

OCCUPATIONAL EXPOSURE OF FOOTWEAR ROUGHING DUST DURING FOOTWEAR MANUFACTURING PROCESS

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ABSTRACT. Footwear roughing dust (FRD) is generated from roughing operations involved in footwear manufacturing. The dust is created by the friction of emery paper against the grain surface of finished leather. FRD coming from finished leather is likely to contain chromium, which is widely used for leather processing. Generally, chromium is found in two forms in the leather industry, namely Cr (III) and Cr (VI), of which the latter has an evident and adverse effect on human health. This study aims to identify the major effects of FRD on workers' health and to find out the correlation with the factors influencing those adverse health effects. In this study, a survey among 30 roughing operators from eight footwear factories in Bangladesh was conducted. The major health effects of FRD are eye irritation, skin itching, chest pain, coughing, and fatigue. This study constructed three hypotheses to investigate whether human health is affected by FRD with working experience, the age of workers, and the use of personal protective equipment (PPE). The results showed that working experience and use of PPE have distinct influences on the health effects caused by FRD, whereas workers' age has no impact on their health effects. Finally, some recommendations are formulated to prevent or mitigate workers' adverse health effects in order to ensure a better working environment in the footwear industry.

KEY WORDS: footwear roughing dust, health safety, occupational exposure, personal protective equipment

EXPUNEREA OCUPAȚIONALĂ LA PRAFUL REZULTAT ÎN URMA ȘLEFUIRII PIELII ÎN PROCESUL DE FABRICARE A ÎNCĂLȚĂMINTEI

REZUMAT. Praful rezultat în urma șlefuirii încălțămintei derivă din operațiunile de șlefuire prezente în procesul de fabricare a încălțămintei. Praful este generat de frecarea hârtiei abrazive pe suprafața granulată a pielii finisate. Praful rezultat din șlefuirea pielii finite este foarte probabil să conțină crom, care este utilizat pe scară largă în prelucrarea pielii. În general, cromul se regăsește în industria de pielărie sub două forme, și anume, Cr (III) și Cr (VI), cel din urmă având un efect evident și negativ asupra sănătății umane. Acest studiu își propune să identifice efectele majore ale prafului de la șlefuire asupra sănătății lucrătorilor și să găsească o corelație cu factorii care influențează aceste efecte adverse asupra sănătății. În acest studiu, s-a efectuat un sondaj în rândul a 30 de lucrători din opt fabrici de încălțămintă din Bangladesh. Efectele majore asupra sănătății ale prafului de la șlefuire sunt iritația ochilor, mâncărimea pielii, durerea în piept, tusea și oboseala. În acest studiu s-au construit trei ipoteze pentru a investiga dacă sănătatea umană este afectată de prafului de la șlefuire, și anume experiența de lucru, vârsta lucrătorilor și utilizarea echipamentului individual de protecție (EIP). Rezultatele au arătat că experiența de lucru și utilizarea EIP au influențe distincte asupra efectelor cauzate de praful de la șlefuire asupra sănătății, în timp ce vârsta lucrătorilor nu are niciun impact asupra acestor efecte. În cele din urmă, s-au formulat câteva recomandări pentru a preveni sau atenua efectele adverse asupra sănătății lucrătorilor în vederea asigurării unui mediu de lucru mai bun în industria de încălțămintă.

CUVINTE CHEIE: praf de la șlefuirea încălțămintei, securitate și sănătate, expunerea la locul de muncă, echipament individual de protecție

