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Industrial hazards and safety management in pharmaceutical industry

Shmmon Ahmad[1], Abdul Hafeez[1], Anmar Al-Taie[1], Sameera Ali Siqqqui[1], Isha Talwar[1], Anjoo Kamboj[1], and Mumtaz Ahmad[1]

[1]Affiliation not available

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Dr. Abdul Hafeez
Associate Professor, Department of Pharmaceutics, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Shmmon Ahmad
Associate Professor, Department of Pharmaceutics, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Anjoo Kamboj
Professor& HOD., Department of Chemistry, Chandigarh College of Pharmacy, Mohali, Punjab, India

Mumtaz Ahmad
Assistant Professor, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Dr. Anmar AL-TAIE
Pharmacy Department, Faculty of Pharmacy, Girne American University, Kyrenia, North Cyprus, Mersin 10, Turkey

Sameera Ali Siqqqui
Department of Pharmacology, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Isha Talwar
Department of Pharmacology, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Correspondence Author:
Shmmon Ahmad
Associate Professor, Department of Pharmaceutics, Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

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Dr. Abdul Hafeez, Shmmon Ahmad, Anjoo Kamboj, Mumtaz Ahmad, Dr. Anmar AL-TAIE, Sameera Ali Siqqqui and Isha Talwar

Abstract
Hazard is a term associated with a substance that is likely to cause an injury in a given environment or situation. Industrial hazards are major occupational health and safety (OHS) issue in Pharmaceutical manufacturing. In recent years chemical safety and the sound management of chemicals have seen great progress at the global level. At the same time, the rapid growth in production and dissemination of both natural and synthetic chemicals has led to concern about their impact on the natural environment, and human health. In this way, the pharmaceutical industry has come to occupy a unique position. Practically no other commercial enterprises present such as a wide variety of potentially toxic exposures or such a rapidly changing advent of new chemical substances. In the pharmaceutical industry, this dynamic situation has been created by the increasing application of organic chemical synthesis as a technique for producing therapeutic substances. This renders the work of the plant physician so instructive. Industrial safety is needed to check all the possible chances of accidents for preventing loss of life and permanent disability of any industrial worker, any damage to machine and material leads to the loss of the whole establishment.

Keywords: Hazards, safety, management, pharmaceutical industry, toxic effect, health hazard

Introduction
Industrial hazard may be defined as any condition created by industries that will cause injury or death to personnel or loss of product or property [1]. Over the past decades, successive major accidents, More than two thousand deaths from the deadly toxic gas release in Bhopal, India in 1984 to the Bunce field fire in the United Kingdom in 2005, the Deepwater Horizon oil spill in the Gulf of Mexico in 2010, and the Bento Rodriguez dam disaster in Brazil in 2015, have caused deaths, numerous injuries, significant environmental pollution and massive economic loss. Drew world attention to serious chemical hazards in the industry [2, 3]. Industrial safety refers to reduce the risk of injury or loss and danger to persons, property from the industrial hazards [4]. Effective management of worker safety and health protection is a decisive factor in reducing the extent and severity of work-related injuries and sicknesses and their related costs [5].

Routes of industrial hazards entry into the body
Working with chemicals will involve the chance of exposure, becoming hazardous to a person's health. Those health risks are dependent upon the toxicity of the chemical, the types of effects [6]. Acute health effects develop soon after exposure whereas chronic toxic effects develop gradually over a prolonged period of exposure, many years after initial exposure [7]. There are four major routes by that hazardous chemicals entered the body. Inhalation, skin or eye absorption, ingestion, and injection [8].

Inhalation (breathing): Hazardous chemicals can enter the body through the respiratory tract through inhalation [9]. They enter the body in the form of vapours, gases, mists, or particulates (are shown in Figure.1) [6]. Once inhaled, chemicals are deposited in the respiratory tract and damage the tissue, or they diffuse into the blood through the lung-blood interface. Upon contact with tissue in the upper respiratory tract or lungs, chemicals may

cause health effects starting from simple irritation to severe tissue destruction. Substances absorbed into the blood are circulated and distributed to organs [8].

