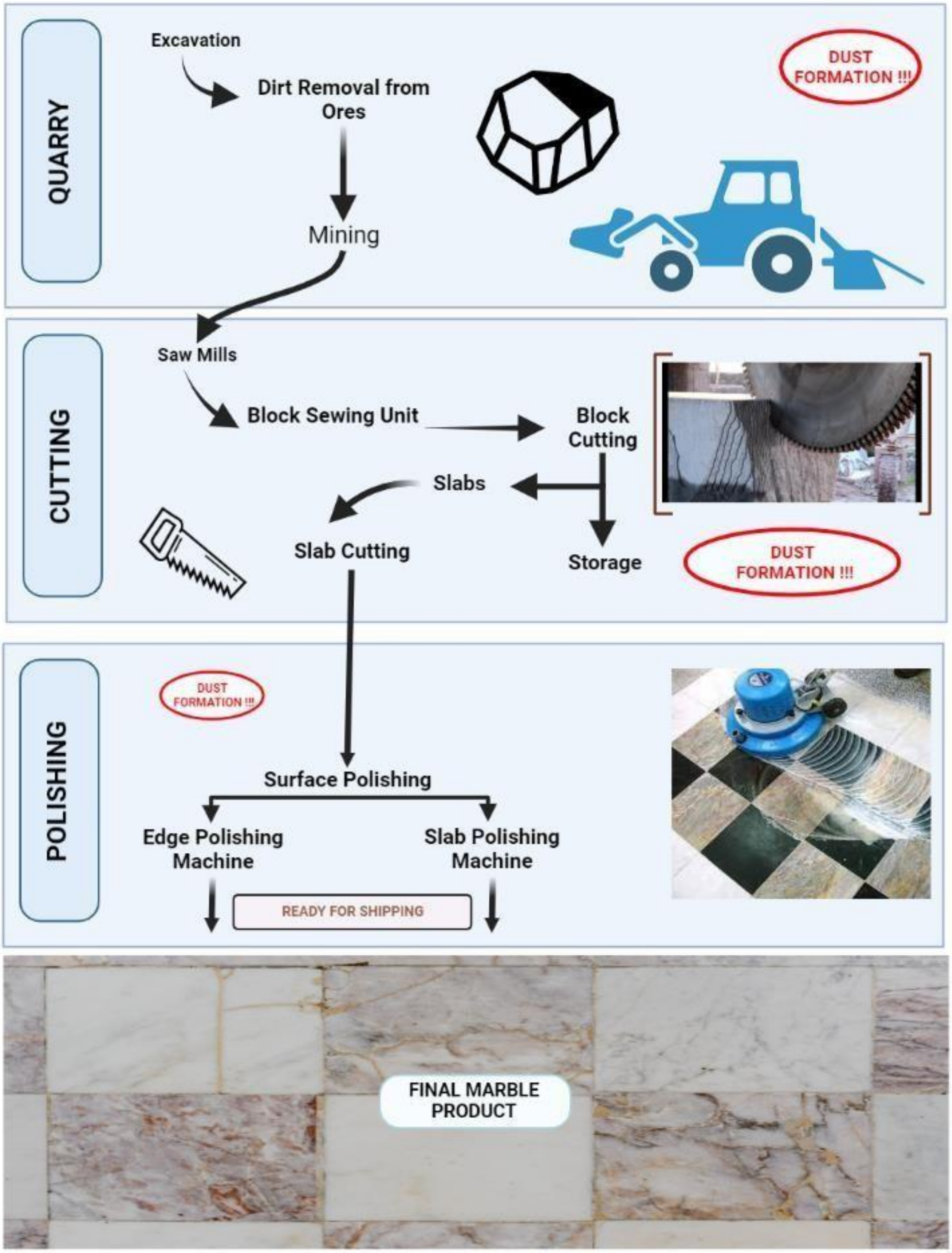

Figure1.2: Industrial Processing of Marble and Final Product Formation

1.11.5 Marble Dust as a Source of Air Pollution

Extensive waste material is from the marble industry. During mining, processing, and polishing processes, almost 70% of this precious mineral resource is lost. These wastes come in a variety of shapes and sizes, including dust, effluents, and rock pieces. These are thrown away on the neighboring pastures, roadways, riverbeds, and agricultural fields, as well as in landfills. As a result, a variety of environmental contamination is being produced, particularly in water bodies that damage aquatic life (Akbulut & Gürer, 2003). When marble is processed, 30% of it is lost as dust and marine effluents (El-Gammal *et al.*, 2011). Workers in the marble industry are morevulnerable because of their low socioeconomic standing, lack of education regarding personal protection measures (PPM), ignorance of safety regulations and their implementation, and employer exploitation (Sivacoumar *et al.*, 2006).

Exposure to marble dust poses threats to your health. The production of toxic substances, gases, and respirable dust in marble workshops poses a health danger to the workers in various marble workshop units (Hae-Rim *et al.*, 2020). Marble dust, comprising silica and calcium carbonate particles, is inhaled by workers who cut, polish and install marble. One of the earliest recognized occupational diseases, silicosis, is known to be brought on by prolonged contact with respirable crystalline silica (Nij *et al.*, 2003; Pilkington *et al.*, 1996). lung cancer, non- malignant renal illness, chronic obstructive disease (COPD), and respirable crystalline silica have all been related to autoimmune diseases in addition to silicosis. (Hnizdo & Vallyathan, 2003; Humans *et al.*, 1997; Parks *et al.*, 1999; Steenland & Sanderson, 2001).

1.11.6 Respiratory Problems due to Marble Dust

Since free silica is not mixed with silicon dioxide or other elements, it is referred to as "free of elements" and makes up most of the marble dust (SiO2). Alpha quartz, beta quartz, manganite, granite, slate, sandstone, and keatite are all typical components of the Earth's crust that include silica, which is hazardous to the human respiratory system. In the construction, mining, metal foundry, ceramic manufacturing, stone, granite, and glass industries, workers are exposed to dust containing crystalline silica (Poinen-Rughooputh *et al.*, 2016).

The primary cause of several occupational lung disorders, including pneumoconiosis, chronic obstructive pulmonary disease (COPD), silicosis, and asthma, is airborne dust (free silica), which is produced in marble workshops during quarrying, grinding, mining, cutting, and polishing activities (W. Chen *et al.*, 2012; Pollard, 2016).

1.11.7 Respiratory problems in Industrial Workers

When exposed to respirable silica dust for an extended period, employees exposed to silica were at an increased risk of acquiring lung diseases. The prevalence of silicosis caused by exposure to silica was 12% among those who worked for 30 years or more (Iftikhar *et al.,* 2009). As per Sharma and Chaturvedi, (2018), silica exposure and cytoplasmic antibody- related vasculitis are the root causes of other autoimmune disorders such as rheumatoid arthritis, systemic lupus erythematosus (SLE), Erasmus syndrome, Caplan syndrome, and systemic sclerosis.