EXPOSITION PROFESSIONNELLE À LA POUSSIÈRE RÉSULTANT DU POLISSAGE DU CUIR DANS LE PROCESSUS DE FABRICATION DE CHAUSSURES

RÉSUMÉ. La poussière résultant du polissage des chaussures provient des opérations de polissage présentes dans le processus de fabrication des chaussures. La poussière est générée par le frottement du papier abrasif sur la surface granuleuse du cuir fini. La poussière issue du polissage du cuir fini contient très probablement du chrome, largement utilisé dans le traitement du cuir. Le chrome se trouve généralement dans l'industrie du cuir sous deux formes, à savoir Cr (III) et Cr (VI), ce dernier ayant un effet évident et négatif sur la santé humaine. Cette étude vise à identifier les principaux effets de la poussière sur la santé des travailleurs et à trouver une corrélation avec les facteurs influençant ces effets néfastes sur la santé. Dans cette étude, une enquête a été menée auprès de 30 travailleurs de huit usines de chaussures au Bangladesh. Les principaux effets sur la santé de la poussière résultant du polissage sont l'irritation des yeux, les démangeaisons cutanées, les douleurs thoraciques, la toux et la fatigue. Dans cette étude, trois hypothèses ont été construites pour déterminer si la poussière affecte la santé humaine, à savoir l'expérience de travail, l'âge des travailleurs et l'utilisation d'équipements de protection individuelle (EPI). Les résultats ont montré que l'expérience professionnelle et l'utilisation d'EPI ont des influences distinctes sur les effets sur la santé de la poussière, alors que l'âge du travailleur n'a aucun impact sur ces effets. Enfin, certaines recommandations sont formulées pour prévenir ou atténuer les effets néfastes sur la santé des travailleurs afin d'assurer un meilleur environnement de travail dans l'industrie de la chaussure.

MOTS CLÉS : poussière résultant du polissage des chaussures, sécurité et santé, exposition professionnelle, équipement de protection individuelle

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INTRODUCTION

Roughing is regarded as one of the major and critical operations in the lasting department of any footwear manufacturing unit. In order to attach the upper to the corresponding sole, it is necessary to 'scrape' a thin layer of material off the upper surface so that glue can penetrate the leather and adhere properly, which is called 'roughing' [1]. This task contributes to producing leather and sole material fibres, dust, or small scraps, which represent 5–15% (w/w) of the solid wastes generated by shoe-making companies [2]. A major portion of these dusts are big particles (greater than 50 μm) [3], which are collected by a dust collector attached to a roughening machine (a bag where dusts are collected from the air by using the extractor hood with a cyclone system). However, a significant portion of small or tiny particles (<1 μm to 13 μm) [4, 5] of these dusts spread out during roughing and affect the surrounding workers. A study found that concentrations of these airborne particles may vary from 0.07 to 1.01 mg/m^3 , and the amount of insoluble and hexavalent chromium may vary from 0.10-0.32 and 0.01-0.0811 g/m^3 , respectively [6]. To manage this solid waste, the FRD is conventionally dumped in the open environment for landfilling purposes [2], which results in an unpleasant odour and severe impact on the environment due to the leaching of chromium ions and the generation of toxic emissions including nitric oxide [7]. Some of the roughing dusts are incinerated [8], which may create hexavalent chromium through an oxidation process [9]. This hexavalent chromium causes an increased risk of bone, prostate, lymphomas, Hodgkin's, leukaemia, stomach, genital, renal, and bladder cancers in the human body once taken up [10]. Therefore, the dust particles generated from leather can cause several health hazards like cancer, respiratory diseases, and central nervous system abnormalities once they are entered into the human body through any route of exposure [7]. However, the nature and magnitude of these effects may vary from factory to factory and person to person depending on various factors such as working experience, age and use of

Personal Protective Equipment (PPE), frequency of personnel exposed, contact time, route of exposure, immune system of the host, etc. Against this backdrop, this study was conducted on the identification of associated factors of health hazards emanating from the FRD. It also aimed to find out the possible adverse effects of FRD on human health and test several hypotheses regarding health hazards related to FRD. Also, this study proposes several recommendations that should be followed to alleviate the adverse health impacts brought by the FRD. In this line, this study sets the following objectives:

- i. To identify the major effects of FRD on workers' health.
- ii. To identify the factors that influence adverse health effects emanating from the FRD.
- iii. To propose necessary recommendations to prevent or mitigate the adverse health effects caused by the FRD.

