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Risk analysis of chemical and mechanical hazards in a medical center of Pakistan

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Abstract

Risk evaluation of chemical and mechanical hazards was done in a medical institution of Pakistan. Its aim was to raise awareness among hospital staff regarding health and safety (H&S) at the workplace. Walk through survey was done for the identification of various chemical and mechanical hazards in the hospital. Through risk assessment it was found that people in the hospital were at a risk of minor to severe injury due to both chemical and mechanical hazards. It was interpreted that, out of all the hazards, three hazards, discharge of glutaraldehyde, cuts by sharp blade and release of carbon monoxide caused low level risk at the work place, whereas, escape of methyl methacrylate was at critically high level of risk. Avoidance of occupational hazards (chemical and mechanical) should be of paramount importance in order to reduce the risk associated with these hazards.

Keywords: Risk Assessment, Chemical, Mechanical, Hazard, Hospital.

Introduction

A diverse group of individuals interact with a variety of objects in a hospital under working environment and are therefore vulnerable to occupational hazards and risk of injury[1]. It is counter-intuitive that the hospitals whose mission is the well-being of its patients, is itself an extremely hazardous place for the employees it hires[2].

Human beings have had to deal with various types of hazards since the emergence of modern industrial revolution. Mass production has speed up the severity of the harmful impacts of occupational hazards. By coming in contact, directly or indirectly, with a variety of work-related gadgets, workers are exposed to potential chemical and mechanical hazards in a hospital[3].

Clinical dangers in several health protection departments have allured the attention of regulating agencies[4]. In developing countries, billions of people join the workforce every year. Workplace environmental hazards, therefore, puts a large number of people at risk.

In terms of occupational health, purpose of risk assessment is to find out whether there is any possibility of a potentially dangerous circumstance causing ill health, injury or death of people in the occupational setting, how serious that risk is and whether the risk needs immediate attention and how urgently[5].

Occupational hazards refer to hazards experienced in the workplace with the potential to cause harm, while risk involves the chances of a person being harmed by getting exposed to a hazard[6]. Hazards are divided in different groups such as chemical (solid, liquid, and vapors), mechanical (cutting, shearing etc.), physical (extremes of temperature, noise, radiation etc.), psychosocial (psychological and social stressful factors), ergonomic (awkward posture, forceful movement, vibration etc.) and biological (viruses, bacteria etc.). Exposure to any of the above mentioned hazards are responsible for causing work related diseases and accidents[7].

In the present study chemical and mechanical hazards were chosen for risk assessment. Chemical hazards, as the name implies, are caused by exposure to different toxic chemical substances. Mechanical hazards are caused by tools, moving vehicles, parts of machines, energetic release of liquid or solid materials etc and are likely to cause damage to people in contact with such hazards. Mechanical hazards are responsible for causing scratches, sprains, deep cuts, burns and laceration in human beings[3].

It was found in a research study that a wide variety of mechanical hazards are linked with clinical equipments that consist of mechanical parts[8]. Chemical and mechanical hazards are common in the workplace. Chemicals enter into the human body mostly through inhalation, followed by contact with skin and subsequent dermal absorption. Although digestive tract is a possible site of absorption but exposure to large amount of toxic chemicals through ingestion is not frequent at the workplace[9].

A research study was conducted on risk assessment of various hazards in a hospital of Egypt. It was found that nurses who

were working in operating theatres were at a high risk of getting injured by sharp objects used during aciurgy. Skin, mucosa and respiratory system of nurses were also at a greater risk of being damaged because of exposure to harmful radiations, analgesic gases, sterilizing gases, antiseptics and other lethal agents. The study found that occupational hazards in operating rooms could deteriorate health of nurses, leading to their death[10].

There is lack of data on risk analysis of chemical and mechanical hazards in healthcare institutions of Pakistan. Aim of present work was to evaluate the risk of chemical and mechanical hazards in a medical center and reducing the risks associated with them, so that hospitals of Lahore could be made as safe as possible for its patients, visitors and employees.