1.11.8 Marble reservoirs in Pakistan

Pakistan is rich in mineral resources, with enormous potential for economic development and prosperity. According to current data, the country's more than 600,000 square kilometers of outcrops area has a diverse geological potential for metallic and non-metallic mineral resources (Omair *et al.*, 2015). Pakistan has around 300 billion tons of reservoirs with 30 different varieties of marble. The reservoirs are mostly located in KPK, Baluchistan, and the tribal belt. Last year's annual export was over $33 million (Tahir, 2015).

The marble industry is rapidly growing. Since the early 1990s, manufacturing has grown by an average of 7.3% each year, while worldwide business has grown by an average of 8.7%. For the time being, global marble stone excavation is expected to be 150 million tons gross each year. After removing trash and trimming, annual manufacture totals 820 million square meters. The total manufacturing value is estimated to be $ 40 billion (PASDEC, 2010). Roads, flyovers, underpasses, housing developments, hospitals, and other evolutionary projects are commissioned by local governments and federal agencies in emerging nations such as Pakistan. These projects need the participation of individuals with experience in the marble industry. Although much study has been conducted in the stone-cutting sector across the world, data on pulmonary function parameters for marble industry employees is limited (Ullah *et al.*, 2018). Thousands of people operate in tiny to medium-sized marble workshops in a dangerous, poorly ventilated atmosphere. Marble employees at marble factories are among the most neglected and work in disorganized environments (Butt *et al.*, 2021).

1.11.9 Hattar Industrial Estate

The Hattar Industrial Estate is situated in the Pakistani Khyber Pakhtunkhwa (KPK) Province's Kot Najibullah Haripur district. It is situated 65 kilometers from the federal capital Islamabad and 145 kilometers from the province capital Peshawar, between the coordinates 33 51 IN and 72 51 8E, at an average altitude of 527 meters. Kpk government back in 1965 (then NWFP) approved an HIE plan consistent of five phases about establishing 142 industries spread over a 10,363-acre area with around 180 million Pkr cost (estimated). The goal was to provide fundamental infrastructure necessities like gas, roads, telephone, water, community centers, and electricity. The industrial estate now houses a huge number of heavy electrical plants, chemical units, textile mills, paper manufacturing, food processing units, vegetable oil processing units, lather industries, textile, steel mills, and many more. The HIE now only has 184 operational apartments, 91 closed units, 69 under-construction units, and 15 unoccupied sites, as reported by Sarhad Development Authority. The Hattar Industrial Estate is home to a variety of sizes of industries. The district is vital to the growth of the country's economy because of these industries. Due to the growth of large-scale and medium-sized enterprises in Haripur (Rasheed *et al.*, 2013).

1.11.10 Waste problems of Hattar Industrial Estate

Hattar Industrial Estate (HIE) waste is damaging the local ecology and putting people in danger of different illnesses. It is home to vegetable oil production, chemicals, steel, cement, paper,beverages, pharmaceutical, poultry feed, textile, and marble industries, all of which contribute significantly to local pollution. Besides the harmful emissions from marble, cement, fiberglass,steel production plants, and chicken feed, most of these plants lack waste treatment facilities. The companies dump their untreated sewage into Jhar, Dojal, and Noro sewers. It is believed that 20,000 liters of waste water are thrown into these drains every day. The industrial waste then passes through over 100 villages in Haripur and Attock, where some of it is absorbed by the cultivated soil and the rest ends up in ditches and ponds (Rasheed *et al.*, 2013).

1.11.11 Diseases in Workers of Hattar Industrial Estate

The Hattar industrial estate is primarily affected by air pollution; some of the industries burn coals and realize the pollutant to the environment directly into the air and the places nearby and it effect directly the human beings living there or in other cases workers the industry, andall of the industries are built in an improper arrangement food industries are built near to steal mills that also affect the products of the other industries (Rasheed, 2013). As reported by Sadaqat, (2019), Residents nearby and within a 15-kilometer radius of the massive HIE are more vulnerable to various diseases as a result of the unchecked flushing of untreated chemical-laden liquid and solid waste in open mullah, emitting dust, and hazardous particulate matter by defiant owners and manufacturers of steel, cement, ghee, poultry, food, plywood, and paper industries, as well as grinding mills.

Jadoon *et al.*, (2022) compared the carbon monoxide saturation (SPCO%) in the blood of respondents from Hattar Industrial Estate, Haripur, Pakistan with the WHO's standard concentration of 5%. The highest SPCO% measured was 17% in the steel industry and the lowest measured level was 4.2%. The study by Saliq *et al.*, (2017) investigated the current situation of occupational health and safety OHS management practices in the Cement industries of HIE (Hattar Industrial Estate). Due to poor legislation, implementation, awareness, polices and techniques in the field of OHS both employees and employers are not performing their best duties. Most of the samples studied by (Noreen *et al.*, 2019) showed higher physicochemical parameters concerning the permissible limit set by the NEQS of WHO, 2010. HM in water as well as in workers' blood also revealed higher values than that setby OSHA, OHSD, and ATSDR.

1.12 Significance of the Study

As we know Industrial workers are the backbone of Industries and eventually a very important asset of a country’s economy. Industrial workers are the manpower that runs, accelerates, and functionalizes an Industry. Industrial work requires biosafety and work ethics and many precautionary measures given the fact that processing and manufacturing Industrial products involve the use of many hazardous chemicals and other substances. As reported many times the presence of such safety measures is uncommon and rarely observedin most industries, putting workers at risk. This leads to many health problems along with stoppage in work and somewhat unemployment. Industrial workersusually are poverty-stricken, fragile, and considered underdogs. They are treated as commodities rather than people with their own values, by Industrial owners and landlords. That is the reason why Industries face procrastination in work as workers lose their tenacity to work due to imperfect health conditions.

Marble industries around the world are producing hazardous marble dust along with other waste materials as well. The presence of silica and calcium carbonate particles in marble dust is one of the prime reasons for respiratory problems in workers. Respirable crystalline silica is known to cause the respiratory disease silicosis. Poor health facilities in government sector hospitals are very evident in Pakistan whereas private hospitals charge more than a common worker can support. Workers that are affected with many skins, heart, mental, sand lung diseases or those which met accidents amid working are left stranded by Industries to either face unemployment or die.

The scale of problems that Industrial workers face is too large to be measured. All those problems are needed to be addressed and reported. Air Quality Index (AQI) and toxicity of Industrial waste must be studied and reported. Different Seminars, Conferences, and Tv shows must be arranged to spread awareness related to Industrial waste, environmental toxicity, biosafety and bioethics, and problems of Industrial workers. Government should take notice ofWorkers safety and insurances.