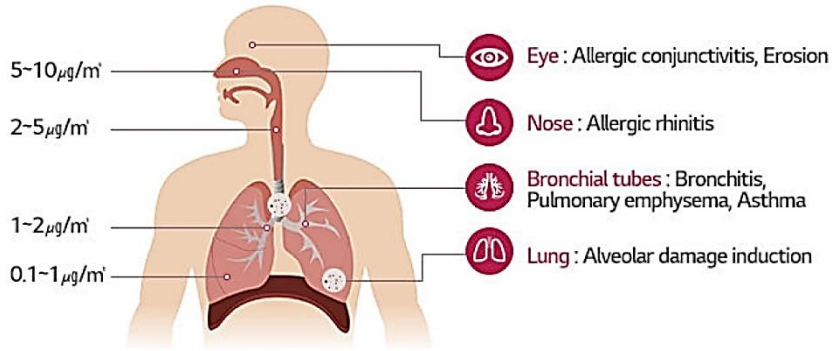

Fig 1: Dust size absorbed in the body and their effect on the body

Absorption: Chemicals that pass through the skin are nearly always in liquid form. Solid chemicals and gases or vapours don't usually pass through the skin unless they are first dissolved in moisture on the skin's surface. The skin is the second most common route by which occupational chemicals enter the Body [10]. Chemicals cross the skin barrier and are absorbed into the blood system. Once absorbed, they may produce systemic damage to internal organs [8]. Small amounts of chemicals may enter by dissolving in the liquid surrounding the eyes, may enter the eyes if they are splashed with chemicals. The eyes are richly supplied with blood vessels and many chemicals can penetrate the outer tissues and pass into the veins. The eye may or may not be damaged depending on the corrosive nature of the chemical and its ability to penetrate the outer tissues [10].

Swallowed: Chemicals can enter the stomach either by swallowing (ingested) contaminated mucus which has been expelled from the lungs or by eating and drinking contaminated food. Food and drink are most often contaminated by contact with unwashed hands, gloves or clothing, or by being left exposed in the workplace.
Once chemicals enter the mouth, it passes down the esophagus and then into the stomach. Alcohols may pass across the stomach wall and enter the bloodstream, but most chemicals move from the stomach via the small intestine. The small intestine has many hundreds of villi, it has very thin walls and is filled with tiny blood vessels (vein). Chemicals to pass from the small intestine across the walls of the villi and enter in the veins. The chemical is then carried around the body by the bloodstream [10].

Injection: Chemical substances may enter the body if the skin is penetrated or punctured by contaminated objects. Though less common in most workplaces, it can occur when a sharp object (needle) punctures the skin and injects a chemical (or virus) into the bloodstream, or when a chemical is sprayed at the body at high pressure [6]. Effects can then occur as the substance is circulated in the blood and deposited in the target organs [8].

Toxic effect of industrial hazard
Toxicity is the relative ability of a substance or chemical to cause adverse effects in living organisms [8]. We can reduce their toxic effects through the management of industrial waste. The chemical industry is important in many countries of the WHO. Many Member States are actively seeking to carry out the aims of the Strategic Approach, above all to deepen the involvement of their health sectors in the sound management of chemical safety to prevent the negative impacts of chemicals on health both directly and through the environment [11].

Effect on environment: Pharmaceutical industries also have many environmental problems, like the other chemical industries [12]. Environment safety directly or indirectly related to human health, contaminated air in the environment or workplace can be inhaled. Air is drawn through the mouth and nose, and then into the lungs. An average person breathes in and out about 12 times a minute. Each of the twelve breaths brings in about 500 mL of air, corresponding to 6 litters of air per minute, together with any contaminants that the air contains. Over an 8-hour working day, more than 2,800 litters of air will be breathed in and out of the lungs. In conditions of hard physical work, up to 10,000 litters may be exchanged [10]. Many tons and various types of pharmaceutical substances are used. They enter the environment via excretion of industrial waste. If they are not treated and degraded completely, they could contaminate the environment [12].

Effect on health: Hazardous gases (CO, CN^-) prevent the tissues from getting enough oxygen. Carbon monoxide binds to haemoglobin 200 times more readily than oxygen. Cyanide prevents the transfer of oxygen from the blood to tissues by inhibiting the necessary transfer enzymes. Carcinogen chemicals are associated with lung cancer [8]. Long-term exposure to chemicals such as silica dust, engine exhaust or welding fumes has been shown to increase the risk of heart disease, stroke, and high blood pressure [13].

Hazard categories
Hazard is a term associated with a substance that is likely to cause injury to personnel or one which may lead to loss of property, products, etc. [15]. Harmful chemical hazards in the Industry may be generally categorized into four different groups, and this is because industries employ many different processes involving a wide range of different raw materials, intermediates, waste products, and final products. The hazards encountered are fire, explosion, toxic release, and environmental damage.

