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EFFECT OF STONE DUST ON THE HEALTH STATUS OF WORKERS IN MARBLE INDUSTRIES OF KHYBER PAKHTUNKHWA, PAKISTAN

Sulaiman Shams[1]*, Fawad Iqbal[1], Muhammad Ayaz[1], Haider Ali Khan[1], Ome Kalsoom Afridi[2], Huma Rafiq[1], Nazia Imran[1], Maryam Iqbal[1], Sapna Quraish[1],

[1]Department of Biochemistry, Abdul Wali Khan University Mardan, Mardan-23200, Khyber Pakhtunkhwa, Pakistan
[2]Department of Biochemistry, Women University Swabi, Khyber Pakhtunkhwa, Pakistan

***Corresponding Author:** Dr. Sulaiman Shams
*Department of Biochemistry, Abdul Wali Khan University Mardan, Mardan-23200, Khyber Pakhtunkhwa, Pakistan, Email: sulaiman@awkum.edu.pk, Contact: +92-333-9202865

Abstract:
Various industrial dust pollution causes different health problems in workers including respiratory complaint, eye and skin disorders. Based on the concentration and chemical nature, stone dust also effect the liver and kidney related parameters especially in stone crushing workers. The purpose and aims of this study was to report for the first time the effect of stone dust on the health status of worker in marble industries of Pakistan. In the current study the effect of stone crushing dust on liver and kidney related serum parameters were estimated among the stone crusher's workers in marble factories at district Mardan and Charsadda of Khyber Pakhtunkhwa, Pakistan. Blood samples were collected from 180 stone crushing workers (aged 20-60 years), grouped as exposed workers and 180 unexposed healthy persons considered as healthy control. The exposed workers were further classified on the basis of age, time of exposure to stone dust, disease and smoking history. The liver and kidney related serum biochemical parameters were evaluated through wet reagent diagnostic kits while a standardized questionnaire was used for risk factors assessment**.** The results indicate a considerable raise in liver related parameters such as serum Glutamate Pyruvate Transaminase (GPT), bilirubin and manganese in workers, compared to control group. Creatinine results of kidney related serum parameter also confirmed increased levels in exposed workers as compared to healthy control. Overall result indicated that the mean values of liver and kidney related parameters were considerably high (SGTP level 130 ± 5.42U/L, Bilirubin level 1.7 ± 0.13 mg/dl and Cretinine level 2.31 ± 0.14mg/dl)in exposed workers than healthy control (SGTP level27 ± 2.23 U/L, Bilirubin level 0.62 ± 0.02 mg/dl and creatinine level 0.82 ± 0.04 mg/dl). The stone dust also leads to improvement in respiratory and skin infection due to lack of protective equipment among manual stone-quarry workers. It is concluded that chronic exposure of workers to stone dust in marble factories induces irregular elevation in the normal value of serum GPT, bilirubin, creatinine and manganese due to hazard effect on liver and kidney and also causes severe medical complications related to skin and respiratory system.

