Research Paper

Evaluating Critical Safety and Health Risks by Job Safety Analysis and Analytic Hierarchy Process in Industrial Printing

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ABSTRACT

Background: Critical risks are one of the most important problems in industries, which have high costs for the industry. This study aimed to assess critical safety and health risks through job safety analysis and analytic hierarchy process in industrial printing.

Materials and Methods: The present study was conducted as a descriptive and analytical in one of the printing industries in Iran, in 2020. Critical risks were collected by visiting and observing the job safety analysis checklist. Then, critical risk prioritization was performed by an analytic hierarchy process using Expert Choice software, version 11.

Results: A total of 23 hazards were identified. Mechanical hazards (61%) and chemical hazards (9%) had the highest and lowest frequencies, respectively. The identified safety and health hazards included musculoskeletal disorders (MSDs) in the upper and lower back, respiratory and skin exposure to chemicals, the risk of electric shock, and mechanical hazards (hand entrapment, hand amputation, and falling objects).

Conclusion: The highest priority of critical risk was related to MSDs of the upper and lower back. The next priority of critical risk was related to chemical agents, respiratory exposure to organic solvents, and dermal exposure to organic solvents.

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1. Introduction

An important topic of problem in various industries is work-related accidents, which have high costs for the industry [1]. To prevent accidents, it is necessary to identify all the various critical risks in the work process, and then control them with proper evaluation [2]. One of the indicators to evaluate the performance of an industry is the number and severity of accidents in that industry [3]. Identifying critical risks and providing control measures are important in reducing accident costs and increasing system efficiency. Reducing work-related injuries and illnesses, creating effective and efficient ways of doing work, reducing compensation costs, and increasing worker productivity are among the benefits of critical risk management [4].

One of the methods of accurate and systematic study to identify the potential risks of each job is the job safety analysis (JSA) method, which is recommended in the operation phase to identify and analyze the risks [5]. This method is implemented with minimal equipment and financial resources and only with a careful study based on the ability of the assessment team and the experience of the interviewees (workers and operators). All people, both managers, and workers benefit from the results in proportion to their information which will increase employees' understanding of the level of risk and will have a positive effect on their behavior [6]. As a result, it will reduce critical safety and health risks [7]. OSHA recommends that by performing proper occupational safety analysis, many accidents and diseases can be prevented, and finally, the necessary measures of engineering control, training, personal protection, and executive instructions can be determined [8].

Studies show that analytic hierarchy process (AHP) hierarchical analysis is the most popular and widely used method among various multifunctional decision-making methods [9]. This method calculates the prioritization of options by considering different weighting criteria and is used for problems with more than one decision criterion. In some studies, this method has been used to analyze risk factors affecting the occurrence of accidents, safety management, and risk assessment. AHP hierarchical analysis method is used to identify and prioritize safety risk factors affecting the occurrence of accidents [10].

Understanding the causes of occupational accidents and prioritizing them is helpful in risk management and prevention. This method was developed by the clock in 1970 to solve problems caused by complex decisions with a relatively simple method [11]. One of the most important industries in the country is the printing industry. The printing industry is 13% and the book printing and binding industry is 40% of the total industry [12]. Cleaning and preparing the printing machine, embedding the paper, removing the printing machine jam, maintaining the machines and supervising the printing process, moving the printed paper, cutting the paper, and binding are among the important tasks defined in the printing industry that usually involve difficult situations and cause unsafe situations and behaviors. The rate of accidents and occupational diseases in the printing industry depends on the final product. Workers in this industry are exposed to extensive mechanical, ergonomic, physical, and chemical hazards [13]. Therefore, this study aimed to assess critical safety and health risks through JSA and AHP in industrial printing.

2. Materials and Methods

The present descriptive and analytical was conducted in one of the printing industries in Iran, in 2020. Because JSA had to be performed by a team, the executive team consisted of a researcher, an occupational health officer, a workshop supervisor, and an operator.

Information was collected by visiting, observing, and completing an occupational safety analysis checklist. Then, the steps of the work were determined and the hazards (ergonomic, mechanical, physical, and chemical) existing or potentially related to each step were identified and determined [5-7]. Critical health and safety risks were considered for tasks that are a real threat in which decision-making and action to correct that situation are necessary.

To correctly prioritize the identified critical risks, the probability and severity criteria were first determined. In the next step, the importance of each of these criteria was determined, which was done by pairwise comparison of criteria. Finally, critical safety and health risks were prioritized using the AHP method using Expert Choice software, version 11 [9-11].

In this method, in each pairwise comparison of critical health and safety risks according to the personal judgments of decision-makers and experts, a number from 1 to 9 is assigned, and the meaning of each number is given in Table 1. These comparisons were made once based on the intensity criterion and the next time based on the probability criterion.

Relative weights are obtained from paired comparison matrices, while the absolute final weight of each option is obtained by combining relative weights.

One of the advantages of the hierarchical analysis process is the possibility of examining the consistency of the judgments made in determining the coefficient of the importance of the criteria.

