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Occupational Toxicity an Unnoticed Health Risk: A Review

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Abstract
Occupational toxicity is a branch of science that focuses upon the study and assessment of harmful chemicals or toxic substances, captivating the workplace. This field is critical for ensuring the health and safety of workers by identifying, evaluating, and controlling exposures to hazardous substances. Occupational toxicologists identify chemicals, dusts, fumes, gases, and physical agents (like radiation) that workers may be exposed to during their jobs and also identify their routes of exposure. The dose of the toxic substances and the frequency of exposure lead to many acute and chronic clinical conditions for workers. Developing safety guidelines preventive measures, such as permissible exposure limits (PELs) and threshold limit values (TLVs), workers can be protected in the work zone. Toxic substance induced occupational diseases, such as respiratory disorders, skin conditions, neurological effects, and cancers have become common for now these days. Ergonomics and occupational health management aim to identify and prevent those health risks. Recommendation of PPE, gloves, masks, and covered clothing, reduce the chances of toxicity. There are many standardise protocols declared by OSHA, NIOSH have been followed by industries as well as organizations for taking best protection. By understanding the risks associated with workplace, occupational toxicologists or health experts help in designing safer industrial processes, implementing effective control measures, and developing policies that protect workers from harmful effects, thereby reducing the incidence of occupational diseases by improving overall workplace health.

Key words: OSHA, NIOSH, Occupational Toxicology, respiratory disorders, workplace health

1. Introduction

Occupational toxicity is a branch of science that focuses upon the study and assessment of harmful chemicals or toxic substances, captivating the workplace. It aims to understand how these substances can affect human health, both in the short term (acute exposure) and over prolonged periods (chronic exposure), as well as help to develop safety standards in minimizing health risks (1).These chemicals include solvents, pesticides, biological agents like bacteria, fungi, and physical agents like radiation, noise etc. Exposure to them in many ways may lead to cause numerous clinical correlations. There are many ways by which infections can occur like inhalation, ingestion, dermal contact and intravenous pathways etc (2). The following review is aimed to analyse the gap between growing tendencies of occupational toxicity compared to the remedial approaches made so far.

2. Review of Literature

In India one of the major causes for the significant health risks is occupational toxicity. Exposure to the hazardous substances in the workplace leads to cause tremendous health conditions amongst the workers in India. The irony of fate is that this particular reason has always been ignored or untreated as earning livelihood for the family with growing population has become an extreme challenge for the earners. So with silent ignorance they have to earn without thinking of their major health risks. The scenario is very dominant and painful when it is captivating the society for the countries like India.
Breathing in toxic vapours, gases, dust, or fibres (common with airborne pollutants) can induce chances of respiratory or cardio-pulmonary risks and can be fatal if not identified or neglected. Swallowing contaminated

