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CARCINOGENESIS IN OCCUPATIONAL DISEASE

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ABSTRACT
Carcinogenesis is one of the most significant research topics in the realm of occupational disorders. Substances with the potential to cause cancer are known as carcinogens. Carcinogens have a significant impact on public health and on worker safety. Worldwide, occupational exposure to carcinogens is a leading cause of mortality and disability, with an estimated 666,000 fatal work-related cancer cases occurring each year. The burden of occupational diseases is expected to increase in the future due to worker exposure to carcinogens, and occupational cancers are still cause for concern today. The objective of the study is to identify Occupational Carcinogens, to assess the epidemiological status of occupational cancer globally, to identify and assess the cancer risk and to determine which occupations have a potentially higher risk of developing cancer and to establish preventive measures for occupational cancers.

KEYWORDS: *Occupational diseases, Workplace cancer, Occupational cancer, Carcinogenesis, Occupational health hazard.*

INTRODUCTION
Occupational cancers are types of cancer that employees develop after extended exposure to carcinogenic substances in the workplace during a protracted latent phase . The process via which a normal cell can become cancerous is known as carcinogenesis. The development of cancer is the result of a cascade of events arising from the unchecked growth of malignant cells due to the combined influence of several genetic mutations [1]. Many carcinogens have been discovered in the workplace over the past few decades, and their presence is frequently linked to an increased cancer incidence. Occupational exposure involves several factors, and it is still unclear how carcinogens, occupational exposure, and cancer are related.

The type and length of exposure, a person's susceptibility, and other lifestyle choices like smoking or diet all have an impact on the development of occupational cancers. Certain heavy metals like arsenic and cadmium, asbestos, benzene, formaldehyde, diesel exhaust fumes, silica dust, and ionizing radiation (like X-rays) are a few common occupational carcinogens . A comparable cancer risk has been noted for individuals working night shifts; therefore, the most likely hypotheses regarding the causal relationship between shift work and breast cancer are still the changes in the circadian system and the decrease in melatonin production brought on by exposure to light during the night [1].

PURPOSE
The aim of studying carcinogenesis in occupational disease is to understand the mechanisms and factors involved in the development of cancer due to workplace exposures.

OBJECTIVES
1. To identify Occupational Carcinogens.
2. To assess the epidemiological status of occupational cancer globally.
3. To identify and assess the cancer risk and to determine which occupations have a potentially
higher risk of developing cancer.
4. To establish preventive measures for occupational cancers.

METHODOLOGY FOR SELECTING BIBLIOGRAPHIC SOURCES
To achieve the purpose of this work, a search was performed on specialized platforms for relevant articles written in English about the carcinogenesis in occupational diseases that were published in international journals between 2014 and 2024. The final bibliography of the paper included 72 articles, which were selected for this review. The articles selection was selected from the sources: NCBI, Medscape, PubMed, Google Scholar.

BIBLIOGRAPHIC ANALYSIS
1.1 Definition and Classification of Carcinogens
The term "occupational carcinogens" describes exposures at work, especially those involving chemicals that are employed or emitted as intermediate compounds during manufacturing that have been linked to cancer, either conclusively or suspectly .

The International Agency for Research on Cancer (IARC) has classified agents into five groups: group 1 (probably carcinogenic to humans; 120 agents), group 2A (probably carcinogenic to humans; 82 agents), group 2B (possibly carcinogenic to humans;

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311 agents), group 3 (its carcinogenicity to humans cannot be determined; 499 agents), and group 4 (probably not carcinogenic to humans; Based on available data, IARC divides substances into five categories (Table 1; IARC,) [2][3].

Table 1. Carcinogenicity of different substances [2][3]

Group	Definition	Used when
1	Carcinogenic to humans	Sufficient evidence in humans
2A	Probably carcinogenic to humans	Limited evidence in humans, and sufficient evidence in experimental animals
2B	Possibly carcinogenic to humans	Limited evidence in humans, and absence of sufficient evidence in experimental animals, or inadequate evidence in humans or human data nonexistent and sufficient evidence in experimental animals
3	Not classifiable as carcinogenic to humans	Inadequate or unavailable evidence in humans and inadequate or limited evidence in animals
4	Probably not carcinogenic to humans	Evidence suggests a lack of carcinogenicity in humans and in experimental animals

1.2 Common Types of Occupational Carcinogens

The petroleum industry is the one with the highest concentration of common occupational carcinogens, followed by the automotive and pharmaceutical industries, mining and quarrying (particularly copper and aluminum), and the production of metals, asbestos, rubber, and plastic products . Few of the common carcinogens found in the occupational setting are recorded in the following table (Table 2) [4].