For this purpose, a coefficient called the compatibility coefficient is considered, which is obtained by dividing the compatibility index by the randomness index.

If this coefficient is less than or equal to 0.1, consistency in the judgments is acceptable; otherwise, the judgments should be revised.

The index of randomness is RI can be extracted from Table 2 according to the number of criteria.

3. Results

Study units included design, lithography, cutting, offset printing, coating, bonding, packaging, and warehousing.

Identified tasks include four-color two-sheet offset user, one-color two-sheet offset user, one-color offset user, two-color two-sheet offset user, propeller user, letterpress user, cutting user, thermal and manual cellophane user, user Envelopes, adhesive box user, punch user, sewing machine user, carrier user, and warehouse load were.

A total of 23 hazards were identified.

The results of Figure 1 showed that mechanical hazards (61%) and chemical hazards (9%) had the highest and lowest frequencies, respectively.

The highest priority of critical risk related to upper musculoskeletal disorders (MSDs) was related to bookbinding and cutting tasks and MSDs in the lumbar region and manual loading.

Injuries to the back and back of the printing industry are common. In warehouses, it is typically caused by improper lifting, stretching, and twisting.

The next priority of critical risk was related to chemical agents, respiratory exposure to organic solvents, and dermal exposure to organic solvents.

The chemicals used include a type of detergent used to wash the machine.

Oil is used to wash the whole car or certain parts that need to be cleaned, and gasoline is used to wash the rollers, gaskets, and rubber parts of the car. Ink or paint is poured into the device tank.

Table 1. Preference values for pairwise comparisons

Score	Definition	Explanation
1	Equally preferred	In achieving the goal, two indicators are equally important.
3	Moderately preferred	Experience shows that i is slightly more important than j to achieve the goal.
5	Strongly preferred	Experience shows that i is more important than j to achieve the goal.
7	Very Strongly preferred	Experience shows that i is much more important than j to achieve the goal.
9	Extremely preferred	The importance of i over j has definitely been proven.
2, 4, 6, 8	Intermediate values	When there is a middle mode.

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Table 2. Calculation of randomness index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.45

RI: Randomness index

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All steps of the AHP are implemented by Expert Choice software.

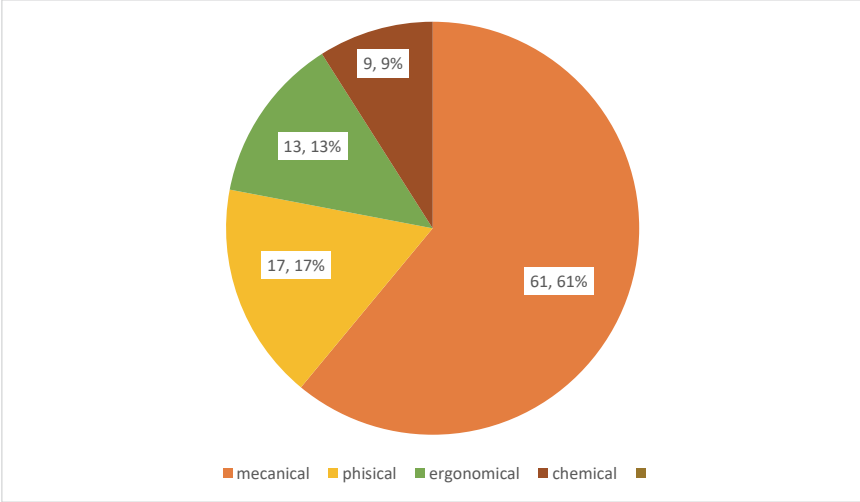

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Figure 1. Percentage of identified hazards

Water, alcohol, and hydrophilic are used in the tank for roller machines such as offset printing to wash and facilitate the rolling process, and the presence of benzene, toluene, ethyl-benzene, and xylene compounds due to the lithographic unit of the offset machine.

The most important sources of sound production are propellers, liter presses, two-color two-sheet offset, and monochrome two-sheet offset.

Table 3. Prioritized critical task risks based on expert choice software

Row	Safety and Health Hazards Identified	Proposed Control	Weight
1	MSDs in the upper region	Adjust the height of the work surface	0.133
2	MSDs in the lumbar region, lifting and carrying a load manually	- Use a cart - Carry two people	0.132
3	Respiratory exposure to organic solvents	Local ventilation	0.116
4	Skin exposure to organic solvents	Use gloves	0.115
5	Risk of electric shock by contact with the device	- Keeping dry around the device - Use electrical insulating shoes and gloves - If possible use insulated underfoot in the presence of the operator. Check the earth's system	0.091
6	Stuck finger in the paper guide (offset printing)	- Observe the appropriate distance with the paper guide section - Complete training to work with the machine to the worker	0.088
7	The stuck hand between rollers (offset printing)	Ensure that the machine is off during lubrication and repair - Use a guard that prevents the chlorinator from getting into the rollers - Training with the device	0.088
8	The hazard of getting your hands stuck between the paper guide plate and the female edge (locust)	- Installation of the electronic eye to prevent the occurrence of an accident when the worker has his hand between the paper guide and the edge of the woman - Complete training to work with the machine - Ensure that the machine is off during repair	0.079
9	Hand cuts caused by contact with the edges of paper and cardboard	Use of personal protective equipment and assistive devices	0.079
10	The paper falls off the machine (propeller and cutter)	Insert the amount of paper that the machine can withstand	0.079

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According to the available documents, the sound level range was at least 68 decibels and at most 80 decibels at the sound pressure level in the measuring stations, which is within the allowable limit.