Keywords: Marble, Stone, Dust, Workers, Bilirubin, creatinine, manganese

1. Introduction

Worldwide, the stone crushing business is a vital component of the industrial sector since it provides the raw materials for many different construction projects, including roads, highways, canals, and bridges. The process of quarrying stone included a number of processes, including the removal of rock from the ground and subsequent crushing to produce aggregate sizes [1]. Stone crushing involves manufacturing and construction processes that expose workers to stone dust. Because of the impending global increase in morbidity and mortality among workers exposed to silica, both industrialized and emerging nations have high-priority public health concerns. Among other industries that significantly contribute to the national Gross Domestic Product, the stone crushing business organizes an important industrial area of Pakistan [2]. The demand for stone is high throughout the entire country, which explains why there are stone crushing units present in all major cities and towns in Pakistan, even though there are more stone crushing plants operating in developed cities like Karachi, Lahore, Multan, Faisalabad, Peshawar, and Quetta [3]. A number of stone crushing plants are also active in several districts of Khyber Pakhtunkhwa (KP), including Mardan, Swat, and Dir, among others. The stone crushing workers are exposed to silica, also known as silicon dioxide (SiO_2), in significant amounts through the stone dust produced by the crushing units. Large stones obtained from mining operations are crushed into smaller, more useful sizes during stone crushing methods. These crushing operations produce microscopic, dry dust particles with a diameter of 1 to 100 micrometres. In addition to contributing to environmental degradation, the stone dust that is produced contains silica, lead, asbestos, and other airborne materials [4]. Calcite ($CaCO_3$), dolomite [$CaMg(CO3)_2$], or a mixture of the two minerals make up the majority of marble, a crystalline, compact type of metamorphosed limestone. Commercially, the term "marble" refers to any calcium carbonate-containing rock that can be polished, including common limestone [5]. Extensive deposits are located in Italy, India, Pakistan, Greece, Brazil, China, Afghanistan, Turkey, Great Britain, and in the United States. Since ancient times, marble has been most frequently utilized in the creation of monuments, buildings, and statues. The disposal of marble dust by industry is currently one of the leading causes of environmental pollution in many nations [6]. Cutting and finishing marble that is sourced from quarries is a multi-step process. In order to create specified dimensional marble for a variety of tasks, specialized mill equipment such as saws, polishing machines, etc. was utilized. During the cutting process, about 25% of the original marble mass is lost as dust [7]. Epidemiological research conducted in the past showed that personnel engaged in the processes of quarrying, grinding, polishing, and installing marble were exposed to dust comprising calcium carbonate and silica particles. A substantial risk of respiratory disorders, such as chronic bronchitis, asthma symptoms, nasal irritation, and lung function impairment exists for workers exposed to marble dust, according to these previous studies [8, 9].The inhalation of airborne fibers found in stone dust is linked to a range of major health issues aside from respiratory illnesses, such as asbestosis and lead toxicity, different dermatoses, cadmium poisoning, pneumoconiosis, and liver conditions. By assessing the serum levels of GPT, bilirubin, and creatinine, researchers can better understand the liver and renal profiles of the stone crushing industry's employees [10]. Liver damage results from occupational exposure to many forms of dust and chemicals. The liver is the primary organ for the biotransformation of many substances within the body, and because of its unique position within the circulatory system, it is particularly sensitive to chemical injury. Additionally, it is the primary organ responsible for toxin and drug metabolism [11]. There is ample evidence that employees exposed to stone crushing dust have occupational injuries as well as a number of health issues, including silicosis [12, 13], tuberculosis [14], and occupational hearing loss [15]. Since the liver is the primary organ for the biotransformation of various substances within the body and is involved in the metabolism of toxins and medicinal agents, previous studies tended to evaluate health complications other than liver and kidney function tests. In Pakistan, hundreds of underprivileged individuals work in stone crushing facilities without any safety equipment, endangering their own health. This cross-sectional study aimed to explore the liver and kidney function parameters and the associated risk factors in stone dust exposed workers of plants located in Mardan and Charsadda districts of KP, Pakistan.

2. Methods

2.1. Study design and subjects

A cross sectional study investigated the stone dust exposed workers of plants located at district Mardan (Shaikh Maltoon Town) and Charsadda (Sanam Ghari of Tehsil Shabqadar). Stone dust exposed workers (n=180) and healthy subjects (n=180) with mean age ± 35.5 were enrolled in this study.

2.2. Subgrouping of Stone Dust Exposed Workers

The stone dust exposed workers were further classified into four subgroups on the basis of age, duration of exposure to stone dust, other ailments and history of smoking.

2.3. Data Collection

Using a standardized questionnaire, all study participants, including exposed workers and healthy controls, were interviewed. Important details on the worker's age, medical history, smoking habits, length of exposure to stone dust, and other health issues, if any, are included in this questionnaire. Before collecting any blood samples, all subjects provided written, informed consent. The study protocol was approved by the Ethical Committee of Biochemistry Department, Abdul Wali Khan University Mardan, KP-Pakistan.