Material and Methods

Workers in the hospitals come in contact with different types of chemical and mechanical hazards on a daily basis. Present research work carried out risk analysis of chemical and mechanical hazards in a well-known healthcare facility of Lahore. For this purpose, prior permission was granted from the medical center. Chemical and mechanical hazards were noticed in the medical center through workplace inspection checklist. Personal observation was used for the identification of various hazards. Following steps were involved in the risk analysis of hazards[11].

Hazard Identification: In this step hazards and their health impacts on humans were noticed in the hospital.

Dose-response Assessment: In this step it was determined that how increasing the level of exposure would affect the health of an individual.

Exposure Assessment: In third step, population exposed to various types of hazards, their pathway of exposure, nature and duration of exposure was noticed.

Risk Characterization: This last step was done in order to find out the extent of risk that a specific hazard could cause in an occupational setting. Risk was calculated through risk matrices by multiplying severity with likelihood.

Results and Discussion

Chemical and mechanical hazards were noticed in the hospital. After this step, assumed values above and below threshold level were taken for different hazards and the health impacts associated with them in an individual were represented in tables. After this, exposure assessment was done for the population (patients, doctors, nurses, sweepers, administrative staff, visitors etc.) which was exposed to different chemical and mechanical hazards in the hospital.

Table-1: Chemical hazards noticed in different places of a hospital.

Zone	Hazard	Metabolism
Medical labs, washrooms, waiting area, kitchen, corridors, wards	Vapor evaporation of cleaning agents	Once in the body, they are metabolized in various species resulting in the formation of several metabolites. The major site of metabolism is liver.
Operating theatres, sterilization units	Release of ethylene oxide	When inhaled, ethylene oxide is readily absorbed, distributed throughout the body, and rapidly metabolized.
Autopsy suites, laboratories	Formaldehyde emission	It enters the body through respiratory tract and is broken down into soluble methane diol or gaseous formaldehyde.
Primarily used on nursing floor, pharmacy, medical labs	Mercury	When in body, it interferes with the normal protein synthesis and enzyme functions and may change from less toxic to more toxic form by changing its valence state.
Dialysis ward, ICU, operating rooms, endoscopic unit	Discharge of glutaraldehyde	Once in the body, it reacts with and cross-link proteins and undergo reactions with DNA
Surgical unit, dental unit, orthopedic unit, operating rooms	Escape of methyl methacrylate (MMA)	Once it enters the human body, it damages the trachea and disturbs the normal functioning of respiratory system.
Operating theatre	Surgical smoke	After entering human body, it damages human cells and makes the blood thicker.
Cafeteria	Release of carbon monoxide	It enters human body and bind with hemoglobin which reduces hemoglobin availability to bind to oxygen.
Histology, hematology, cytology and microbiology laboratories	Vapors of toluene and xylene	Once they are inhaled, they undergo irrigational reactions in the upper respiratory tract.

Hazard identification: Various chemical (Table-1) and mechanical hazards (Table-2) were observed in the medical wing.

Table-2: Mechanical hazards noticed in different places of a hospital.

Zone	Hazard	Metabolism	Health impacts
Hematology lab	Crushing	-	Amputate body parts
Operation theatre	Surgical forceps	-	Crushed tissues, cuts
Operation theatre	Sharp tip scissors	-	Laceration
Pathology lab	Sharp blade	-	Cuts, burns
Autopsy suites	Skull key (a T shaped chisel)	-	Deep cuts (in flesh or skin)

Chemical hazards and their effects at different doses: Vapor Evaporation of Cleaning Agents: Potential health effects of cleaning agents at different doses are shown in Table-3.

Table-3: Potential health effects of cleaning agents.

Duration (Hours)	Potential Health Effect
2	Dizziness
3	Drowsiness
4.5	Loss of coordination
5.5	Mild loss of memory
7.5	Redness and blistering of the skin

Formaldehyde Emission: Potential health effects of formaldehyde at different doses are shown in Table-4.

Table-4: Potential health effects of Formaldehyde.

Dose (ppm)	Potential Health Effect
20	Eyes Irritation
27	Nose Irritation
35	Throat Irritation
45	Lung Injury
53	Nausea/Vomiting
60	Skin Irritation
67	Asthma
80	Death

Release of Mercury: Potential health effects of mercury at different doses are shown in Table-5.