Table 2. Common carcinogens in the working environments [4]

	Carcinogen factors to people	The organ it affects	Source or exposition
1	Nickel	Nose, nasal cavities, the bronchi, lungs	Metallurgy, alloys, catalysts
2	Cadmium	Lungs, prostate	Dyes and pigments production
3	Arsenic and compounds	Lungs, skin, liver	Arsenical insecticide production and packaging
4	Chromium (6 valent)	Nasal cavities, the bronchi, lungs	Galvanizing metals, dyes and pigments production
5	Asbestos	Lungs, serous membranes pleura, peritoneum	Insulation, filters, asbestos cement products and asbestos textile products
6	Hematite	Lungs	Miners in iron ore mines
7	Vinyl chloride	Liver	Plastics, monomer
8	Tar, paraffin	Skin, lungs, bladder	Fuels
9	Benzene, toluene, xylene	Leukemia	Organic solvents, fuels, rubber manufacturing
10	Ethylene oxide	Leukemia	Sterilization, chemical intermediator
11	Mineral oils	Skin	Lubricants
12	Formaldehyde	Pharynx, lungs	Foundry, melamine, resin, and health care centers
13	2-Naphthylamine	Bladder	Dyes and pigments production
14	Bis-ether Chloromethylethylethe	Lungs	Chemical semi-finished products and by-products, manufacturing workers using bis (chloromethyl) ether and chloromethyl methyl ether
15	Oil from fossil fuels	Skin	Lubricants
16	Soot	Skin, lungs	Pigments
17	The fog of strong inorganic acids with sulphur	Lungs	Metals
18	Coal tar pitch	Skin, lungs, bladder	Construction material, electrodes
19	Wood dust	Nasal cavity	Wood industry, firewood
20	Benzidine	Bladder	Dyes and pigments production, laboratories
21	4-Aminobiphenyl	Bladder	Rubber manufacture
22	Pitch volatiles; aromatic amines	Lungs, bladder	Aluminum production

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23	Cadmium and cadmium compounds	Respiratory and digestive systems, prostate	Battery manufacture
24	Leather dust; benzene and other solvents	Lymphatic and haemopoietic system (leukemia), nose, paranasal sinuses, bladder	Boot and shoe manufacture and repair
25	Crystalline silica	Lungs	Ceramic and pottery workers
26	Dyes (aromatic amines, aminophenols with hydrogen peroxide); solvents; propellants; aerosols	Bladder, lungs, lymphatic system (non-Hodgkin lymphoma), ovaries	Hairdressers and barbers
27	Ionising radiation	Skin, lymphatic and haemopoietic system (leukemia)	Medical personnel
28	Arsenic compounds	Lungs, skin, lips	Vineyard workers using arsenic insecticides
29	Aromatic amines	Bladder	Synthetic latex production, tyre curing, calendaring operatives (calendaring is a finishing process used on cloth), reclaim rubber, cable makers
30	Diesel engine exhaust; extremely low-frequency magnetic fields	Bladder, stomach, larynx, lymphatic and haemopoietic system (leukaemia), lungs	Filling station attendants,railway workers, bus and truck drivers, operators of excavating machines
31	UV radiation	Skin, lips	Fishermen, sailors, agriculturists

According to Table 2 above, the most frequent occupational carcinogens include dyes, benzine, asbestos, ionizing radiation, diesel engine exhaust, crystalline silica, and UV radiation. Also, most occupational settings where people are exposed to carcinogens include railway workers, bus and truck drivers, hair salons and barbers, rubber manufacturers, and cement sectors associated with asbestos. People who work in synthetic latex production, vineyard workers using arsenic insecticides, medical personnel, fishermen, sailors, and agriculturists are also exposed to workplace carcinogens.

1.3 Epidemiology of Occupational Cancer

According to estimates from the International Labour Organization (ILO), occupational cancer kills 666,000 people worldwide each year—more than double the number of deaths caused by occupational accidents. Within the European Union (EU28), occupational cancer kills 102,500 people annually—twenty times more than occupational accidents.