EXPERIMENTAL

Materials and Methods

This is a survey work that aims to explore the influencing factors for adverse health effects on the workers of the footwear lasting department in Bangladesh. This study took 30 workers as a sample, both for the experimental and control groups. As the survey was conducted during the COVID-19 pandemic and the minimum sample size of 30 confirms normal distribution in statistics [11], this study took 30 respondents as the sample. The experimental group was composed of 30 roughing operators (28 males and 2 females) selected from the lasting department. The age range of the participants was from 19 to 35 years, and the working experience was from 3 to 17 years. On the other hand, the control group was formed with 30 workers (28 males and 2 females) from random working sections (e.g., cutting and sewing department, human resource department (HR), management department, marketing department, merchandising department, etc.) except the lasting department, with the same age range and working experience as the experimental

group. This study followed a purposive sampling technique to select footwear factories, and a simple random sampling technique was followed to select respondents. A total of eight footwear factories were selected purposively from the Dhaka and Chittagong divisions. The sampling technique is illustrated in Figure 1. A survey questionnaire was developed to collect data from the respondents. The duration of data collection was from November 1, 2021, to November 27, 2021. Face-to-face interviews were conducted

to collect primary data from the selected factories. In order to validate the responses of the respondents regarding their health effects, this study formed an expert panel of four members, consisting of two medical officers and two industrial experts. The model of the used roughing machine in the footwear factories was a Volber 152. For the data analysis, appropriate graphical analysis was conducted to find out the health effects on workers due to FRD. Using STATA software, a T-test is carried out for the hypothesis test.