2.4. Blood Samples Collection and Serum Isolation

Blood samples were collected aseptically from stone dust exposed workers (n=180) and healthy subjects (n=180) with mean age ± 35.5. Five ml blood was drawn aseptically from the radial vein of exposed workers and control group in EDTA tubes (BD Vacutainer, Becton, Dickinson, Franklin Lakes, NJ, USA) and labeled accordingly. Following blood collection, serum was isolated from each sample by centrifugation (SIGMA 1-14 Microfuge, SciQuip Ltd, Newtown, Wem, Shropshire UK).

2.5. Biochemical Assays

The serum samples of exposed workers and healthy control were analyzed for the serum biochemical parameters measurement using UV spectrophotometer (Hitachi U-2900 **,**Tokyo**,** Japan)**.**

2.6. Serum Biochemical Tests

All the serum samples (stone dust exposed workers and helathy subjects) were subjected to quantitative determination of SGPT, total bilirubin, and creatinine levels using the commercal kit regents (VitroScient, Belbis, Alsharkia, Egypt) following manufacturer’s instructions

2.7. Serum Manganese Measurement

For serum manganese concentration measurement, first the serum was digested by nitric acid and hydrogen peroxide. After digestion, the samples were cooled and then transferred into 10ml graduated cylinder, supplemented with deionized water. Then the concentrations of serum manganese were determined using Atomic Absorption Spectrophotometer.

2.8. Data Analysis

Data were statistically analyzed using Graphpad Prism (version 8.4.0). Values were expressed as mean ± SD. *t* test was used to compare means between exposed and control groups. A $P<0.05$ was considered statistically significant.

3.Results

3.1. Subgrouping of Workers on the Basis of Questionnaire History

The majority of the workers (n=62, 34.4%) who were subgrouped based on multiple risk variables (age, duration of exposure, other illnesses, smoking history) belonged to group II, followed by group III (n=55, 30.5%), with mean ages of 43.5 and 58.5, respectively. Workers in groups I and II were likewise found to have very poor income status. Group IV (n=28, 15.5%) was the category with the fewest number of workers (n=28%) and had a mean age of less than 50.3. Members of group III also displayed a high risk of cutaneous and respiratory complications. Groups II and III smoke more frequently than Groups I and IV do. Compared to other groups, group IV had a fairly small number of workers. Due to old age, frailty, and a high incidence of respiratory and skin infections brought on by stone dust, group IV's workforce was significantly smaller than that of the other groups. Additionally, none of the participants in the group have ever used any safety Personal protective equipment (PPE). Furthermore, it was discovered from the data gathered using a standardized questionnaire that none of the plant's employees had any safety instruction about the usage of PPE. Table 1 provides comprehensive data on all exposed employees gathered through the use of a standardized questionnaire.

Table 1: Grouping of workers on the basis of questionnaire history (n=180)

Groups	Age (Years)	No.Of Samples (N=180)	Exposure Time (Years)	Smoking History Habit (%)	Disease (%)
Group I	16-25	35	1-5	17.57	18.58
13.23Skin Inf.				Respiratory	
8.44 Both					
Group II	26-35	62	6-10	26.93	33.25
22.63 Skin Inf.				Respiratory	
13.82 Both					
Group III	36-45	55	11-15		
31.64 Skin Inf.				32.5	38.33
26.78 Both				Respiratory	
Group IV					
39.03 Skin Inf.	46-55	28	16-20		
33.72 Both					
				22.33	49.55
				Respiratory	

3.2. Prevalence of Liver and Kidney Related Serum Parameters in Exposed Workers

The liver and kidney serum parameters of exposed workers are shown in table 2. The results showed that serum GPT, bilirubin, creatinine and manganese level was significantly high in exposed workers due to hazard effect of stone dust on liver and kidney.