substances (usually accidental) promote digestive hazards like dysentery, typhoid, irritable bowel syndrome, ulcer etc..Direct contacts with harmful substances that can penetrate to the skin also increase tendencies of dermatitis or any other infections of skin. Many researchers have shown evidences on the fact that prolonged exposure to the ultra violet rays can increase the number of basal and squamous epithelial cells in many folds as a result skin cancer may occur. Industries like health care automobiles have frequent release of radioactive agents followed by radioactive rays and the workers working there face continuous exposure to those agents (3). On the other hand workers like pathologies and researchers get exposed to various strains of microorganisms, out of which some are known and some are unknown can cause infections and inflammations due to unintentional contamination, bacterial strains like staphylococcus and streptococcus are very common (4). Involuntary exposure due to puncture wounds, like needle sticks in healthcare settings can be the major reasons behind contamination and dermal hazards. This is a central principle in toxicology says about higher doses of unwanted agents lead to more severe effects (5). Drug based dosages to reduce toxicity promoted by work station are sometimes extremely harmful for sustainability and even fatal in many cases. Rapid onset of symptoms after exposure to a high concentration of a toxic substance over a short period can generate long term effects (6).In a research it has been shown that the annual death rate due to prolonged exposure to occupation based toxicant over the globe is more than three millions. However the workers of manufacturing, wholesale trade, real estate domain, technical service providers, road traffic coordinators have elevated levels of volatile organic compounds (VOCs), cadmium, lead, glycideamide in their blood irrespective of age, gender, race and ethnicity (7). Workers working in the welding industries, agriculture domains, pesticide industries or pharmaceutical companies often suffer from affected reproductive health, causing birth defects or infertility (8). Now the adversity in the health induced by the occupation provoke to establish occupational exposure limits (OELs) which set maximum allowable levels of harmful substances in the workplace. Even the safety protocols due to occupation based toxicity instructs for modifying equipments or processes (e.g., ventilation systems, enclosures), using gloves, masks, goggles, or protective clothing to minimize exposure and implementing safety protocols, training, and work schedules to limit exposure time (9).Occupational toxicologists work closely with regulatory agencies like the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) to set standards and enforce regulations that protect workers from toxic exposures (10). The substantial history of occupational toxicity also induces impaired cognitive functions for example chemical agents inducing reactive oxygen species (ROS) can promote physiological stress followed by psychological stress leading sympathetic discharge and suppress excitation to many physiological stimuli (11). Now there are approximately 150 chemical or synthetic agents have been established so far causing incidences of occupational diseases and accidents (12). On the contrary, occupational toxicology focuses on understanding how workplace exposures to hazardous substances can affect health and what can be done to minimize these risks. It is critical for promoting safe working environments (13).

2.1 Mal effects of occupational toxicity

Every industry depending upon its production and management possesses specific raw materials, and release specific waste. Now variety of waste target definite physiological systems to cause severe damage. For example: Occupational asthma which is caused by exposure to airborne irritants like chemicals (isocyanates, cleaning agents), dust, or fumes engage workers of the industries like manufacturing, painting, and healthcare. So exposed to these irritants develop risk for the respiratory as well as cardiovascular system (14). On the other hand a bunch of respiratory diseases called pneumoconiosis involve variety of constructive and restrictive clinical conditions worldwide (15). This includes Silicosis which causes from inhaling crystalline silica dust (common in mining, quarrying, and construction).Asbestosis is also a condition caused by asbestos exposure (common in construction, shipbuilding, and manufacturing industries) (16).Coal Worker's Pneumoconiosis or Black Lung Disease, caused by coal dust exposure amongst miners. Apart from these, COPD (Chronic Obstructive Pulmonary Disease) is linked to a chronic clinical condition which occurs due to long-term exposure of industrial dust, fumes, and chemicals. Even miners, construction workers, and people those who are exposed to smoke or various gases are often affected by COPD (18).

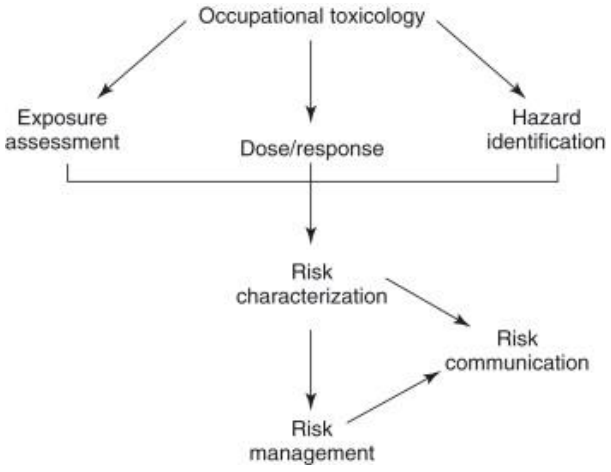

Fig 1: Dose dependent occupational toxicity. (17)