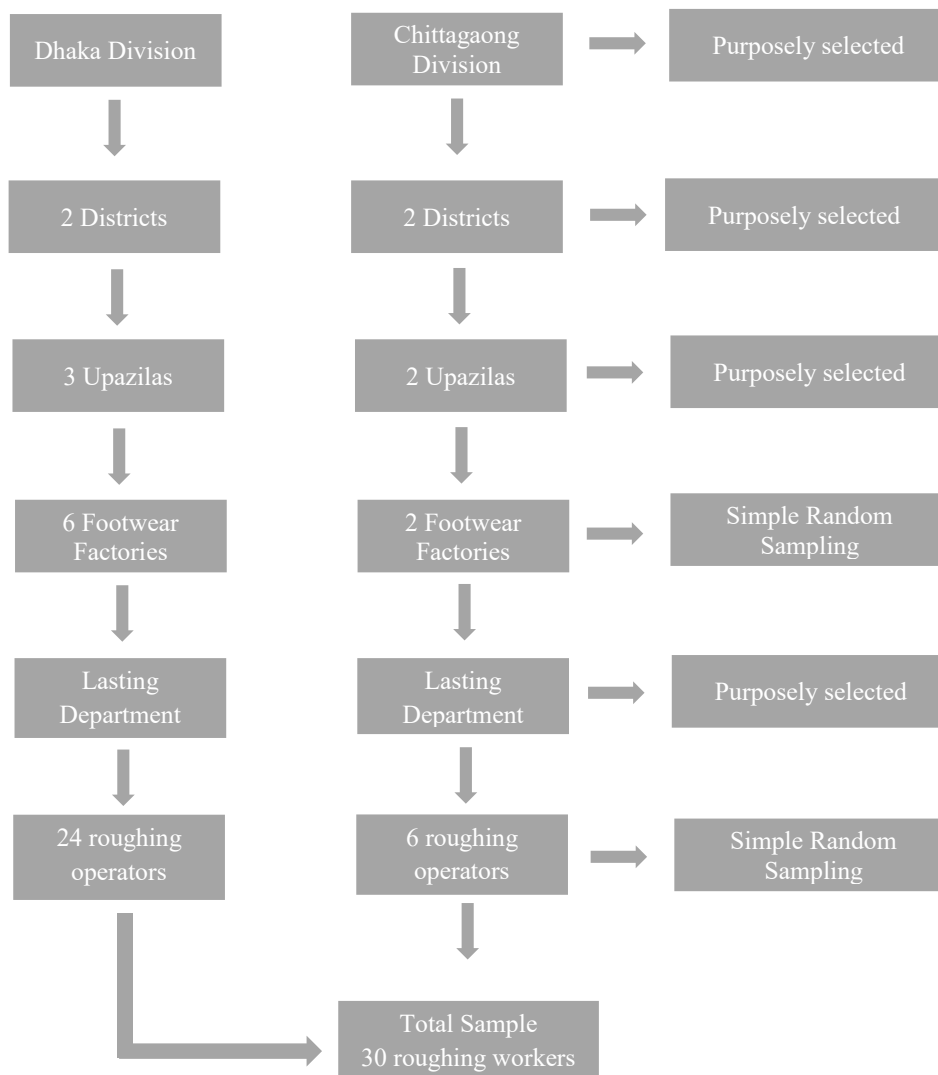


Figure 1. Schematic diagram of sampling technique

For data analysis, three Hypotheses were formulated in this study as follows:

Hypothesis 1: The working experience of the roughing operator influences the health effects caused by footwear roughing dust.

Hypothesis 2: The age of the roughing operator influences the health effects caused by footwear roughing dust.

Hypothesis 3: Awareness of using Personal Protective Equipment (PPE)

influences the health effects caused by footwear roughing dust.

For testing hypothesis 1, roughing operators are divided into two groups: Group 1: Working experience is up to 5 years, and Group 2: Working experience is more than 5 years. For testing hypothesis 2, roughing operators are divided into two groups: Group 1: Age is up to 25 years, and Group 2: Age is more than 25 years. On the other hand, for testing hypothesis 3, roughing operators are divided into two groups: Group 1: Operators who have the awareness of using PPE; and Group 2: Operators who do not have the awareness of using PPE. A paired sample T-test was carried out between Group 1 and Group 2 using STATA software.

RESULTS AND DISCUSSION

This study mainly focused on finding out the possible health hazards of the 30-roughing

operators from 8 footwear manufacturing units due to FRD exposure. The health effects on the participants of the selected footwear units are illustrated in Figure 2. In total, 10 health related issues were identified from the survey among roughing operators. Some of them are major, and some can be considered minor based on their intensity in the collected survey data. From the bar chart below, the major health effects in correlation to exposure to FRD are eye irritation, skin itching, chest pain, coughing, and fatigue, which were experienced by 90%, 83%, 53%, 33%, and 33% of the total respondents, respectively. Other minor health problems faced by workers in these 8 factories are hair itching, breathing problems, dizziness, hair hardening, and insomnia. Although all workers in the experimental group were involved with the same type of operation for 8 hours per day, they did not experience the same degree of health effects created by the FRD.