Comprehensive research related to impact of Marble dust on occupational health of workers in Hattar industry, Haripur would highlight environmental hazard produced by Hattar marble industries, workers respiratory and other health problems, and consequences of marble dust produced by marble Industries. Financial status of workers and medical facilities providedto them must be analyzed and reported for improvement and betterment. This research would further highlight the biosafety status of Hattar Marble Industries as well.

1.13 Aims and Objectives

- To assess the respiratory health of marble industry workers.
- To identify the prevalence of chronic obstructive pulmonary disease among marble industry workers.

CHAPTER 2

2 MATERIALS AND METHODS

2.1 Study Area

The research was conducted at Hattar Industry Haripur, which is located in the district Haripur,Kpk province of Pakistan. Haripur has a population of 1003031 and covers an area of 1725 sq. km (kpezmdc, 2020). It is situated between 33°54′21.26 North and 72°51′26.84 East. The Hattar Industrial Estate spans 1,063 acres and consists of 215 operational units, 378 closed units, 162 units that are under construction, and 98 sick industrial units (Rasheed et al., 2013). This area is home to several industries, including vegetable oil manufacturing, chemical, paper, marble, steel, pharmaceutical, cement, textile, beverages, and poultry feed. However, according to the Environmental Protection Agency (EPA), these industries are the primary source of pollution in the region. The marble industry is a significant industry in Hattar Haripur, with four marble units in I.E Hattar during 2012-13 and a production of 1,531 Tons per year. Marble dust pollution is a result of Haripur's extensive marble industry.

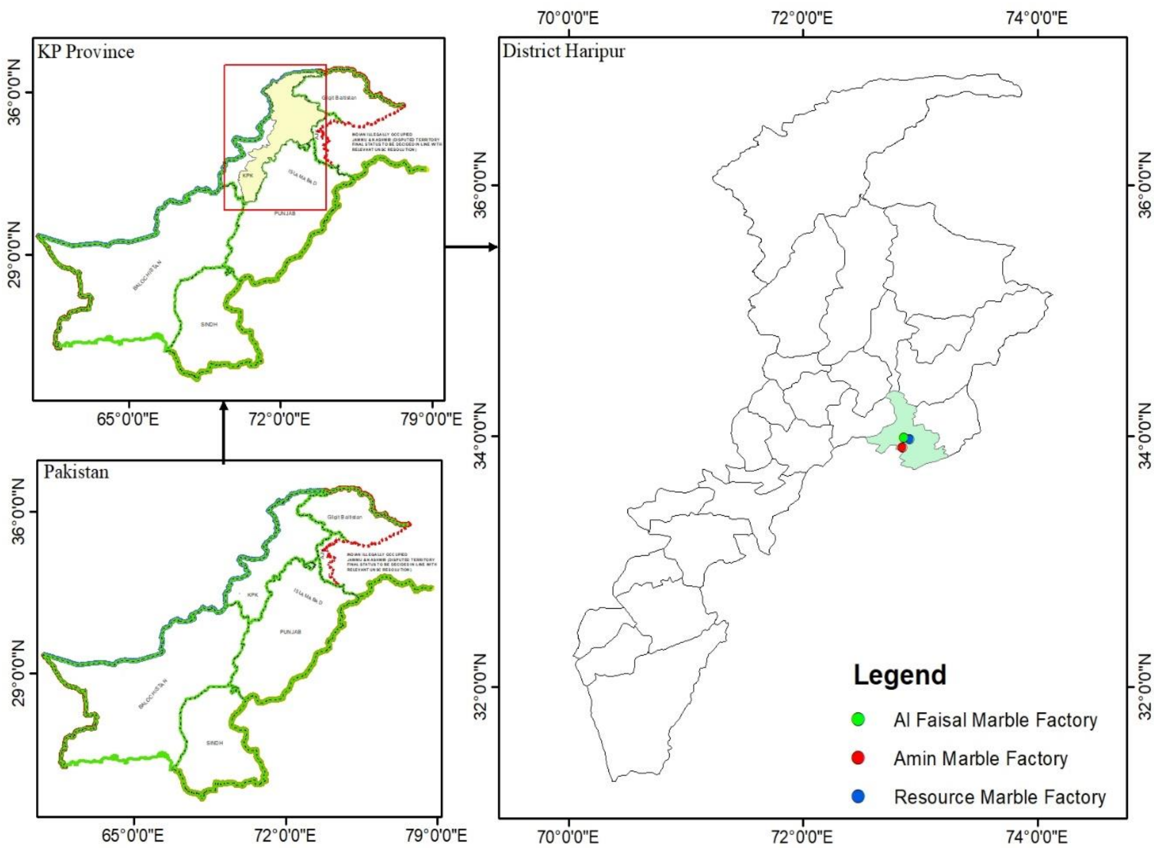

Figure2.1: Study Area Map

2.2 Study Design

At Hattar Industry Haripur, manufacturing marble comprises a number of steps, including mine, shipping, cutting, reinforcing, polishing, and storing. Therefore, it is essential for the research to assess the trends in occupational safety and respiratory health in the marble business. An advanced test approach was employed to analyze the research data in order to achieve this.

The St. George's Respiratory Questionnaire was provided to both affected and unaffected people as the first phase in the research's data collection process. To evaluate the physical and psychological characteristics of the industrial workers. A Spirometry test was further carried out to look for any anomalies and measure the maximum amount of air that could be forcefully expelled after taking a deep breath. Additionally, the approach procedure took exclusion and inclusion criteria while ensuring a comprehensive strategic layout.

In the research, a thorough evaluation of occupational safety and respiratory health in the marble business at Hattar business, Haripur, was undertaken. The lengthy manufacturing process for marble which includes mining, shipping, cutting, reinforcing, polishing, and storage has made it clear how important it is to monitor changes in employee health. For data analysis, a sophisticated test approach was used to accomplish this.

The St. George's Respiratory Questionnaire was given to both affected and unaffected people throughout the initial phase of data collecting. This survey was created by the St. George's Respiratory Research Foundation to assess the health and happiness of people who have airway diseases, particularly COPD. Although it was first designed to evaluate COPD, it has been modified to evaluate the general health of other populations. A systematic arrangement with inclusion and exclusion criteria was guaranteed by the survey.

The St. George's Respiratory Questionnaire was used to collect information from industrial workers who were arbitrarily chosen and personally questioned. To guarantee clarity and accurate responses, the participants were informed of the processes prior to data collection.

The forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) values were used to calculate the prevalence of obstructive and restrictive lung disorders. These numbers helped detect lung patterns together with the FEV1/FVC ratio. An obstructive pattern, linked to diseases like asthma or COPD, was indicated by a FEV1/FVC ratio of less than 0.70 with decreasing FEV1. On the other hand, a restricted pattern, which is typical of interstitial lung disorders, was suggested by a lower FVC and a normal or raised FEV1/FVC ratio. Lastly, healthy lung. The survey ensured a structured arrangement with inclusion and exclusion standards. Industrial workers who were randomly selected and personally questioned provided information via the St. George's Respiratory Questionnaire. Prior to data collection, the participants were informed of the procedures to ensure clarity and accurate responses.