Fire: Fire is an exothermic chemical reaction between oxygen and fuel at a certain temperature. It is the most frequent of the hazards however the consequences are generally less. People affected to fire usually take the form of skin burns and is usually dependant on the exposure time and the intensity of the heat. Physical structures can be damaged either by the intensity of the heat or combustion [14]. Three things essentials for the combustion of fire are Fuel (any combustible material), Oxygen (at concentrations above 23% in air, the situation becomes dangerous due to the increased fire hazard.) and Temperature. [15].

Explosion: The explosion mainly happens due to the rapid combustion of a flammable material however may be led to the chemical reactions they release a large amount of energy (heat). Examples of these chemical reactions are Polymerizations, the decomposition of unstable substances and exothermic interactions of many kinds [16]. There are various types of explosions which include gas explosions and dust explosions. Gas explosions occur when a flammable gas mixes with air and is exposed to a combustion source. Dust explosions occur when flammable solids, especially metals, in the form of fine powders are intensively mixed with air and ignited [14]. Factors affecting an explosion are [17].

1. Particle size
2. Chemical properties
3. Moisture content
4. Cloud dispersion

Chemical hazard: Several volatile and flammable liquids are employed in chemical industries. These liquids are vaporized when exposed to at room temperature or above causing air pollution. Sudden releases of toxic vapours have the potential to cause death and severe injuries several miles from the discharge point [14]. They are carried by water and air. The vapour gets combusted causing fire accidents and explosions. Further, they spread rapidly into the surrounding area and result in the loss of life and property [17].

Combustible gases

- Explosion hazard
- Must maintain below lower explosive limit.

Toxic gases

- Hazardous to human health.
- Employee exposure must be limited.

Oxygen displacing gases

- Indirect human health hazard.
- Deficiency of breathing oxygen

Electrical hazards: Electrical hazards occur when a person comes in contact with the conductor carrying current [15]. Current level probable effect on human body 1mA slight tingling sensation. 5mA slight shock felt not painful but disturbing. 6-30mA painful shock, muscular control is lost. 50-150mA extreme pain, respiratory arrest, severe muscular contraction, and death are feasible, 1000-4300mA muscular contraction and nerve damage occurs and death is presumably. 10,000mA cardiac arrest, severe burns and probable death [14]. Sources of Electrical Hazards are.

- Short circuits
- Electrostatic hazards
- Arcs and spark hazards
- Combustible and explosive materials
- improper wiring

Safety management and its responsibilities

The objective of industrial safety is to understand the harmful effects of industrial hazards & it defines the relationship between hazard and risk. Industrial safety refers to the protection of workers from the major industrial accidents. An International Conference on Chemicals Management was convened in 2006 to work out how to ensure that all activities involving chemicals should be undertaken in such a way as to ensure the safety of human health and the environment [18]. The chemical industry is important in many countries of the WHO. Many Member States are actively seeking to carry out the aims of the Strategic Approach, above all to deepen the involvement of their health sectors in the sound management of chemical safety to prevent the negative impacts of chemicals on health both directly and through the environment [11].

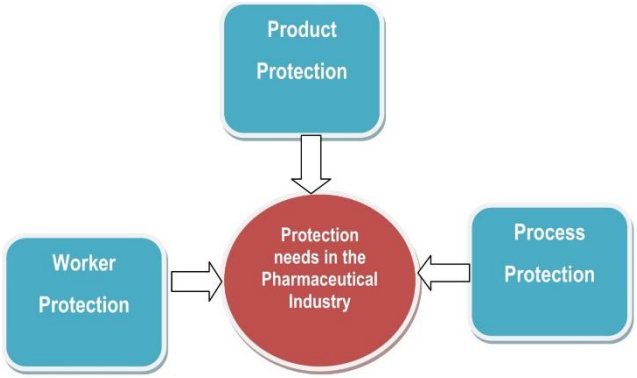

Fig 2: Protection needs in the pharmaceutical industry

Accident reduction: Industrial accidents and hazards have become the order of the day with new technologies evolving everyday and few people knowing how to use these technologies. This dangerous trend is more likely by a low experience person. An accident is an unplanned event involving hazardous substances that cause or is liable to cause, harm to health, and the environment. This excludes any long-term events (such as chronic pollution) [2]. There are some factors we should consider [14].

Design and pre-modification review: This involves correct layout, facilities, and material choice. Lesser chemicals should be stored, a reduction in inventory will automatically mean less damage if an accident is to occur.