Table-5: Potential health effects of Mercury.

Dose (ppm)	Potential Health Effect
1	Gingivitis
1.5	Stomatitis
2	Dermatitis
2.5	Mercurial pneumonitis
3	Kidney failure
3.5	Erethism

Discharge of Glutaraldehyde: Potential health effects of glutaraldehyde at different doses are shown in Table-6.

Table-6: Potential health effects of Glutaraldehyde.

Duration (Hours)	Potential Health Effect
2	Eyes Irritation
2.5	Nose Irritation
3	Throat Irritation
3.5	Coughing/Wheezing
4	Dizziness
4.5	Drowsiness
5	Nausea
5.5	Headache
6	Nosebleeds
7	Tightness in the chest
7.5	Asthma

Release of Carbon Monoxide: Potential health effects of carbon monoxide at different doses are shown in Table-7.

Table-7: Potential health effects of Carbon Monoxide.

Duration (Minutes)	Potential Health Effect
2	Headache
3	Dizziness
4	Nausea
5	Unconsciousness
6	Comma
7	Death

Release of Ethylene Oxide: Potential health effects of ethylene oxide at different doses are shown in Table-8.

Table-8: Potential health effects of Ethylene Oxide.

Duration (Hours)	Potential Health Effect
2	Respiratory Irritation
2.5	Headache
3	Lung injury
3.5	Nausea/vomiting
4	Diarrhea
4.5	Shortness of breath
5	Chronic
5.5	Reproductive effects
6	Mutagenic changes
7	Neurotoxicity
7.5	Cancer

Escape of Methyl Methacrylate (MMA): Potential health effects of methyl methacrylate at different doses are shown in Table-9.

Table-9: Potential health effects of Methyl Methacrylate.

Duration (Hours)	Potential Health Effect
2	Eyes Irritation
3	Nose Irritation
4	Throat Irritation
5	Skin Irritation
6	Decreased pulmonary function
7.5	Dermatitis

Mechanical hazards and their effects at different doses: Sharp blades: Potential health effects of sharp blades at different doses are shown in Table-10.

Table-10: Potential health effects of Sharp blade.

Duration (Hours)	Potential Health Effect
4	Shallow cuts
8	Deep cuts

Exposure Assessment: Table-11 and 12 shows exposure assessment of chemical and mechanical hazards respectively that was noticed in the medical center.

In fourth step, risk matrices were used to highlight the serious risks in the medical center. Measurement of the severity and likelihood ratings were determined. The adequacy level of the risk was also described as shown in Table-13[12].

Risk Matrix for Chemical Hazards: Hazard 1: Vapor evaporation of Cleaning Agent: Risk was taken as 9 (Figure-1) because its likelihood was very little. Its severity was 3 because its impacts include pneumonia, bronchitis, skin, eye and mucous membrane irritation.

Hazard-2: Discharge of Glutaraldehyde: Risk was taken as 3 (Figure-1) because its likelihood was very little. Its severity was 3 because its impacts include irritation of upper respiratory system, nose bleed, headache and wheezing.

Hazard 3: Release of Ethylene Oxide: Risk was taken as 12 (Figure-1) because its likelihood was irregular. People working in operation theatre and sterilization unit are usually affected by the release of this chemical.

Hazard 4: Formaldehyde emission: Risk was taken as 15 (Figure-1) because possibility of its occurrence was not regular. Its severity was 5 because the effect of this hazard is a bit dreadful e.g. excessive vomiting which requires immediate treatment.

Hazard 5: Release of Carbon Monoxide: Its risk was taken as 5 (Figure-1) because its likelihood was very improbable taken here as 1 and severity was taken as 5 because it causes neurological damage which requires prolonged hospitalization.

Hazard 6: Release of Mercury: Its risk was taken as 10 (Figure-1) because its likelihood was very rare taken here as 2 and severity was taken as 5 because it causes increase in blood pressure and heart rate as well as damage to kidneys and brain which requires prolonged hospitalization.