Table 2: High level of liver and kidney related serum parameters in exposed workers (n=180).

Samples	**SGPT (%)**	**Bilirubin (%)**	**Creatinine (%)**	**Manganese (%)**
Group I	17.21	18.8	13.41	32
Group II	47.74	46.44	39.5	58
				67
Group III	61.46	57.08	52.63	74
Group IV	81.67	78.85	71	

3.3. Serum GPT Level in Exposed Workers and Healthy Control

Figure.1 displays the SGPT levels of exposed workers and healthy controls. The average SGPT was determined to be in the normal range in healthy controls (27 ± 2.23 U/L), but it was significantly higher in exposed employees due to the harmful effects of stone dust on liver function. A slightly higher SGPT value than the healthy control was found in group I (57 ± 2.39 U/L), however significantly higher SGPT values were found in groups II (81.62 ± 4.07 U/L) and III (109.21± 4.52 U/L) as a result of prolonged exposure times to stone dust in marble factories. Due to a very lengthy exposure time to stone dust, group IV's mean value of SGPT (130.17± 5.42 U/L) was much higher than that of the other groups.

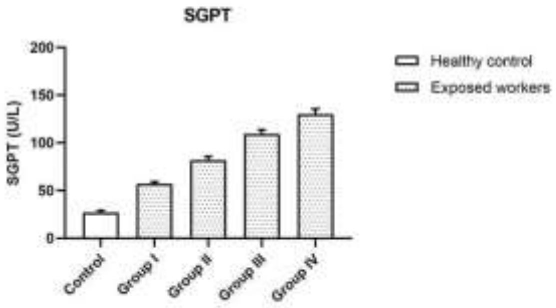

Figure 1. Based on the length of time employees exposed to stone dust, both groups of healthy controls and exposed workers had normal blood SGPT levels. Data are presented as the mean ± SD and $P<0.05$.

3.4. Measurement of Serum Bilirubin Level

Blood serum total bilirubin levels of exposed workers and healthy controls were measured (Fig. 2). Depending on the length of exposure to stone dust, the average total bilirubin level of healthy controls was normal (0.62 ± 0.02 mg/dL), however it was significantly higher in exposed workers. Due to prolonged exposure to stone dust in marble manufacturers, group I's total bilirubin concentration (0.92 ± 0.06 mg/dL) was marginally elevated, whereas groups II (1.32 ± 0.09 mg/dL) and III (1.49 ± 0.1 mg/dL) both had significantly elevated levels. The very high blood bilirubin content in Group IV workers (1.7 ± 0.13 mg/dL) is a result of their prolonged exposure compared to other groups.

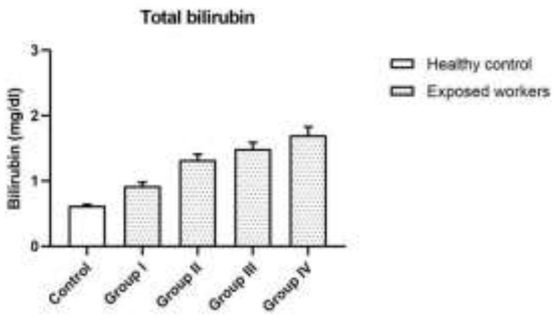

Figure 2: Total bilirubin levels in blood serum in the exposed workers' and healthy control groups, according to the amount of time they were exposed to stone dust. Data are presented as mean ± SD and $P<0.05$

3.5. Analysis of Serum Creatinine

Figure 3 shows the serum creatinine concentrations of exposed workers and healthy controls. The results demonstrated that, in contrast to the healthy control group, exposed employees' blood creatinine levels were considerably higher than normal (0.82 ± 0.04 mg/dL), indicating that stone dust exposure has a risky influence on renal function dL. Because of their prolonged exposure to stone dust in marble manufacturers, group II (1.86 ± 0.1mg/dL) and group III (2.06 ± 0.13 mg/dL) workers' blood creatinine levels significantly increased whereas group I workers' levels only marginally increased (1.51± 0.07 mg/dL). Additionally, group IV's mean serum creatinine readings (2.31 ± 0.14mg/dL) were substantially higher than those of the other groups' mean values.