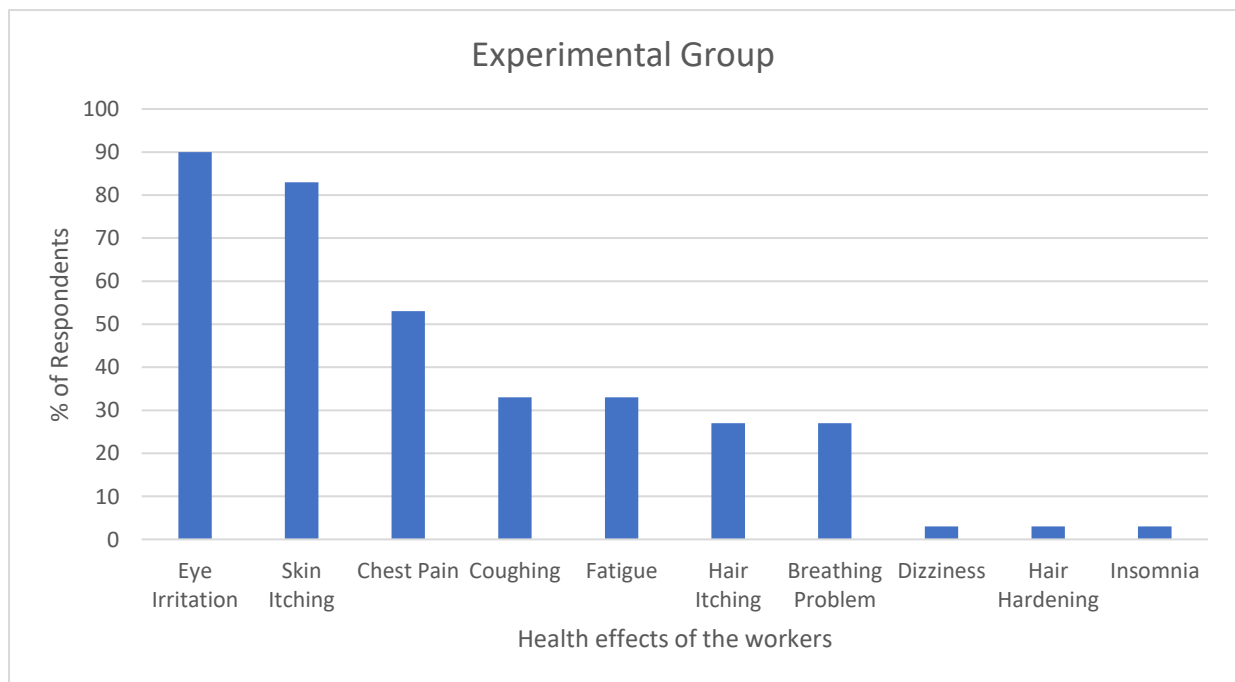


Figure 2. Different health effects and their intensity among the respondents caused by FRD (Experimental group)

On the other hand, only 13.33% of respondents in the control group reported that they experienced skin itching problems. The

remaining 86.67% of respondents did not experience any health-related issues, as shown in Figure 3.

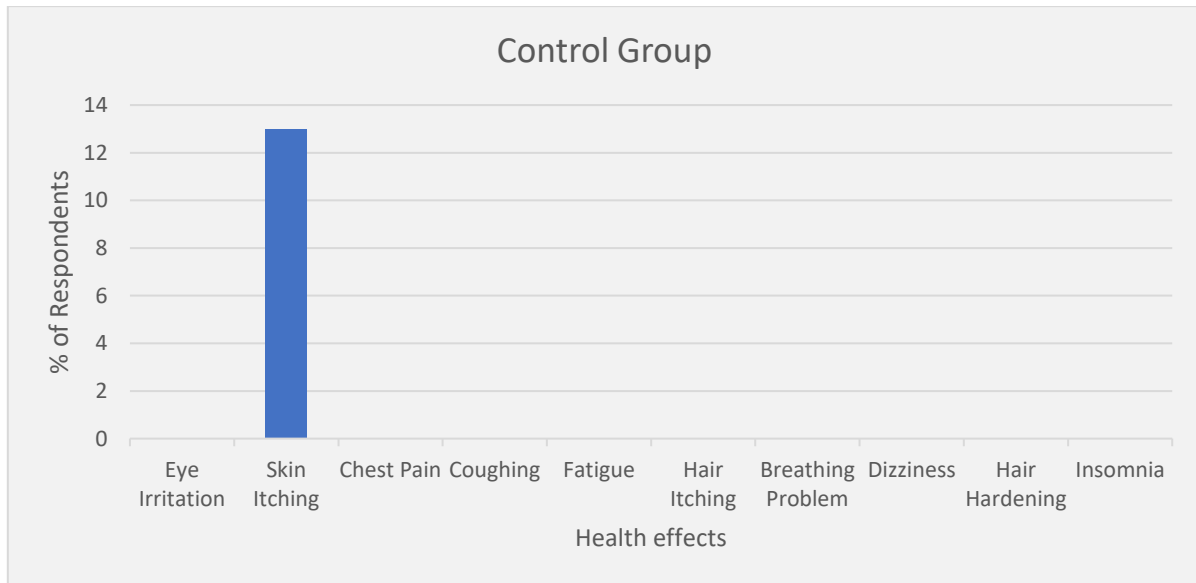


Figure 3. Different health effects and their intensity among the respondents (control group)

From the findings between the control and experimental groups, it can be concluded that a roughing operator is more likely to be

affected by the FRD than workers in other departments.