Chemical risk assessment: Chemicals are assessed supported on compatibility, flammability, toxicity, explosion hazards and storage.

Process safety management: Before effecting major process changes. Management should try to develop a culture of safety, reliability assessment of process equipment, incorporating safety trips and interlocks, scrubbing system, etc in industrial organizations.

Safety audits: Periodical assessment of safety procedures and practices, the performance of safety systems and gadgets along with following up measures should be carried out.

Training of employees: Proper training of staff and protective services should be done.

Proper storage: All chemicals and hazardous materials should be kept in proper storage temperature and in locked cupboards away from children and animals. Also, if reactive substances are stored, they should be stored is a watertight container [14].

Employer responsibilities: Employer is fully responsible for the unauthorized activity. It is common observation management using 'Rule by Fear' method with employees (for example- employee do what employer are told him). This leads to a culture of fear and blame and an inability of employees to challenge and not follow regulatory guidelines. An employee should be encouraged to take advantage of an open-door route to organization top management when it comes to raising compliance issues and discussing potential compliance concerns pertaining to safety management [19]. There are some responsibilities of the employer

- To identify hazardous chemicals and prepare a list of hazardous chemicals in their workplaces.
- Obtain Material Safety Data Sheets (MSDSs) and labels for each hazardous chemical, if not provided by the manufacturer, importer, or distributor.
- Implement a written Hazard programas well as labels, MSDSs, and employee training.
- Communicate hazard information to staff through labels, MSDSs, and formal training programs

Hazards management

Control of fire accidents: Fire protection is an important part of Industrial safety. There are some precautions through which we can control fire accidents.

- Prohibition of smoking in the manufacturing area.
- Oxygen present in the atmosphere may be reduced by dilution with gases like Nitrogen, Carbon dioxide.
- Identification and control of combustion sources in areas where flammable chemicals are stored, handled or transferred.
- Elimination of combustion sources.
- Carefully design the plant layout.
- Should be fire resistance brick walls or reinforced concrete walls.
- Plant layout to provide suitable exit facilities.
- Adequate ventilation facility.
- Sprinkle with reliable water supply.
- Installation of sufficient fire alarms.

Management of hazardous gases: Compressed gases are filled in cylinders and distribute to require place. The important precautions to be followed are given below [17].

1. Cylinders should not be dropped or permitted to strike against each other.
2. Standard tools should be used on valves and safety instrument should be high quality. Normally these are provided by manufacturers.
3. Cylinders should be protected against extremities of weather, particularly against an excessive rise in the temperature.
4. Cylinders should bear a conspicuous standard label indicating the kind of gas. The colour or pictograms of the label shows whether gas is inflammable, corrosive or inert.

Explosion and fire management: Fire occurs in the industry more frequently than explosions and toxic release, although the consequences in terms of loss of life are generally less. So, a fire might be less hazardous [17]. To control of fire and explosion following precautions should be followed.

1. Careful plant layout and judicious selection of constructional materials can reduce fire and explosion hazards.
2. Fire resistance brick-walls can limit the effects of an explosion.
3. The roof should be designed to lift easily under an explosive force.
4. Possible sources of fire are reduced by eliminating unnecessary ignition sources like flames, spark, smoking, welding etc.
5. The installation of sufficient temperature alarms, fire alarms, firefighting equipment etc.
6. Fire extinguishers are installed inside the hose. These are designed for extinguishing the incipient fires. The incipient fires are divided into three categories,

Class A fires: These types of fires are originated from ordinary combustible materials.
They are controlled using water which produces quenching and cooling effects.

Class B fires: These types of fires are originated from oil's, greases, flammable liquids etc. In class B fires the extinguishing agent should produce a blanketing or smoothening effect.

Class C fires: These types of fires are originated in electrical equipment. The extinguishing agent produces a non-conducting property.

Health hazards in the pharmaceutical industry

Workers generally had a better experience than their referent populations, they experienced adverse health outcomes including cancer, endocrine dysfunction, and liver disease. Industrial hygiene measurements supported the likelihood of high exposure levels to sex steroids. Suppression of endocrine function and disruption of reproductive function are evident in expose workers. The most commonly reported allergic diseases have been occupational asthma and contact dermatitis. Occupational asthma may occur among production workers, especially in the manufacture of antibiotics and enzymes.
Occupational exposure to oral contraceptive pills had an adverse health effect on exposed workers resulting in an alteration in liver function and sex hormone levels. Estrogens exposure may increase the risk of Hypoestrogenism in exposed men and women [20].