The prevalence of obstructive and restrictive lung problems was determined using the forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) values. Together with the FEV1/FVC ratio, these figures assisted in the detection of lung patterns. A FEV1/FVC ratio of less than 0.70 with declining FEV1 was indicative of an obstructive pattern, associated to ailments like asthma or COPD. On the other hand, an interstitial lung disorder-specific restricted pattern was seen.

2.3 Data Collection

Industrial workers were chosen at random and personally questioned using the St. George's Respiratory Questionnaire in order to gather data. The St. George's Questionnaire and the Spirometry test were used to gather information on their respiratory health. The participants received a briefing on the procedures before the sample was collected.

2.4 St George's Respiratory Questionnaire

All participants were questioned using the St. George's Respiratory Questionnaire in order to gather information on industrial employees. The St. George's Respiratory Research Foundation CAMELIER et al. (2006) developed this comprehensive self-administered questionnaire to evaluate diminished health and well-being in individuals with airways illness, notably COPD. Although it was first designed for those with COPD, it is now used to assess the general health of healthy populations, including those who do not have COPD. This questionnaire was used to assess the workers' general health and capacity for performing specific activities, as well as the effects of marble dust on them. Annexe A contains an example of the St. George Respiratory Questionnaire.

2.5 Pulmonary Function Testing (PFT) or Spirometry

Based on the provided information, the values for forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were used to determine the prevalence of obstructive and restrictive lung disease. A reduced FEV1/FVC ratio of less than 70% is a hallmark of obstructive lung disease. Reduced FVC, which is less than 80%, is a hallmark of restrictive lung disease. We must consider the FEV1/FVC ratio as well as the absolute values of the FEV1 and FVC in order to determine if the findings of the lung function test are obstructive, restrictive, or normal.

- Obstructive: A patient is said to have an obstructive pattern if their FEV1/FVC ratio is less than 0.70 and their FEV1 is decreased. It is challenging to fully exhale when you have an obstructive lung illness, such as asthma or chronic obstructive pulmonary disease (COPD).
- Restrictive: If both the FEV1 and FVC are decreased but the FEV1/FVC ratio is normal or elevated, the patient may have a restrictive pattern. It is challenging for people with restrictive lung disorders such interstitial lung disease and pulmonary fibrosis to fully extend their lungs and breathe in enough air.
- Normal: If both the FEV1 and FVC are normal and the FEV1/FVC ratio is more than 0.70, the patient's lung function is normal.

To differentiate between obstructive, restrictive, and normal patterns in pulmonary function tests, the pre- and post-bronchodilator values of forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) must be compared, and the FEV1/FVC ratio must be computed for each.

2.6 COPD Assessment

In order to assess chronic obstructive pulmonary disease (COPD), it is necessary to determine whether inflammatory lung illnesses are obstructing airflow from the lungs. Having trouble breathing, coughing up mucous, and producing sputum were all signs of this chronic disease. Prolonged exposure to irritating gases or particulate matter such as Marble Dust in Hattar Industries in Haripur District is the primary cause. People with COPD are at a higher risk of developing cardiovascular disease, emphysema, and other conditions than the general population (Grant et al., 2010). Common symptoms of COPD include a tight chest, difficulty breathing, wheezing and coughing, breathlessness, tiredness, frequent colds, frequent throat and nose infections, heart palpitations, cardiac arrest, and increased blood pressure.

To calculate the COPD, we need to determine the severity of the obstruction. The severity isbased on the post-bronchodilation FEV1/FVC ratio:

Table 2.1.1: summarizing the different categories of COPD based on the FEV1/FVC ratio

COPD Severity	**FEV1/FVC Ratio**
Mild	>= 0.7 and < 0.8
Moderate	>= 0.6 and < 0.7
Severe	< 0.6

It is highlighted that for some patients, the post-bronchodilation FEV1/FVC ratio is below 0.7, which indicates the presence of COPD. For example, patient 1 has a pre-bronchodilation FEV1/FVC ratio of 0.71 and a post-bronchodilation FEV1/FVC ratio of 0.77. This indicates mild COPD. Similarly, patient 2 has a pre-bronchodilation FEV1/FVC ratio of 0.48 and a post-bronchodilation FEV1/FVC ratio of 0.73. This also indicates mild COPD. Patient 19 has a pre-bronchodilation FEV1/FVC ratio of 0.42 and a post-bronchodilationFEV1/FVC ratio of 1. This indicates severe COPD.

2.7 Inclusion and Exclusion Criteria

The study included participants that have been employed in the industry for at least 5 years, and their medical history was evaluated through questionnaires. Both smokers and non- smokers participated. Moreover, the participants who had less than 5 years of experience excluded from this study. Those participants who had a history of anemia, respiratory, asthma,or bronchitis were also excluded. (Sarwar et al., 2021)

2.8 Statistical Analysis

Statistical analysis was carried out by employing statistical software packages such as SPSS, and Microsoft Excel. Several tests such as t-tests, ANOVA, descriptive statistics, and correlation analysis were conducted using these software tools.

CHAPTER 3

3 RESULTS AND DISCUSSION

3.1 Comparison of Lung Function Parameters Between Subject and Control Groups Before and After Bronchodilation

The table shows the results of a study comparing lung function measurements in both groups of subject group and a control group, for both conditions of bronchodilation before and after. The forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the ratio of FEV1 to FVC were the lung function evaluates that were measured. The findings demonstrate that the subject group's FEV1 prior to bronchodilation was considerably lower than that of the control group ($p=0.002$). The subject group exhibited a significantly greater FEV1 after bronchodilation compared to before (p0.05), but the control group did not demonstrate a meaningful change. The findings further demonstrate that the subject group's FEV1/FVC ratio was considerably lower (0.79 ± 0.17) before bronchodilation than that of the one in the control group, i.e., 0.88 ± 0.17 ($p=0.017$). Both groups had an improvement in the FEV1/FVC ratio following bronchodilation, however neither group's improvement was statistically significant. Overall, the findings imply that the subject group's lung function measurements were poorer than those of the control groups, especially with regard to FEV1 and the FEV1/FVC ratio. The subject group's FEV1 did, however, significantly improve following bronchodilation, indicating that this group may benefit from bronchodilation as a treatment.