Hazard 7: Escape of Methyl Methacrylate (MMA): Its risk was taken as 16 (Figure-1) because its likelihood was quite probable depending upon the polymer material containing MMA and was therefore taken as 4 here and severity was taken as 4 because it causes cough and nasal irritation which may lead to permanent damage to the tissues of airways, if left untreated, and therefore, requires immediate hospitalization.

Risk Matrix for Mechanical Hazards: Hazard 1: Sharp Blade: Risk was 6 (Figure-2) because chances of its occurrence was quite low. Only a few individuals may be affected due to this hazard, usually those working in operation theatre, autopsy suits and pathology laboratory.

Table-11: Exposure assessment of Chemical Hazards.

Hazard	Exposure pathway					Nature of exposure		Extent of Vulnerability	
	Source	VF	Route of intake			Cont	Intermittent	Dose	Duration (hrs)
			I.G	I.H	A.B				
Vapor evaporation of cleaning agents	House-keeping activities	Contaminated air	—	Yes	Yes	—	ü	2 mg/m^3/day	8
Release of ethylene oxide	Sterilization of medical equipment	Contaminated air	—	Yes	Yes	—	ü	1 mg/m^3/day	2
Formaldehyde emission	Preservation of tissues	Contaminated air	—	Yes	Yes	—	ü	0.5 mg/m^3/ day	2
Mercury	Blood pressure machines and thermometers	Contaminated food and water	Yes	-	-	-	ü	3 mg/kg/day	3
Discharge of Glutaraldehyde	Disinfection of medical equipment	Contaminated food and water	Yes	Yes	—	—	ü	5 mg/kg/day	1
Escape of Methyl methacrylate (MMA)	In making polymers that bond tightly to a variety of other sources	Contaminated food and water	Yes	Yes	—	—	ü	0.2 mg/kg/ day	2
Surgical smoke	Electrocautery ablation and thermal tissue destruction	Contaminated air	—	Yes	—	—	ü	6 mg/m^3/day	4
Release of carbon monoxide	Gas stove for cooking	Contaminated air	—	Yes	—	—	ü	0.8 mg/m^3/day	8
Vapors of toluene and xylene	Solvents to fix tissue specimens and rinse stains	Contaminated air	—	Yes	—	—	ü	0.4 mg/m^3/day	2

Table-12: Exposure Assessment of Mechanical Hazards.

Hazard	Exposure pathway					Nature of exposure		Extent of Vulnerability	
	Source	VF	Route of intake			Cont.	Inter-mittent	Dose	Duration (hrs)
			I.G	I.H	A.B				
Crushing	Centrifuge rotor	Accidents	—	—	—	—	ü	—	—
Surgical forceps	Instrument set	Accidents	—	—	—	—	ü	—	—
Sharp tip scissors	Instrument set	Accidents	—	—	—	—	ü	—	—
sharp blade	Microtome	Accidents	—	—	—	—	ü	—	—
Skull key (a T shaped chisel)	Using a lever while removing skull- source	Accidents	—	—	—	—	ü	-	-
								—	—

Table-13: Key for risk of a hazard.

Level of Risk	Descriptor	Description
1	Desirable	Minor effect
2	Acceptable	Survey of a place required.
3	Undesirable	Detailed inspection of a place needs to be done.
4	Unacceptable	Precautionary measures required.
5	Critical	Urgent safety measures required.

Present study is the first of its kind in Pakistan, as far as the authors know. It was observed that employees at the workplace were exposed to chemical hazards (vapor evaporation of cleaning agent, discharge of glutaraldehyde, release of ethylene oxide, formaldehyde emission, release of carbon monoxide, release of mercury and escape of methyl methacrylate) and mechanical hazards (cuts, burns etc.). The hazard of sharp blade was slightly more but the level of risk was still acceptable. This was in consistent with the research work done on risk assessment of hazards which was a source of threat for nurses working in operating rooms. It was found that as regard mechanical hazards, the risk of exposure to sharp objects was very low[10]. Results of present study were not compatible with previous studies, which stated that nurses working in intensive therapy units were found to be at a great risk of damage caused by needle sticks[13,14].