Table 1: Testing hypothesis between working experience and health effects

	Obs.	Mean1	Mean2	Dif.	St Err	t value	p value
Group 1 – Group 2	13	4	5.231	-1.231	.612	-2	.067

Table 2: Testing hypothesis between workers' age and health effects

	Obs.	Mean1	Mean2	Dif.	St Err	t value	p value
Group 1 – Group 2	14	4.072	4.643	-.571	.542	-1.05	.311

Table 3: Testing hypothesis between awareness of using PPE and health effects

	Obs.	Mean1	Mean2	Dif.	St Err	t value	p value
Group 1 – Group 2	14	3.143	5.500	-2.357	.52	-4.55	.001

The results of hypothesis test 1, 2, and 3 are provided in Tables 1, 2, and 3, respectively. Here, the t value is -2. As $|t| > 1.96$, there is a significant difference between Group 1 and Group 2. So, the null hypothesis is rejected. Therefore, highly experienced operators have a higher chance of being affected by roughing dust as their exposure time to this dust is higher. Table 2 shows that the t value is -1.05. As $|t| < 1.96$, there is no significant difference between Group 1 and Group 2 for Hypothesis 2. So the null hypothesis is accepted. Therefore, the operator's age does not influence the health effects caused by roughing dust. Alternatively, Table 3 shows that the t value is -4.55. As $|t| > 1.96$, there is a significant difference between Group 1 and

Group 2 for Hypothesis 3. So the null hypothesis is rejected in this regard. Therefore, operators who are aware of using Personal Protective Equipment (PPE) are less likely to be affected by roughing dust.

Generally, necessary personal protective equipment (gloves, safety glasses, shoes, earplugs or muffs, hard hats, respirators, coveralls, vests, and full body suits) is provided to the workers by the authority in order to ensure primary safety. However, this study found only 3% of roughing operators were aware of using this PPE during their working hours. As a result, workers' clothes, hair, and other uncovered parts of the body easily get involved with the dust particles. This practice enables the workers to absorb smaller dust

particles through their eyes and skin. Since workers are not concerned about wearing safety gloves, their palms are found to have scars, rough and dusty in appearance, which may lead to several skin diseases. In addition, more than 80% of the respondents in the experimental group were seen taking foods without cleaning their hands properly, which allows the FRD to reach up to the metabolic organ systems and eventually cause severe health issues. Besides, due to not being aware of wearing safety masks, a distinct inhalation of FRD takes place among the roughing operators, which ultimately causes the breakdown of the effectiveness of the respiratory system of any worker of any age, according to the medical officers. This opinion is relevant to the findings of the second hypothesis, i.e., operator age does not influence the health effects caused by roughing dust. Overall, a common scenario of continuous inhalation and ingestion of the FRD was observed among the workers of all the 8 footwear manufacturing units during the entire study, which is related to fragile and poor health conditions.

According to the expert panel, roughing operators are not able to realize the adverse effects created by roughing dust on their health. Sometimes they are affected by some of those adverse effects, but they do not take them seriously. Even they cannot express it properly, whether they are facing any problems or not. The workers possess a higher chance of suffering from permanent health complications (e.g., skin diseases, various lung diseases like asthma, chronic bronchitis, decreased efficiency, fragile health, etc.) in respect of having a longer period of work experience in the lasting department, which leads to their low life expectancy. This opinion supports the finding of the first hypothesis of this study, i.e., that highly experienced operators have a higher chance of being affected by roughing dust as their exposure time to this dust is higher. The expert panel also stated that most of the roughing operators do not have enough knowledge of Occupational Health and Safety (OHS). Similarly, the authorities of the respective plant are not strict in adopting this safety manner over the workers. To conclude, they suggested using personal protective

equipment (PPE), which may control the rate of adverse effects on health associated with the findings of the third hypothesis of this study.