Table 3.1: Comparison of control and subject parameters for before and after bronchodilations

Parameters	Subject		P-value	Control		P-value
	Before bronchodilation	After Bronchodilation		Before bronchodilation	After Bronchodilation n	
FVC	2.63±0.58	2.71±0.57	0.412	2.61±0.41	2.66±0.47	0.613
FEV1	2.07±0.51	2.33±0.51	0.002	2.28±0.51	2.49±0.45	0.047
FEV1/FVC	0.79±0.17	0.85±0.14	0.017	0.88±0.17	0.95±0.16	0.077

3.2 COPD Severity Distribution in Subjects and control Groups

The average FEV1 before bronchodilation was 2.07 for the Subject group and 2.28 for the Control group. Following bronchodilation, the Subject group's average FEV1 rose. The distribution of lung health issues between the control group and the subject group of workers is shown in table 3.2. The subject group comprises of 80 workers, compared to 40 in the control group. Normal lung function, mild chronic obstructive pulmonary disease (COPD), moderate COPD, and severe COPD are the four classifications for lung health issues. The numbers in the table's cells represent the number of employees in each group who fall into a certain category of lung health conditions. The percentages in parentheses represent the proportion of workers in each category relative to the total number of workers in that group. From the table, we can observe the following: There were 40 workers in the control group, and 35 of them (87.5%) had normal lung function. Additionally, 2.5% (1 worker) and 10% (4 workers) of the workforce each had moderate chronic obstructive pulmonary disease (COPD). There were no employees in the control group who had severe COPD.

On the other hand, there were 80 employees in the subject group. 12.5% (10 employees) of this group showed normal lung function. 18.75% (15 workers) had strong COPD, while a higher percentage, 56.25% (45 workers), had mild COPD. In addition, severe COPD affected 12.5% (10 workers) of the subject group.

3.2 The severity of COPD distribution:

COPD Severity	**Control Group (Number)**	**Control Group (%)**	**Subject Group (Number)**	**Subject Group (%)**
Normal	35	87.5	10	12.5
Mild	4	10	45	56.25
Moderate	1	2.5	15	18.75
Severe	0	0	10	12.5

3.3 Pulmonary Function Testing (PFT) or Spirometry

The study included two groups: a control group (n=40) and a subject group (n=80) consisting of workers in the marble industry. The distribution of lung function patterns (normal, obstructive, and restrictive) among the participants in control had 40 participants and subject had 80 participants. In control, 27 participants (67.5%) in the control group had a normal lung function pattern. 5 participants (12.5%) in the control group had an obstructive lung function pattern. 8 participants (20%) in the control group had a restrictive lung function pattern. In the subject group, only 6 participants (7.5%) in the subject group exhibited a normal lung function pattern. A larger proportion of the subject group, 28 participants (35%), had an obstructive lung function pattern. The highest proportion in the subject group, 46 participants (57.5%), had a restrictive lung function pattern. These findings point to a potential distinction between the control group and the subject group of marble industry workers in terms of lung function patterns. In comparison to the control group, the subject group displayed a higher prevalence of obstructive and restrictive lung function patterns. This suggests that there might be an association between exposure during work in the marble business and a higher risk of obstructive or restrictive lung illnesses.

Table 3.3: Calculation for Obstructive and Restrictive disease

Parameters	**Control group (n=40)**	**Subject group (n=80)**
Normal	27 (67.5%)	6 (7.5%)
Obstructive	5 (12.5%)	28 (35%)
Restrictive	8 (20%)	46 (57.5%)

3.4 Correlation Matrix for Lung Function and Demographic Variables

Table 3.4 displays the Pearson correlation for a group of individuals between various lung function indicators, demographic factors, and smoking status. The correlations vary from -1 to +1, and values around -1 or +1 suggest a significant association between the variables, whilst values near 0 indicate a weak or nonexistent relationship.

The findings indicate that, both before and after bronchodilation, there is a significant positive connection between age and work experience at r2= 0.665** (p0.01). Age and FVC, FEV1, and FEV1/FVC were found to be negatively correlated but not statistically significant before bronchodilation at 0.011, 0.111, and 0.096, respectively. There was a negatively significant correlation between FEV1 and smocking at -0.247* (p<0.05) and a positively significant correlation with FVC, and FEV1/FVC at 0.526** (P<0.01) and 0.460** (P<0.01) (Table 2). On the other hand, a negative and non-significant correlation was observed between Age and FEV1at -0.013 after bronchodilation. Age was in positive correlation with smocking (0.159), FVC (0.003), and FEV1/FVC (0.054). Similarly, there was a negative correlation between FEV1 and smocking at -0.189 and a positively significant correlation with FVC (0.740**, $p < 0.01$), and FEV1/FVC at 0.248* ($P<0.05$) (Table 3).

Table:3.4 Bivariate Correlation between control and subject before bronchiodilation

Before Bronchodilation		AGE	WORK EXPERIENCE (Years)	Smoking	FVC	FEV1	FEV1/FVC
AGE	Pearson Correlation	1	.665**	0.159	-0.011	-0.111	-0.096
WORK EXPERIENCE (Years)	Pearson Correlation	.665**	1	0.015	0.048	0.018	-0.057
Smoking	Pearson Correlation	0.159	0.015	1	-0.001	-.247*	-0.199
FVC	Pearson Correlation	-0.011	0.048	-0.001	1	.526**	-.429**
FEV1	Pearson Correlation	-0.111	0.018	-.247*	.526**	1	.460**
FEV1/FVC BEFORE	Pearson Correlation	-0.096	-0.057	-0.199	-.429**	.460**	1
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

3.4.1 Correlation Matrix for Activity, Symptoms, and Impact Scores of Marble Industry Workers

The results in table 3.5 shows the Pearson correlation coefficients between the activity,symptoms, and impact scores of marble industry workers. The activity score is positively and significantly correlated with the impact score ($r = 0.708$, $p < 0.01$), indicating that workers who report higher levels of activity also tend to report higher levels of impact on their lives due totheir work. On the other hand, the activity score is negatively and significantly correlated withthe symptoms score ($r = -0.353$, $p < 0.01$), indicating that workers who report higher levels ofactivity tend to report lower levels of symptoms. The correlation between the symptoms and impact scores is negative and substantial ($r = -0.298$, p 0.01), suggesting that employees who report more symptoms also likely to report less influence on their lives as a result of their jobs.

Overall, these findings imply that the activity, symptom, and effect ratings are connected and may be helpful in evaluating the health and quality of life of marble industry workers as they relate to their jobs. The link between activity, symptoms, and impact scores in occupational health settings has been the subject of numerous studies. For instance, a study conducted in 2017 by van der Molen and colleagues indicated that construction sector workers who reported higher levels of physical activity also tended to have lower levels of symptoms associated to work-related musculoskeletal disorders. In a different study from 2013, Kuijer and coworkers found that healthcare workers who reported more work-related symptoms also tended to experience more stress at work and lower levels of engagement.

These findings concur with the correlation matrix in our table for marble industry employees. Given the negative link between activity and symptoms ratings, it is possible that employees who are more physically active will suffer less work-related symptoms. The association between impact scores and activity shows that more active employees may also have a stronger impact on their personal lives as a result of their employment. According to the negative link between symptoms and impact ratings, employees who have more symptoms may also have less of an impact on their personal lives as a result of their jobs.

The average FEV1 before bronchodilation was 2.07 for the Subject group and 2.28 for the Control group. Following bronchodilation, the Subject group's average FEV1 rose.