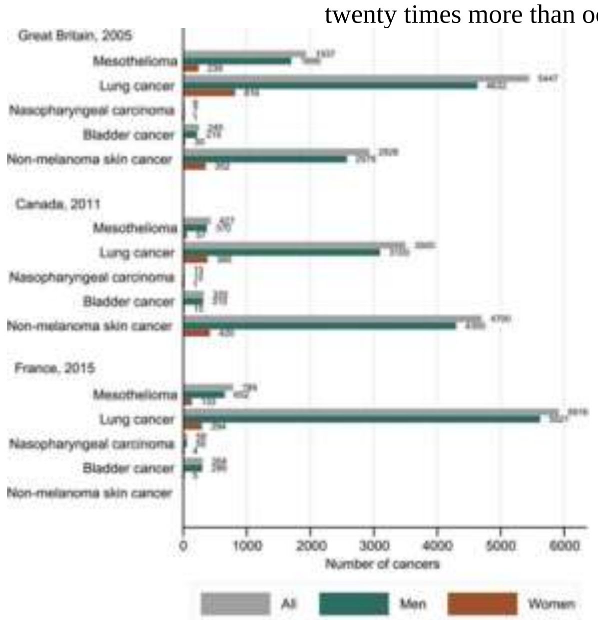

Figure 1. number of cancer cases attributable to occupational exposure at selected cancer sites [5].

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The 10 most significant occupational carcinogens, like asbestos, account for over 85% of all occupational deaths. Work exposures induce malignancies that have a high case fatality rate, such as lung cancer. The estimated total number of cancer deaths worldwide in 2016 attributable to 14 of the Group 1 agents was 349 000 [95% uncertainty interval (UI) 269 000–427 000], or 3.9% (95% UI 3.2–4.6%) of all cancer deaths. Of these, 299 998, or 17.6% (95% UI 13.8–21.3%), of lung cancer deaths were caused by these agents . Figure 2 shows the estimated total number of work-related deaths worldwide per region [6].

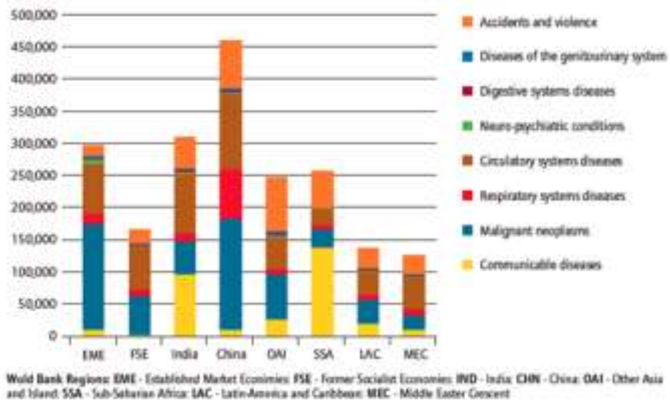

Figure 2. Region-specific estimates of the total number of work-related deaths worldwide [6].

1.4 Risk factors and High-Risk Occupations for Specific Cancers

It has been demonstrated that a variety of occupations and particular chemicals present in workplaces increase the risk of developing different types of cancer. Numerous industrial chemicals, dusts, metals, and combustion products, radiation exposure, entire industries and professions, and behavioral patterns like shift work are among the risk factors for occupational cancer. The risk of developing cancer in various occupations may be slightly elevated due to the things that employees do or are exposed to. Examples of such exposure include working in the sun, silica dust, diesel engine exhaust, asbestos, and other particles [7].

Table 3. High-Risk Occupations for Specific Cancers [8].

Work process / occupations	Cancer type	IARC classification
Asbestos production	Lung	Group 1
Aluminum production	Lung, bladder	Group 1
Auramine production	Bladder	Group 1
Boot and shoe manufacture and repair	Nasal cavity, leukemia	Group 1
Chimney sweeping	Skin, lung	Group 1
Coal gasification	Lung	Group 1
Coal-tar distillation	Skin	Group 1
Coke production	Lung	Group 1
Furniture and cabinet making	Nasal cavity	Group 1
Hematite mining (underground) with exposure to radon	Lung	Group 1
Iron and steel founding	Lung	Group 1
Isopropanol manufacture by the strong-acid process	Nasal cavity	Group 1
Magenta production	Bladder	Group 1
Painter	Lung, bladder (leukemia in offspring with maternal exposure)	Group 1
Paving and roofing with coal tar pitch	Lung	Group 1

Rubber manufacturing	Leukemia, lymphoma, bladder, lung, and stomach (prostate, esophagus and larynx)	Group 1
Manufacture of art glass, glass containers and pressed ware	Lung, stomach	Group 2A
Carbon electrode manufacture	Lung	Group 2A
Hairdresser or barber	Bladder, lung	Group 2A
Petroleum refining	Leukemia, skin	Group 2A
Shift work	Breast	Group 2A

1.5 Preventive Measures and Control Strategies

Table 4. Overview of preventive measures [9].