Some recommendations are made in this study to prevent or reduce the adverse effects on workers' health caused by FRD. The opinions of the expert panel are also considered in making these recommendations. The following recommendations are made, both for workers and the industry:

1. Occupation-based personal protective equipment (PPE) should be used by the roughing operators during roughing machine operation. For example, hand gloves to protect the palm of the hand from the roughing dust, an apron to protect the body from the roughing dust, safety goggles to protect the eye from the roughing dust, a hairband to protect the hair, an earplug to protect from the noise of the machine, and finally, an appropriate mask to protect the respiratory organs from entering the roughing dust should be practiced.
2. Hands, mouth, and nose should be washed properly after finishing the job. During working hours, compressed air can be used frequently to clean the dirty parts of the body.
3. Job rotation or rest can be introduced among roughing operators during working hours to reduce work fatigue.
4. Access to safe drinking water should be ensured by the practitioners of the footwear industry. Meanwhile, the habit of drinking adequate water should be developed among the roughing operators. However, before drinking water, one must rinse the mouth with gargling.
5. Fluorides, povidone iodine, and endodontic chemicals containing mouthwash, toothpaste, and prophylactic gels should not be used by the roughing operators. Fluorides, povidone iodine, and endodontic chemicals are strong oxidants, and they easily oxidize Chromium Cr (III) to Chromium Cr (VI), which is more toxic and carcinogenic to human health.
6. A periodic awareness campaign for ensuring the occupational health and

safety of workers should be conducted by the top management of the footwear factory.

7. Strict and regular monitoring should be carried out by the concerned authority of the footwear factory to ensure workers health and safety. Rewards and recognition for obedient workers can also be introduced.

In general, the common scenario in the footwear industry represents that occupational health and safety (OHS) rules are not properly maintained in the leather and footwear industries in Bangladesh, which is responsible for causing injuries, accidents, and workers' adverse health effects [12]. A study conducted by Deb *et al.* found adverse health effects among the 400 workers of 20 footwear factories, where frequent headache (41.5%), stomachache (18.5%), eye problems (11%), and pain in joints (9.5%) were the most reported problems by the respondents [13]. In this study, respiratory problems, skin irritation, coughing, and ear problems were also found at a noticeable level.

CONCLUSION

Roughing is a critical and sensitive operation in the lasting department of any footwear manufacturing unit. This operation should be carried out with proper care, as faulty roughing may occur, which increases the defect rate and reduces the quality of the footwear. Although modern roughing machines have a dust collector and some particles are large in size, a significant portion of the roughing dust spreads out around the rotating wheel of the machine and affects the roughing operator's health. The aims of this study were to figure out the potential health effects on roughing workers due to exposure to FRD and to identify the factors that influence the potential health effects. In this regard, the total respondents were divided into two groups: the control group, which was composed of 30 workers from random working sections other than lasting, and the experimental group, which was consisted of 30 roughing operators from only lasting department. This research was carried out with the assistance of an expert panel consisting of

four members, including two medical officers and two industry experts, in order to validate the responses of the respondents. This study found several adverse health effects, such as eye irritation, skin itching, chest pain, coughing, fatigue, hair itching, breathing problems, dizziness, hair hardening, and insomnia, that were experienced by the respondents in the experimental group. Based on the information obtained from hypothesis analysis, the degree of the impact on workers' health varies depending on working experience and use of Personal Protective Equipment (PPE) whereas workers' age has no influence on the degree of health effects. Apart from that, maximum workers were found having not even a minimum knowledge about the basic safety and hygiene manner, for example, they were unwary of cleaning their hands during taking food inside the manufacturing plant. In order to mitigate the potential adverse effect, using necessary protective equipment, a periodical awareness campaign, work rotation, and active monitoring are strongly recommended. However, this study has some limitations. The emission of roughing dust may vary depending on a few factors, for example: type of upper materials (e.g., leather, synthetic, polymer, etc.) and types of footwear (e.g., Oxford, Derby, Moccasin, Casual, Boot, Sandal, Court Shoe, etc.), which were not considered in this study. Also, only 30 roughing operators from eight footwear factories were considered for the survey, which could be extended in any future study. A future study can be carried out to find out the impact of volatile organic compounds on human health utilized in the production of footwear.

Conflicts of Interest

The authors declare no conflict of interest.

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