In present study, escape of methyl methacrylate was at critically high level of risk which requires immediate action. Discharge of glutaraldehyde was at low risk depicted here as desirable. The hazard of release of carbon monoxide was slightly more but the level of risk was still acceptable. Release of ethylene oxide and formaldehyde emissions produced unacceptably high level of risk which requires mitigation measures. This was in consistent with the research work done on risk assessment of formaldehyde in the immunology departments of hospitals and suggested to reduce the level of exposure to this carcinogenic chemicals in the targeted departments[15].

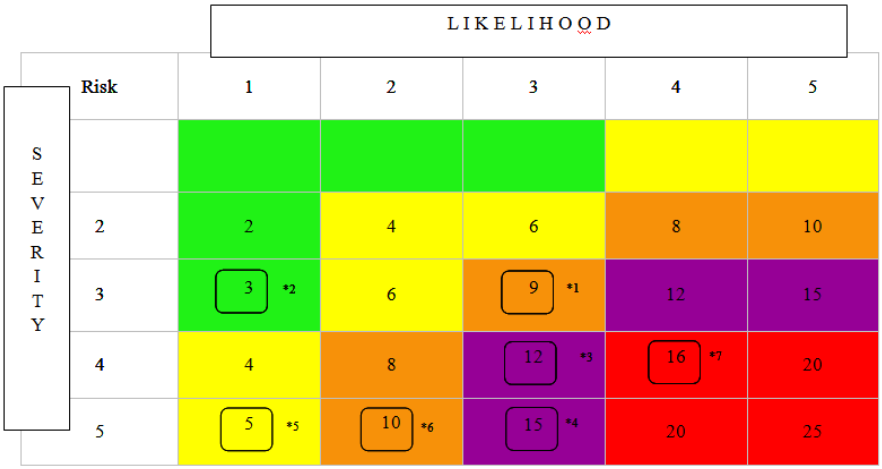

Figure-1: Risk matrix for chemical hazards.

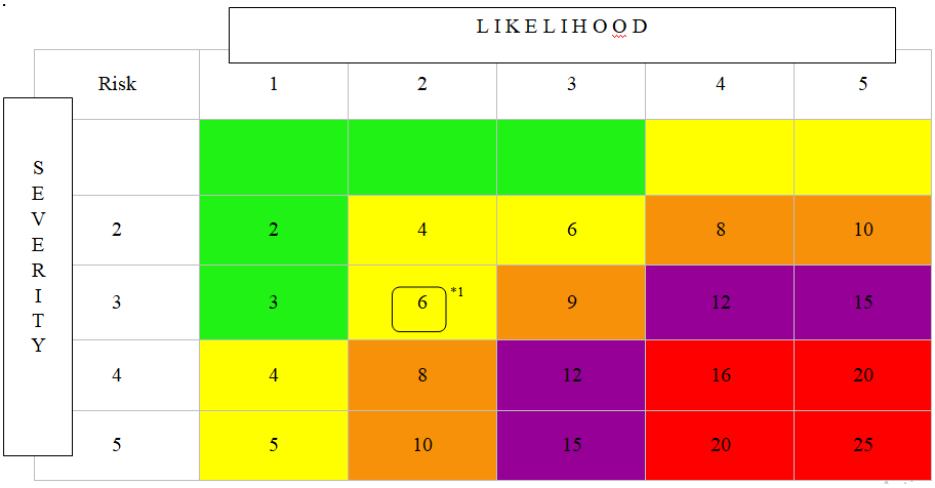

Figure-2: Risk matrix for mechanical hazards.

Conclusion

Existence of hazards in healthcare departments is a serious issue and is least prioritized in Pakistan. Accidents usually hurt both the affected individual and also harm the society involved. Consequently, it is necessary to prevent their occurrence at work. Thus, it is recommended that management should take steps for an establishment of a system including proper training and education, knowledge, direction and monitoring of occupational health and safety standards as necessary. The correct distribution of risk information is essential to ensure a healthy and safe workplace. Regular audits and surveys of workplace should be required in order to assess the risk and mitigation plans should be developed. The government should take initiatives and start programs to engage monitoring teams to regularly monitor the conditions of workplace and to check whether employers are conforming to the regulations set out in the 1934 Labor Act.

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