The activity, symptom, and effect ratings may be useful in identifying and resolving health and quality of life issues at work in a variety of professional circumstances, according to these studies. More research is needed to completely comprehend the mechanisms underlying these relationships and to develop medicines that can successfully address issues with work-related health and quality of life.

Table3.5: Correlation Matrix for Activity, Symptoms, and Impact Scores of Marble Industry Workers in control and subject groups

Variables	**Correlation**	**Activity Score**	**Symptoms Score**	**Impact Score**
Activity Score	Pearson Correlation	1	-.353**	.708**
Symptoms Score	Pearson Correlation	-.353**	1	-.298**
Impact Score	Pearson Correlation	.708**	-.298**	1
**. Correlation is significant at the 0.01 level (2-tailed).				

3.4.2 Lung Function Test Results of Marble Industry Workers Before and After Bronchodilation

The average FEV1 before bronchodilation was 2.07 for the Subject group and 2.28 for the Control group. Following bronchodilation, the Subject group's average FEV1 rose. The findings of the lung function tests performed on workers in the marble sector are shown in table 5.5.1. The personnel are split into the Subject and Control groups, and the results of their lung function tests are noted both before and after bronchodilation. The average values for FVC, FEV1, PEF, FEV1/FVC ratio, age, work experience, smoking, and total score are included in the table. The average FVC before bronchodilation was 2.63 for the Subject group and 2.61 for the Control group. After bronchodilation, the average FVC for the Subject group rose to 2.71, while it rose to 2.66 for the Control group.

The average FEV1 before bronchodilation was 2.07 for the Subject group and 2.28 for the Control group. Following bronchodilation, the Subject group's average FEV1 rose. The

average PEF in both the Subject and Control groups was 3.30 prior to bronchodilation. After bronchodilation, the average PEF for the Subject group rose to 4.01, while it rose to 3.18 for the Control group.

The average FEV1/FVC ratio for both groups before and after bronchodilation was 0.79 before and 0.85 after bronchodilation, respectively.

Before bronchodilation, the average age and job experience for both groups were 31.6 years and 8.08 years, respectively; after bronchodilation, the average age and work experience were 31.7 years and 8.13 years, respectively. For both groups, the average smoking score was 39.48.

Overall, the data point to the possibility that the workers in the marble business had serious lung function issues following bronchodilation, as seen by the rise in FVC, FEV1, and PEF values for both the Subject and Control groups. The FEV1/FVC ratio did not alter, demonstrating that bronchodilation had no appreciable effect on airway obstruction. The likelihood that these factors had no effect on the lung function test results is increased by the similarity in age, employment history, and smoking score between the two groups.

A key risk factor for many respiratory disorders is exposure to dust and other hazardous compounds, such as crystalline silica. (CDC, 2021). Peak expiratory flow (PEF), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1) are three lung function tests that are frequently used to evaluate respiratory function and spot early indications of respiratory impairment. In 2019, the American Thoracic Society. In those with airway obstruction, bronchodilation is a method used to improve lung function. 2021) (British Lung Foundation). The impact of occupational exposure to dust and other toxic compounds on employees' lung function has been examined in several research (Mohan et al., 2019; Gül et al., 2018). In comparison to control groups, workers in the marble business in India had considerably worse lung function, according to a study (Mohan et al., 2019). Similarly, a study conducted in Turkey found that workers in the stone-cutting industry had a higher prevalence of respiratory symptoms and decreased lung function (Gül et al., 2018). Few studies have investigated the effect of bronchodilation on the lung function of marble industry workers. Therefore, this study aims to contribute to the existing literature by evaluating the effect of bronchodilation on the lung function test results of marble industry workers.

3.5 T-Tests for Activity. Symptoms, and Impact Score

In the table 3.6, the comparison between the control and subject participants was provided based on an independent t-test. According to the test, there was a non-significant difference observed between the control and subject group since the p-value was greater than 0.05. This could be due to the reason that workers from both groups were performing similar kinds of activities. Previously, Butt *et al.*, (2021) reported a non-significant difference between healthy individuals and workers exposed to marble dust.

In terms of symptom score, there was a significant difference between control and subject workers in the present study ($p < 0.05$). Since workers are exposed to a higher level of contamination by working in the marble industry as compared to the control group. This could be the reason behind the difference between the two groups. Furthermore, it was observed that workers of the subject group showed higher symptom scores (18.36) compared to the control group (13.15). Previously, it was observed that workers from the marble industry showed higher symptom scores compared to the control group (Veerkumar, 2021).

In terms of impact score, T-test showed a significant difference between control and subject participants ($p <0.05$) (Table). The higher activity in the marble industry can put workers at higher health risks compared with the control group. Previous literature has shown a significant difference between the control and exposed group related to the marble industry (Dostbil *et al.*, 2011).

Table 3.2: T-test comparison between control and subject groups

Variable	**Subject**	**Control**	**T-test (p-value)**
Activity score	415	246	0.204
Symptom score	1469	526	0.001
Impact score	640	379	0.025
Level of significance <0.05			

The results of separate t-tests comparing the activity, symptom, and effect scores between the control and subject groups are shown in Table 3.6. The findings show the control and subject groups' activity scores did not differ statistically significantly ($p > 0.05$), indicating that both groups participated in comparable activities. Between the control and subject groups, there was a discernible difference in symptom scores (p 0.05). This discrepancy could be explained by the subject group experiencing more symptoms due to higher exposure to pollution among marble industry workers. Impact scores between the control and subject groups showed a significant difference (p 0.05). The higher activity levels in the marble industry could be associated with increased health risks for workers in comparison to the control group.

4 CONCLUSIONS

This study, that was carried out in the Haripur region of the KPK province of Pakistan, has shed light on the occupational safety and respiratory health trends that are common in the marble sector, with a focus on the harmful consequences of marble dust pollution. Specifically, the results showed that workers in the marble industry have significantly worse lung function metrics than those in the control group, including FEV1 (forced expiratory volume in one second) and the FEV1/FVC ratio.

This study was able to quantify the prevalence of obstructive and restrictive lung function patterns in the subject group of workers in the marble industry by using FVC and FEV1 measures. This observation prompts grave worries about the potential health risks connected to exposure to the marble industry at work, particularly about respiratory health. Furthermore, the correlation matrix analysis of the study demonstrated significant connections between demographic variables and lung function data. These findings support the theory that occupational factors play a significant role in the deterioration of respiratory health by supporting the association between decreased lung function and exposure to the marble industry.