Other varieties of the chronic clinical conditions include cancers which can also occur due to occupational toxicity. An example of a rare cancer caused due to extreme cytogenesis in the linings of the lungs or abdomen called Mesothelioma, is exclusively caused by asbestos exposure (19).Bladder Cancer is associated with exposure to aromatic amines in industries such as dye manufacturing and rubber production. Lung Cancer relating to asbestos, arsenic, chromium, and certain organic solvents are unpredictable and dangerous. Workers in industries like construction, manufacturing, and mining are at higher risk (20).Leukaemia associated with to benzene exposure in industries like petrochemical production, shoe manufacturing, and printing are also not rare at all. Prolonged exposure to sunlight for outdoor workers or for construction workers to chemicals such as polycyclic aromatic hydrocarbons (PAHs) and arsenic can increase the risk of skin cancer as well (21).

Neurological disease can also occur due to prolonged exposure to lead in industries like battery manufacturing, smelting, and painting can cause neurological damage, cognitive impairments, and behavioral changes (22). This is also every common in industries like gold mining, chemical manufacturing, and healthcare (from broken thermometers or fluorescent lights). Chronic exposure to mercury leads to tremors, memory loss, and cognitive dysfunction. Workers in industries that use organic solvents (like painting, printing, and degreasing) can develop memory loss, depression, mood swings and behavioural changes linked to neurodegenerative diseases like Parkinson's (23). In agriculture sectors, agricultural workers who have long-term exposure to certain pesticides (e.g., paraquat) can also face the same kind of disorders (24).

Skin Disorders are also very common in Indian context, like contact dermatitis caused by direct exposure to irritants or allergens like chemicals, detergents, and solvents. Workers in healthcare, cosmetic designing, beauticians and manufacturing are particularly prone to developing this condition (25). Chloracne is a skin condition similar to acne, caused by exposure to chlorinated hydrocarbons (e.g., dioxins). This condition is more common in chemical and pesticide manufacturing workers (26).

Reproductive and Developmental Disorders for example infertility which shows to be prevalent due to exposure to heavy metals (lead, cadmium), solvents, and pesticides can lead to infertility in both men and women (27). For example, lead exposure is known to impair sperm quality in men. Pregnant women exposed to certain chemicals like mercury, lead, or phthalates (commonly found in plastics) can have a higher risk of delivering babies with birth defects. Frequent occurrence long-term exposure to solvents and pesticides is linked to an increased risk of miscarriage (28).

Liver and Kidney Diseases like Hepatotoxicity (Liver Damage) include certain solvents (e.g., carbon tetrachloride) and heavy metals (e.g., lead, arsenic) can cause liver damage, which may lead to conditions like cirrhosis or liver cancer (29). Nephrotoxicity (Kidney Damage)shows prolonged exposure to heavy metals like lead, cadmium, and mercury, commonly found in manufacturing and mining industries can result in kidney failure or chronic kidney disease (30). Strenuous working hours or shift based working schedules in corporate sectors increase the tendencies of addiction in the younger population lead to cause alcoholic steato-hepatities or fatty liver disease (31).

Hematological (Blood) Disorders like aplastic anaemia which is linked with exposure to benzene, commonly used in the petrochemical industries like printing, and shoe manufacturing. This condition occurs when the bone marrow fails to produce sufficient blood cells (32). Other than haemolytic anemia sickle cell disorders can also occur due to random arsenic exposure and can be fatal after sometime. Many researchers revealed that many workers exposed to combustion engines, particularly in poor ventilated areas (e.g., garages, factories), are at higher risk of inhaling carbon monoxide, leading to poisoning and omission of oxygen in connective tissues and can cause headache, dizziness, confusion, or even death (33).Cyanide exposure, in industries like gold mining, electroplating, and chemical manufacturing, can be fatal for WBCS. Muscle weakness and damage resulting from prolonged exposure to certain toxic chemicals, such as solvents or heavy metals, affecting workers in industries like painting, electronics, and metalworking (34).