Awareness of hazardous waste

It is the responsibility of all of us to aware of everyone about safely handling of chemical, and their exposure. An industrial worker, a transport worker, importer distributor should have knowledge for identification of pictogram (shown in Table 1) and informed of protective and safety measures. MSDS (Material Safety Data Sheet) should be

readily available to the public. Cautions must be placed to standout on dangerous household and car care products [14]. All chemicals we use can potentially cause harm to our health so it's very important that we understand what those hazards are and how to prevent exposure. There are four main classes of health hazard namely corrosive, toxic, harmful and irritant [21]. To protect the people from their toxic effect, they should be aware of the identification of hazard. The public should also cooperate with the police and any tankers and heavy-duty vehicles to avoid accidents and allow for the shortest possible on road time for dangerous vehicles [14].

Identification and labelling: Industrial hazards exist in almost every work environment. Identification of hazards and employing protective measures to control the hazards are important to protect the people from their consequences [15]. This is an essential starting point for any major hazard control system [22]. Through the hazard pictograms, we can alert employees and visitor to the presence of a hazardous chemical. The pictograms help us to know that the chemicals we are using might cause harm to people or the environment [23]. Requirements for identification and labelling of chemical substances exist in several countries but requirements differ from one country to another as to the details of the components of identification and labelling [24]. Easy to read hazard warning signs can help keep alert us to be safe. Here you will find a great selection of industrial hazard signs and labels for your workplace or worksite [25]. Containers of hazardous chemicals in the plant must be labelled, tagged, or marked with the identity of the material and appropriate hazard warnings. Chemical manufacturers, distributors, and importers must ensure that every container of hazardous chemicals shipping is appropriately labeled with such information, and producer name with address. Employers purchasing chemicals can expect on the labels provided by their suppliers. If the material is subsequently transferred or distributed by the employer from a labelled container to other containers, the employer will have to label all those containers. See the below table for specific labelling requirements [12].

Table 1: Globally harmonized system (GHS) pictograms used for chemical hazards

S. No.	Category	Symbol	Pictograms
1	Explosive	Exploding bomb	
2	Flammable	Flame	
3	Oxidising	Flame over circle	
4	Corrosive	Corrosion	
5	Acute toxicity	Skull and crossbones	
6	Hazardous to the environment	Dead tree and fish	
7	Health hazard/Hazardous to the ozone layer	Exclamation Mark	
8	Serious health hazard	Health hazard	

Globally harmonized system (GHS) for hazards identification: In 2003, the United Nations (UN) adopted the GHS [27]. GHS stands for the globally harmonized system of classification and labelling of chemicals [28]. In different countries have different requirements for hazard identity as well as information to be included on a label or material safety data sheet. For example, if a product considered flammable or toxic in one country, but notin another to which it is being shipped. These differences impact both protection and trade. In the area of protection, users have specific requirements may see different label warnings or datasheet information for the same chemical. In the area of trade, manufacture or distributors need to comply with multiple regulations of different countries regarding

hazard classification and labelling is costly and time-consuming. Small to medium industries can effectively follow international trade regulation in chemicals and avoid the double regulatory burden of compliance. GHS develop a worldwide system for hazard communication. It is a common and coherent approach to defining and classifying hazards, and communicating information on labels and safety data sheets to target audiences include workers, consumers, transport workers, and emergency responders.

Storage: Hazardous chemicals that are being improperly stored in the warehouse are capable of causing fire or explosion, or of producing injury by inhalation, skin or eye contact, or by ingestion [29]. Identification and control of ignition sources are necessary for areas where flammable chemicals are stored/handled/transferred. Hence, the storage and handling of these hazardous gases need special attention to avoid hazards [17].

Conclusion

The production and use of pharmaceutical are expected to further increase worldwide but as well as chemical hazard also additionally expected. The extensive review article highlights the safety and efficacy of the industrial worker and the environment. Industrial Workers generally had a better mortality experience than their referent populations, due to this reason they experienced serious adverse health outcomes. Safety aspects must be considered by the pharmaceutical and chemical industry not only in the interest of the employees or property but also in for neighboringenvironment as well. It should be apparent from the foregoing that any pharmaceutical industry, large or small, is particularly in need of expert counsel in matters affecting the health of workmen. There are more researches is needed to elucidate the relationship between workplace exposures and health outcomes. Currently, there are few consensuses or regulatory standards for occupational exposure limits in the pharmaceutical industry.

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