Examination of the documentation related to light evaluation and thermal stresses showed the appropriate limit of the conditions.

The steps of offset printing include turning on the machine, removing the paper from the pallet and placing it in the paper tray in the machine, removing and folding the edge of the zinc and placing the zinc in the zinc roller, washing the ink with gasoline and oil and putting the paint in the ink, cleaning or washing the special washer and rubber roller with gasoline and removing the printed product and placing it on the pallet, which at every step is accompanied by hazards such as electric shock, improper posture, sticking and cutting off fingers, slipping, and exposure to chemical vapors.

Also, the steps of working with the letterpress press include turning on the letterpress machine, removing the paper from the pallet and placing the paper on the work table, pressing to bend the paper by hand to prevent machine error, and placing the paper on the tray. This is accompanied by the hazards of electric shock, noise, wrist flexion, improper posture, direct skin contact with mechanical damage, stuck fingers, and pressing on the rotating rollers (Table 3).

4. Discussion

This study shows mechanical hazards and chemical hazards had the highest and lowest frequencies, respectively. The identified safety and health hazards included MSDs in the upper and lower back, respiratory and skin exposure to chemicals, the risk of electric shock, and mechanical hazards (hand entrapment, hand amputation, and falling objects).

MSDs of the upper region were related to bookbinding and cutting tasks and MSDs of the lumbar region were related to manual lifting and carrying. Injuries to the back in the printing industry are common [14].

In line with the present study, in the study of assessing the risk factors for MSDs using the LUBA and RULA methods and comparing the results obtained by Khandan et al., the results of physical condition assessment in both methods showed that the printing industry workers put a lot of pressure feel at their elbows and shoulders. The results of this study showed that corrective action in manual binding, shearing, and cutting tasks should be given priority. According to the evaluations, the development and implementation of training programs to improve ergonomic behaviors and modify the method of work are recommended [15].

Also, in another study conducted by Khandan et al., the validation of the postural load assessment method on the upper body in the printing industry showed that problems in the lower back with a prevalence of 35.1% had the highest rate, which is consistent with the results of this study.

The next case was respiratory and skin exposure to chemical agents. The chemicals used include detergents, oils, gasoline, inks, paints, and solvents that are used for a variety of purposes [16].

These results are consistent with a study by Rostami et al. on exposure to BTEX concentrations and the assessment of related health risks in print and copy centers. The results showed a significant concentration of BTEX in PCCs. However, the concentrations obtained were below the limit for the workplace and above the allowance of the Environmental Protection Agency (EPA) and the World Health Organization (WHO). The concentration of BTEX in the workshop environment depends on the amount and quality of ventilation and the type of device [17].

A study by Zendehdel et al. on local impact risk assessment for printing press operators in selected industries was conducted using the RISK OF DERM method. According to the risk statements, the inherent toxicity of the thinner in creating local effects was determined as moderate. The actual hand exposure rate score for the hand was determined to be high and the activity time with thinner is 0.4-1 hour per day. The risk of local effects was determined in 75% of the subjects with grade 6. Due to the high skin exposure to thinners, reducing contact with dermal printing operators has a significant effect on reducing the risk of local effects. It was suggested that printing machine operators wear gloves when operating [18].

To control or reduce the risks of ergonomics, measures such as teaching ergonomic principles to employees, double cargo handling, and observing the principles of manual cargo handling can be useful. It is also recommended to use a mask for chemical hazards and to install general and local ventilation.

In the case of the risk of electric shock, such hazards can be controlled by measures such as keeping the device dry around, checking the ground system, using electrical insulation shoes and gloves, and if possible, using insulated footrests in the operator's presence.

5. Conclusion

A total of 23 hazards were identified. Mechanical hazards (61%) and chemical hazards (9%) had the highest and lowest frequencies, respectively. The highest priority of critical risk was related to MSDs of the upper and lower back. The next priority of critical risk was related to chemical agents, respiratory exposure to organic solvents, and dermal exposure to organic solvents.

To improve the conditions of the working environment in terms of critical safety and health risks, improving general and local ventilation, creating a suitable and natural work posture, avoiding excessive force, easy access to tools and equipment, the appropriate height of the work, reducing repetitive tasks and movements, reducing fatigue and static load, reducing the pressure on the organ or tissue, sufficient extra space, regular exercise, and physical exercises are recommended.

Ethical Considerations

Compliance with ethical guidelines

This article was approved by the Student Research Committee, School of Health, Ardabil University of Medical Sciences (Code: IR.ARUMS.REC.1399.144.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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