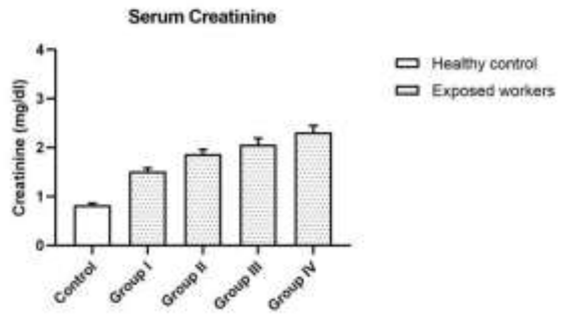

Figure 3: Serum creatinine level in healthy subjects and exposed workers, based on time of exposure to stone dust. Data are expressed as mean ± SD and *P* <0.05.

3.6. Serum Manganese Concentration in Exposed Workers and Healthy Control

Fig. 4 illustrates the analysis of the serum manganese content in exposed employees and healthy controls. The mean serum manganese level in healthy controls was normal (73.92 5.08 µg/L), however it was substantially higher in exposed workers. Due to their brief exposure to stone dust, group I's serum manganese levels (96.23 ± 8.33µg/L) was a little higher than average. Due of their prolonged contact to stone dust in marble manufacturers, group II (141.91± 11.02µg/L), group III (183.54 ± 11.88 µg/L), and group IV (204.30 ± 13.22 µg/L) had considerably higher serum manganese concentrations.

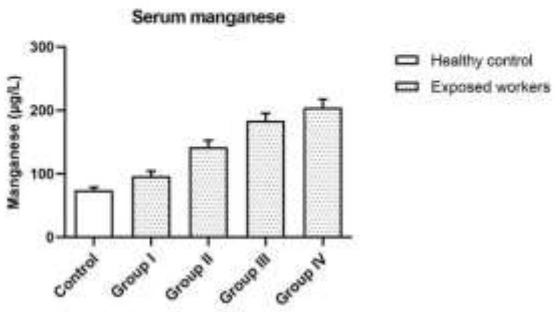

Figure 4: Serum manganese levels measurement in healthy subjects and exposed workers, based on time of exposure to stone dust. Data are expressed as mean ± SD and *P* <0.05.

3.7. Indications of Illness Displayed by the Exposed Workers

The questionnaire revealed that the exposed employees primarily displayed two health complaints, including respiratory and skin conditions, or both. The findings revealed that group I has a low prevalence of respiratory diseases (18.58%), skin diseased (13.23), or both(8.44), compared to group II's high prevalence of respiratory complications (33.25%), skin disorders (22.63%), and both (13.82%). Due to prolonged exposure to stone dust, Group III (38.33% respiratory, 31.64% cutaneous, and 26.78% both) had a significant prevalence of these symptoms (Figure 5). Due to prolonged exposure to stone dust at work, group IV had a higher prevalence of respiratory (49.55%), cutaneous (39.03%), and both (32.72%) symptoms than the other groups. These findings show that exposure to stone dust directly caused respiratory symptoms to be severe in all exposed workers.