Groups	Type of measure	Examples
Chemicals	Avoidance, substitution with harmless agents	Substitution databases and tools
	Technical measures, including substitution with less hazardous agents	Closed system, e.g. airtight metal cleaning plant using perchloroethylene, specific local extraction systems
	Organizational measures	Access system for specifically trained workers
	Personal measures	Respirators with specific filters
Pesticides	Avoidance, substitution with harmless agents	Organic farming
	Technical measures, incl. substitution with less hazardous agents	Integrated pest management, using application procedures and devices that reduce exposure
	Organizational measures	Reducing the number of exposed, avoiding side-exposure of workers who are not applying pesticides, decontamination procedures, proper procedures for storage and cleaning of substances and equipment, maintenance of application devices, machinery and protective equipment
	Personal measures	PPE, protective clothing, hygienic procedures for separating and cleaning contaminated clothing
Pharmaceuticals	General	Best practice examples described in the Commission guideline for the health care sector or NIOSH good practice guide on Managing Hazardous Drug Exposures: Information for Healthcare Settings
Biological factors	Organizational measures	Good hygiene practices, cleaning and hygiene plan, restricted access, black/white areas, spatial separation of polluted and unpolluted areas
	Personal measures	PPE, proper clothing, vaccination
Physical factors	Measures against sedentary work	Avoidance, reduction of sedentary work by dynamic workstations and/or treadmill desks, organization of work to avoid static work, prolonged standing and prolonged sitting, e.g. through breaks and reorganization of work procedures
	Measures against radiation	Closed, insulated systems, cordoning off areas, restricted access, recommended personal protective equipment
Shift work, night work	Technical and organizational	Shift work design according to scientific recommendations and best practice examples, design of schedules, limitation of years worked in shifts, health promotion, organization of rest periods, rest and eating facilities, making available appropriate meals
	Personal measures	Training, instructions regarding eating habits and rest periods
Combination of different risk factors	General	Precautionary approach needed, holistic risk assessment, job-exposure matrices that address all risks, approach by occupations

DISCUSSIONS

In the context of occupational diseases, carcinogenesis is a complex process that includes the development of cancer because of exposure to carcinogens at work. This process is influenced by various factors, including the type of carcinogen, the duration and level of exposure, and individual susceptibility. Various agents, including chemicals, metals, and radiation, are considered occupational carcinogens and have been associated with the development of multiple cancer forms, including skin, bladder, and lung cancer. To minimize exposure and safeguard the health of employees, preventive measures and regulations must be put in place, which requires an understanding of these carcinogens. Moreover, public health policy and workplace safety standards are greatly influenced by research on the carcinogenesis of occupational diseases. Targeted interventions and control methods can be created by gaining insight into the mechanisms and factors that contribute to the development of cancer related to the workplace. This knowledge is essential for maintaining a safe and healthy workplace, lowering the total incidence of occupational cancer, and protecting employees' health [10].

CONCLUSIONS

The first step in preventing occupational cancer is identifying the carcinogens that are present in the workplace. Several important advantages can be obtained from identifying occupational carcinogens, mainly in the areas of public health and workplace safety. Once these carcinogens have been identified and characterized, preventive measures that can effectively lower the risk of occupational cancer can be established.

The global study of the epidemiological state of occupational cancer has provided valuable insights into the prevalence, distribution, and risk factors of malignancies associated with the workplace.

To better understand the intricate interactions between occupational exposures and the development of cancer, it is important to identify risk factors and high-risk jobs associated with cancers.

To reduce the incidence of occupational cancer, preventive actions against carcinogens in the workplace are important. These measures include avoiding harmful agents, substituting carcinogens with less harmful ones, regulating workplace exposures to carcinogens, providing personal protective equipment, the implementing of no-smoking policies, and the provision of information and training to workers.

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