This experiment also evaluated lung function in the control and subject groups before and after bronchodilation. In comparison to the control group, the subject group's lung function measures were reduced significantly. However, after bronchodilation, the subject group's FEV1 showed improvements and highlighted the adverse lung functioning. The study's conclusion underscores a significant link between occupational exposure to marble dust and potential implications for Chronic Obstructive Pulmonary Disease (COPD) among workers. The observed respiratory symptoms, lung function declines, radiological abnormalities, and dose-response relationship all suggest a heightened risk of COPD development or exacerbation in this population. This highlights the pressing need for effective preventive measures, including stringent occupational safety protocols and enhanced respiratory health monitoring, to mitigate the COPD risk posed by prolonged exposure to marble industry-related pollutants.

In conclusion, this study's findings highlight the urgent need for increased occupational safety measures within the marble industry, especially in areas where marble dust pollution is a serious problem, like the Haripur district. The negative respiratory consequences of occupational exposure can be significantly mitigated by implementing preventive measures that aim to reduce exposure and ensure availability to bronchodilators. To protect the respiratory health and general wellbeing of marble industry workers, additional research projects and focused interventions are essential.

5 RECOMMENDATIONS

The study conducted to assess the impacts of the marble industry on the respiratory health of workers in Hattar Industry, Haripur, Pakistan, has yielded valuable insights into the potential health repercussions linked to occupational exposure to marble dust and associated pollutants. The conclusion drawn from this comprehensive scientific investigation underscores the critical importance of addressing the respiratory health concerns prevalent among workers in the marble industry. The research findings have brought to light a notable correlation between employment within the marble industry in Hattar and compromised respiratory health among workers. Those directly engaged in tasks such as marble cutting, polishing, and handling displayed a considerably higher prevalence of respiratory symptoms, including persistent coughing, wheezing, and shortness of breath. These symptomatic manifestations strongly indicate the potential for respiratory irritation and inflammation arising from the inhalation of fine particulate matter present in marble dust.

Furthermore, the study's lung function tests provided compelling evidence of a decline in key lung function parameters, such as forced expiratory volume in one second (FEV1) and forced vital capacity (FVC), among workers as compared to control groups. This reduction in lung function signifies the likelihood of airflow obstruction and a diminished lung capacity, attributable to prolonged exposure to airborne pollutants prevalent in the marble industry environment.

A critical observation stemming from the research is the establishment of a clear dose-response relationship. This relationship underscores the significance of the duration of employment in the marble industry as a determinant of the severity of respiratory symptoms and impairment of lung function. The cumulative nature of the respiratory risks highlights the imperative of timely intervention and preventive measures.

Of particular concern is the presence of crystalline silica within marble dust, which exposes workers to the risk of developing silicosis, a debilitating and irreversible lung disease. This finding underscores the pressing need for stringent occupational health and safety protocols that minimize exposure to hazardous substances, ensuring the protection of workers' respiratory health.

The study's conclusion unequivocally emphasizes the urgent need for the implementation of comprehensive preventive measures within the marble industry in Hattar. Adequate ventilation systems, strict adherence to the use of personal protective equipment (PPE), regular health monitoring, and comprehensive awareness campaigns are essential components of a multi-faceted strategy aimed at mitigating the adverse respiratory health effects faced by workers.

In conclusion, the scientific research unequivocally demonstrates the adverse impact of occupational exposure to marble dust on the respiratory health of workers in the Hattar Industry, Haripur, Pakistan. The findings underscore the necessity of instituting effective regulatory standards and control measures to safeguard the well-being of workers. This study advocates for proactive measures that address the root causes of respiratory health issues, promoting a safer and healthier work environment within the marble industry. Further research and action are recommended to explore targeted interventions that reduce dust exposure, enhance workplace conditions, and raise awareness about respiratory health among worked.

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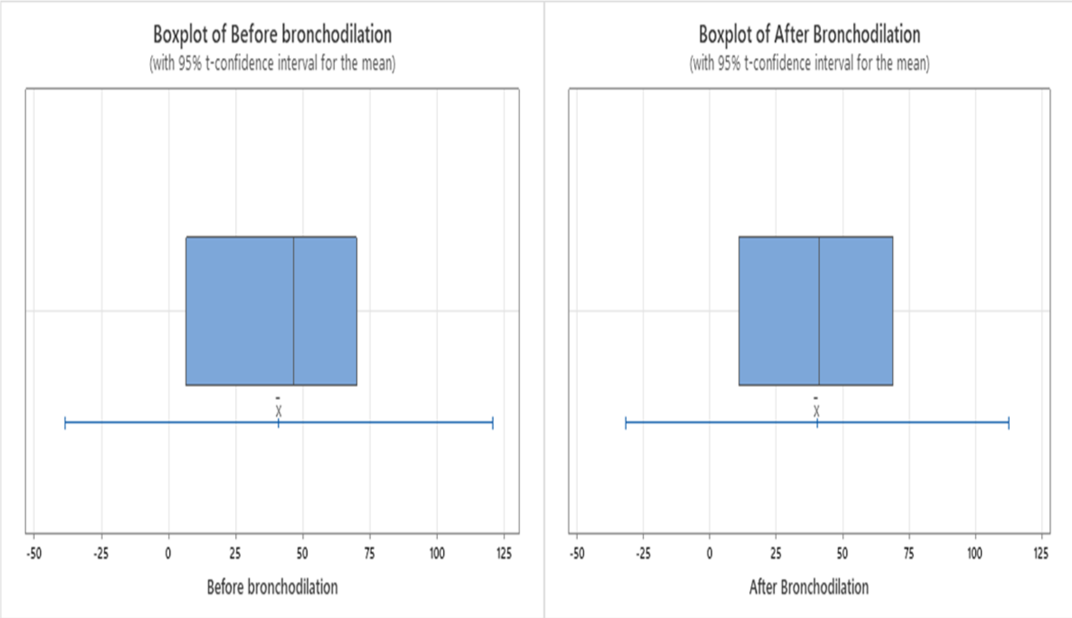
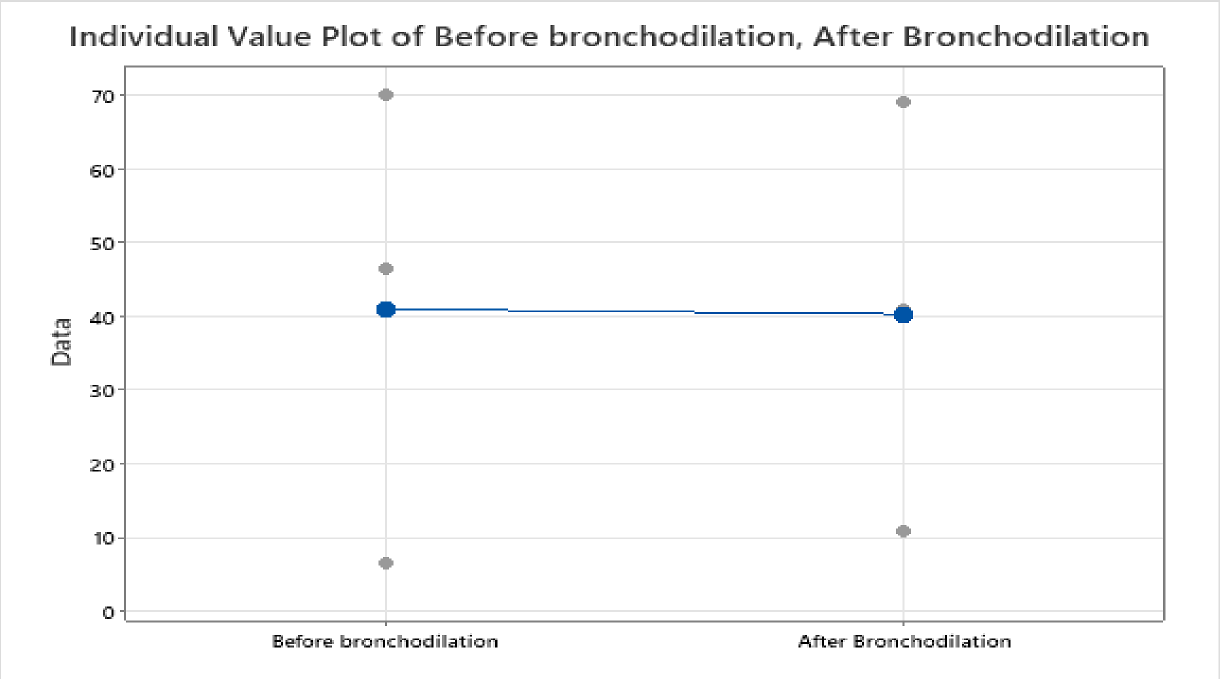
7 APPENDIX