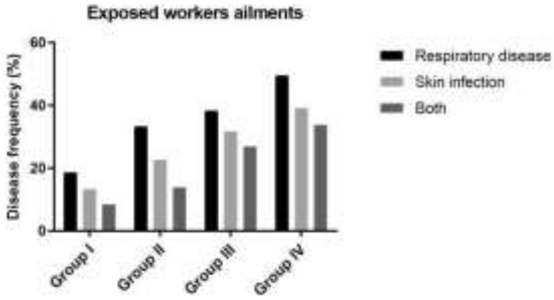

Figure 5: Ailments exhibited by exposed workers in relation to stone dust exposure time

3.8. Risk Factors
Among other risk variables such as a history of smoking, hypertension, unclean drinking water, and other physical ailments, the absence of safety precautions against dust, including a lack of personnel protective equipment, and the length of time of exposure to dust, were the significant risk factors. Therefore, in addition to the length of exposure, the high prevalence of respiratory and skin problems among manual stone dust exposed employees was also a result of inadequate use of PPE such as dust masks, overalls, and eye goggles.

4. Discussion
The country's economy has benefited greatly from the quarry sector, which is a significant source of building construction, a source of tax and royal revenue for the government, and a source of employment possibilities, particularly for rural populations [9, 17]. It is the main source of income for individuals employed in the stone quarrying, crushing, transporting, building, and road construction industries, as well as for those who make their living from these jobs. On the other hand, prolonged worker exposure to stone dust, their interaction with dust and powder materials without any safety protection, and their strenuous physical activity all increase the risk of accidents and injuries. This atmosphere can lead to serious health problems and injuries with long-term effects [18]. This study examined the impact of smoke dust exposure on workers' SGPT, total bilirubin, creatinine, and manganese levels in stone crushing units in KP, Pakistan. The negative consequences of stone dust on exposed employees are a serious concern, especially in developing nations like Pakistan where workers are exposed to high levels of stone dust and lack access to safety precautions. Alanine aminotransferase (ALT) is more specific indicator for liver functions. Elevated level of aminotransferase most commonly occur in acute and chronic hepatitis, hepatic congestion, cirrhosis, and cancer [12, 19]. In the present study elevated level of SGPT were observed in exposed workers, compared to healthy control (Figure 1). The result of Himmerich *et al.* (2001) strongly supported our results indicating that SGPT is more sensitive enzyme to liver injury and their raise level indicate liver stress [20]. It is an important marker of liver dysfuncation and its alterations is directly associated with exposure to various occupational environmental hazards such as stones dust, pesticides, various chemicals in car paintings, and lead among the others. Damaged liver releases SGPT enzymes which later enters blood stream [21-23]. Therefore, blood serves as an important source for SGPT determination. SGPT determination was carried out using blood samples. Our results revealed that stone dust exposed workers had an elevated levels of SGPT than the healthy controls. Our results of increased SGPT levels of exposed workers is supported by recent literature indicating alteration in the SGPT levels in response to various environmental pollutants [22-24]. Occupational hazard exposures play an important role in the acquisition and aggravation of various ailments such as hepatocellular carcinoma and various other complications [25]. Similarly, the mean values of serum total bilirubin of exposed workers were considerably high in exposed workers than healthy control due to hazardous effect of stone dust. Group IV workers (1.7 ± 0.43 mg/dL) have very high total bilirubin value due to longer period of exposure time, shown in Figure 2. Our bilirubin result is in agreement with the findings of a previous study [26]. Their results indicate that total bilirubin in Brazilian workers was high due to their exposure to solvents in car repainting shops. The same findings were also reported

by another group of researchers [27]. They examined higher level of blood total, direct and indirect bilirubin in miners with 10-15 year's exposure. In addition, a recent study evaluated the effects of liver cement dust exposure on selected liver function parameters (AST, ALT and bilirubin) in cement plant workers at Ekpoma, Nigeria. Their results revealed that cement dust smoke markedly ($p< 0.05$) increased and altered the liver function parameters [28]. Similarly another study conducted in Egypt, evaluated the hepatic function parameters in silica exposed workers in clay brick industry. Their results also revealed significantly alterations in the mean levels of liver function tests [29].
Creatinine is a breakdown product removed by the kidney through urine and thus a sanative indicator to examined clearance test of GFR. Generally, the creatinine level is nearly constant but sometime high in case of muscle and kidney damage [12]. Our results showed an elevated level of serum creatinine in exposed workers as compared to healthy control. Among the four subgroups, Group IV (2.31 ± 1.13 mg/dL) showed significant increase due to longer time of exposure to stone dust, shown in Figure 3.