3. Discussion

The outcomes of this review paper have provided the insight into the field of industrial toxicology emphasizing its definitions, history, and the sources of toxic compounds and how they affect the workers body of various domains. It discusses how toxicants interact with the environment and enter the human body, as well as their potential harmful effects. Along with the methods for monitoring and controlling exposure in occupational setting, the importance of minimizing the exposure to toxic substances is also highlighted, based on which various hypothetical outcomes have seen with non-translational approach. The role of health surveillance programs, therapeutic interventions, administrative measures, training and other preventive strategies are mainly outlined as crucial for reducing the risk of exposure and ensuring workers safety against toxic substances (35).

Toxicity causes from organized sectors are comparably lower than that of the unorganized ones. In India, Safai workers or cleaners work under Municipal Corporation leads to get exposed in various organic and inorganic wastes, which cause severe disorders relating stomach and lung (36). The organization in that case took an initiative in the name of municipal solid waste management system where they identify numerous risk factors relating solid waste and their uneven disposal. Many nutrition supplements and alternative medicines were introduced in controlling the clinical conditions growing for continuous exposure of the waste. Personal protective equipment is also introduced to the workers (37). For reducing occupational hazards branded organizations like TATA Motors, L&T, Vale have incorporated risk handling workshops, AI based health monitoring system, so that the health of the workers working in risky zones can be monitored continuously or periodically & may also give a collective output for physiological as well as mental health. For example, smart skin monitoring device is one of the commonly used device to screen dermatological hazards based on workstation of leather industry (38). Industries exposing chemical agents like lead and others can be also taken into account and the adults working their need to be taken various medicines to induce their therapeutic interests like edetate calcium disodium and dimercaprol, which are chelators help to reduce the tendencies of lead toxicity amongst the workers (39). So, chelating therapy is said to be one of the most potential therapies for reducing lead toxicity. Heavy metal toxicosis generate progressive allergy amongst the workers of heavy metal sectors, various types of dermatitis can be leading cause of skin necrosis followed by skin cancer in the workers. Researchers had developed many herbal remedies in compare to western drugs for the better recoveries along with lower side effects to reduce inflammation in the dermis they believed that plant extracts and their numerous compilations can be helpful and trustworthy in this case (40). The gap of the remedial approaches& safety measures in the way of translation and healing is still too far to accomplish in all the sectors of India. Socio-economic barriers and lack of education are still very evident in fighting challenges raised in day to day lives. Government and non-government proposals are required to be made on immediate basis by every state and country. Awareness or empowerment programs to be organised to enlighten the workers for their healthy survivals. It has been observed that whatever remedies have been researched and rehearsed are so far made for the workers of organised sectors, where as about 60% of the population who are still suffering from numerous fatalities based on occupational toxicities belong to unorganised sectors (41). No such healthcare models and remedial approaches are made accountable in taking care of health and health related hazards. Lack of monitoring and vigilance the risk factor and death ratio are increasing in many folds.

4. Conclusion

Occupational diseases can often be prevented by in many ways like substitution of less toxic materials, engineering controls (e.g., ventilation, enclosure of processes), administrative controls (e.g., training, work rotation), personal protective equipment (PPE) (e.g., respirators, gloves, protective clothing). Regular monitoring of exposure levels and health surveillance for early detection of problems.Understanding the risks and implementing proper safety measures can help minimize the incidence of these occupational diseases (42).Controlling occupational toxicity involves several **therapeutic interventions** and **preventive measures** aimed at minimizing the harmful effects of toxic exposures in the workplace. These therapies are focused on reducing exposure, treating symptoms of toxicity, and preventing the recurrence of harmful health outcomes (43).The management of occupational toxicity requires a comprehensive approach, combining **engineering controls**, **administrative measures**, **personal protective equipment**, and **medical interventions (44)**. Preventive strategies help reduce the risk of exposure, while medical treatments aim to manage acute and chronic toxic effects (45). Long-term monitoring and rehabilitation ensure that workers receive appropriate care and are protected from future risks. Effective control of occupational toxicity is essential for maintaining workers' health and safety in hazardous environments.

5. Authors Conflict:

As the research is based on review, so we wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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