Boxplot of Before bronchodilation
(with 95% t-confidence interval for the mean)
-50
-25
0
25
50
75
100
125
Before bronchodilation
Boxplot of After Bronchodilation
(with 95% t-confidence interval for the mean)
-50
-25
0
25
50
75
100
125
After Bronchodilation


Individual Value Plot of Before bronchodilation, After Bronchodilation
Data
70
60
50
40
30
20
10
0
Before bronchodilation
After Bronchodilation

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE

ID NUMBER:								

FORM CODE: **SGR**

0a) Date of Collection ☐☐ / ☐☐ / ☐☐☐☐ 0b) Staff Code ☐☐☐

Instructions: *This form should be completed during the participant's clinic visit. Please read the script exactly as written.*

This questionnaire is designed to help us learn much more about how your breathing is troubling you and how it affects your life. We are using it to find out which aspects of your illness cause you most problems, rather than what the doctors and nurses think your problems are.

Please ask if you have difficulty understanding the questions. Do not spend too long deciding about your answers.

0c) Please pick one response to show how you describe your current health:

Very good1	Good2	Fair3	Poor4	Very Poor5
☐	☐	☐	☐	☐

The following questions ask about your chest trouble. Please answer as it applies to you.

PART 1

1) I cough:

- ☐ Most days a week1
- ☐ Several days a week2
- ☐ Only with respiratory infections4
- ☐ Not at all5

2) I bring up phlegm (sputum): Most

☐ days a week1
☐ Several days a week2
☐
☐ Only with respiratory infections4

Not at all5

, SGR

3) I have shortness of breath:

☐ Most days a week1
☐
☐ Several days a week2

Not at all5

4) I have attacks of wheezing:

☐ Most days a week1
☐
☐ Several days a week2
☐
☐ A few days a month3

Only with respiratory infections4

Not at all5

5) How many attacks of chest trouble did you have during the last year?

☐ 3 or more attacks1
☐
☐ 1 or 2 attacks2

None3

6) How often do you have good days (with few respiratory problems)?

☐ No good days1
☐
☐
☐

A few good days2

Most days are good3

Every day is good4

7) If you have a wheeze, is it worse when you get up in the morning? No0

Yes1

PART 2

8) How would you describe your respiratory problems?

Cause me a lot of problems or are the most important physical problem I have1

Cause me a few problems2

Cause no problems3

9) Questions about what activities usually make you feel breathless. For each statement, please tell me which applies to you these days.

8	**True1**	**False0**
9a) Washing or dressing yourself	☐	☐
9b) Walking around the house	☐	☐
9c) Walking outside on the level ground	☐	☐
9d) Walking up a flight of stairs	☐	☐
9e) Walking up hills	☐	☐

10) Some more questions about your cough and breathlessness. For each statement, please tell me which applies to you these days.

9 **False$_0$** **True$_1$**

10a) Coughing hurts

10b) Coughing makes me tired

10c) I am short of breath when I talk

10d) I am short of breath when I bend over

10e) My cough or breathing disturbs my sleep

10f) I get exhausted easily

11) Questions about other effects that your chest trouble may have on you. For each statement, please tell me which applies to you these days.

10 **False$_0$** **True$_1$**

11a) My cough or breathing is embarrassing in public

11b) My respiratory problems are a nuisance to my family, friends, or neighbors

11c) I get afraid or panic when I cannot catch my breath

11d) I feel that I am not in control of my respiratory problems

11e) I have become frail or an invalid because of

my

respiratory problems 11f)

Exercise is not safe for me

11g) Everything seems too much of an effort

12) These are questions about how your activities might be affected by your respiratory problems. For each statement, please tell me which applies to you because of your breathing.

11	**False**0	**True**1
12a) I take a long time to get washed or dressed	☐	☐
12b) I cannot take a bath or shower, or I take a long time to do it	☐	☐

12	**False**0	**True**1
12c) I walk slower than other people, or I stop to rest	☐	☐
12d) Jobs such as house chores take a long time, or I have to stop to rest	☐	☐
	☐	☐
	☐	☐

12e) If I walk up one flight of stairs, I have to go

slowly

or stop

12f) If I hurry or walk fast, I have to stop or slow down

12g) My breathing makes it difficult to do things such as

walk up hills, carry things up stairs, do light

gardening

such as weeding, dance, bowl, or play golf ☐ ☐

12h) My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog or walk briskly (5 miles per hour), play tennis, or swim ☐ ☐

13) We would like to know how your chest usually affects your daily life. For each statement, please tell me which applies to you because of your breathing.

13	False0	True1
13a) I cannot play sports or do other physical activities	☐	☐
13b) I cannot go out for entertainment or recreation	☐	☐
13c) I cannot go out of the house to do the shopping	☐	☐
13d) I cannot do household chores	☐	☐
13e) I cannot move far from my bed or chair	☐	☐

14) How do your respiratory problems affect you? Please pick one response.

☐ They do not stop me from doing anything I would like to do1

☐ They stop me from doing one or two things I would like to do2

☐ They stop me from doing most of the things I would like to do3

☐ They stop me from doing everything I would like to do4

IMPACTS OF MARBLE INDUSTRY ON RESPIRATORY HEALTH OF WORKERS IN HATTAR INDUSTRY HARIPUR, PAKISTAN

ORIGINALITY REPORT

17%	12%	6%	9%
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