A previous study also reported that paint sprayers with exposure to paint-based hydrocarbons have higher prevalence of elevated serum creatinine than other groups [30]. Our creatinine result showed deviation from a previous study [31]. They reported that there is a significant reduction in serum creatinine level of construction workers due to the presence of toxic metals such as chromium in construction dust.

Like other trace elements, manganese is also an important element in plants and animals and therefore, for proper growth human body need about 3-9 mg manganese. Manganese is present in various part of the body tissue like liver, kidney, pancreas, and most commonly in bones [32]. Ours results showed that the mean value of manganese for exposed worker was significantly higher as compared to healthy control (Figure 4). Our findings concur with research from prior studies that found manganese miners had higher serum concentrations of the elements [27, 33]. The results of marble dust exposure show a direct risk effect on the skin and respiratory health of stone dust exposed personnel. The findings indicated that exposed workers had a higher prevalence of cutaneous and respiratory complaints than the control group. Figure 5 demonstrated that group IV had considerably high prevalence to these symptoms as a result of prolonged exposure to stone dust, whereas group I, II, III, and employees showed higher prevalence of respiratory and skin illness. In addition to the length of exposure, other risk factors that enhance the likelihood that exposed employees would have these symptoms include a history of smoking, a lack of protective gear, and a lack of basic health knowledge. According to a previous study's findings, although dust deposition results in skin and eye problems, inhalation of dust results in major health concerns such respiratory and pulmonary disorders. According to their research, 7.4% of the employees occasionally coughed, 5.2% wheezed, and 6.4% had breathing problems [34].

5. Conclusion

The study's findings led to the conclusion that exposure to the stone crushing industry has a negative impact on workers' health. Stone dust has adverse impacts on employees' health, according to findings of biochemical tests on exposed workers (SGPT, bilirubin, creatinine, and manganese) [30]. Our results revealed that stone dust exposure seriously impaired the liver and kidney's normal functions, as seen by the exposed workers' high levels of SGPT, bilirubin, creatinine, and manganese. From the results, it was concluded that stone crushing industries produces adverse effects on health status of exposed workers. Biochemical test (SGPT, bilirubin, creatinine and manganese) results of exposed workers revealed that stone dust have hazard effects on workers' health. High SGPT, bilirubin, creatinine, and manganese levels of exposed workers indicated that stone dust severely affect the normal functions of liver and kidney.

According to the questionnaire data collected, exposed employees had considerably higher rates of respiratory and skin infections than healthy controls, which may be related to prolonged exposure to stone dust, smoking history, a lack of protective equipment, and a lack of fundamental health awareness. Based on the results of the current study, occupational health hazards regulation authorities should take immediate action to increase public knowledge of the problem and inform employees of the value of wearing personal protective equipment. The outcomes would aid in increasing awareness of the problem. Last but not least, it would increase awareness of the altered liver and kidney function parameters and other related health issues that affect workers in Pakistan's stone crushing industries. This would then help the government to develop policies for the prevention, control, and elimination of stone dust exposure and the related health consequences, improving public health policy and practices throughout the nation. To the best of our knowledge, this is the first report from the region highlighting the deleterious impact of stone dust onto the liver and kidney function parameters of marble crushing workers. Studies comprising of larger sample size across the country should be conducted for the bigger picture of liver and kidney function parameters of marble crushing workers.

Institutional Review Board Statement: The present study was approved by the Institutional Review Board of Abdul Wali Khan University Mardan, Pakistan according to Helsinki's declaration 2013.

Informed Consent Statement: Informed consent was obtained from all the participating members.

Conflict of Interest: The Authors declare no conflict of interest.

Data Availability Statement: All the data is contained within the manuscript.

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