

# Occupational and Environmental Cancer

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Environmental pollution is one of the main causes of disease, death, and disability worldwide. International Labor Organization (ILO) estimates mortality caused by occupational cancer worldwide to be two times higher than occupational accidents. Approximately, 10 important risk factors account for 85% of all occupational cancers. Factors for occupational cancer includes Asbestos, chemicals such as aniline, chromates, dinitrotoluene, arsenic and its inorganic compounds, beryllium and its compounds, cadmium and nickel compounds, wood dust, crystalline silica, brown coal phosphors, furnace emissions, pollution caused by diesel equipment, Nano-Materials, biological agents, ionizing radiation and non-ionizing radiation, thermal shock, shift work, stress and work while sitting. Also some other environmental factors can cause cancer which concludes air, water and soil pollutions, smoking, sunlight, radon gas, electromagnetic fields, agriculture, behavior and lifestyle (such as alcohol and tobacco consumption, diet, sleep patterns, personal habits and social and cultural environment behaviors). More than 75% of mortality due to cancer can be avoided via controlling occupational and environmental risk factors. Most of cancers are not hereditary and caused by occupational and environmental biological agents, and are potentially preventable. So, it is recommended that more researches should be performed in this field in order to detect more scientific and effective methods to detect number and type of cancers due to occupational and environmental factors.

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## Introduction

Although some of natural activities (volcano, fire, so on) may result to different pollutions to be distributed in environment, human activities is the most critical cause of air pollution [1]. Dangerous chemicals can be randomly distributed in the environment, but a wider range of air pollutants could be released in industrial areas and due to other activities that can harm human health and environment [2]. Air pollution can increase mortality or cause serious diseases with a potential danger for human health [3]. So, environmental pollution is one important cause of disease, death, and disability worldwide [4]. So that, WHO introduces air pollution to be responsible for almost 7 million mortality in the last year [5]. Cancer is the second main cause of mortality worldwide, and after cardiovascular diseases [6,7]. So that, in 2000, approximately 10.1 million peoples were estimated to be affected by it and it is predicted that this rate will reach to 15 million peoples in 2020. Prevalence rate of cancer between years 2000 to 2020 will be approximately three times higher than past, and this rate will be two times higher to 2030 [8,9]. International Labor Organization (ILO) estimates mortality due to occupational cancer worldwide to be two times higher than occupational accidents [10].

“Cancer” is a word for diseases in which cells will be divided in an abnormal and uncontrolled manner. There are a number of well-known conditions that undoubtedly show a correlation between some occupational exposures and some types of cancer [11]. On the other hand, cancer epidemics is one of the most important problems of general health worldwide [10], and due to problems in proving causality, and the time between occupational exposure and cancer, there is no

available information about the actual rate of occupational cancer [12]. Nowadays, Information of estimation of human health and environmental risks are incomplete for more than 10,000 existing chemical compounds, and hundreds of other compounds will be added to this amount annually. Also, the potential of most commercially used materials is not quantified for human exposure [13,14]. Moreover, there are many chemicals which were categorized as harmless or cause of few harms for human health, and after evaluation of risk and doing related tests were recognized to be oncogene (such as asbestos), and/or reproductive disorders (such as thalidomide) [13]. Now, 202 factors have introduced by International Agency for Research on Cancer to be certainly or most probably oncogenes (groups 1 and 2a), and 302 other factors are categorized to be human possible oncogenes (group b2) [15]. A big part of these factors such as cigarette smoke is presented in the daily work or living places [16]. Fig. 1 shows the worldwide mortality rate due to cancer (except skin cancer besides melanoma) based on the Age-Standardized Rate (ASR) [17]. Fig. 1 indicates that about 48,000 cancer cases per year are detected in the United States, about 4-10% of all cancers in the United States and now in the EU account for 53% of all deaths associated with occupational cancer [18]. It is estimated that 19% of worldwide cancer cases are related to environment or occupation that is equal to 1.3 million deaths per year [19].

**Fig. 1** Worldwide mortality due to cancer (except skin cancer besides melanoma) based on age standardized rate (ASR).

Previous estimations of ILO regarding occupational cancers show that 32% of worldwide mortality happens due to occupational cancer [20]. Approximately 1.5 million workers in Australia are potent to have oncogenes exposure [21]. Lung cancer, mesothelioma, leukemia and bladder cancer are some of the most common types of occupational cancers [22,23]. One out of ten cases of lung is a result of occupational exposures [24]. Until recently, cancer was a disease in western and industrial countries, though, in 2008, 56% of new cases (7.1 million) and 63% of total cancer deaths (4.8 million) were reported to occur in low-income and middle-income countries (LMICs) [12,25]. Cancer in many Asian countries is a serious health threat and is the major cause of death in Asia and the Pacific, such as Japan and Korea [26]. Detected cancers in Asia are respectively related to lung, breast, colon, and rectum, and the main cause of death are cancers of lung, stomach, and liver [24, 26,27]. In 2000, there were more than 3 million new cases of cancer and more than 2 million cancer deaths in Asia, and it is predicted that if current management and protective strategies remain unchanged, new detected cases in Asia will arise to 1.7 million cases to 2020 [26]. In the study of Paolo and colleagues that performed to assess cancer among middle and lower middle-income countries (LMICs), and high-income countries (HICs), it became clear that the factor of infection in both groups is decreased, the nutrition and hormone factors in both groups are increased, and job, smoking and alcohol factors in LMICs are increasing, unlike HICs [28].

## Occupational cancers

In the eighteenth century, Percivall Pott was the first one to describe occupational cancer, and by the 1970s, most known oncogenes in the workplaces were found [29, 30]. Occupational cancers are rapidly increasing worldwide [18]. Occupational cancer is related to exposure to factors such as chemicals, dust, radiation, and some industrial processes [31, 32]. Exposure to chemical oncogenes can cause mutations that result to cells to become out of control and cause cancer [33, 34]. Mortality due to cancer and occupational cancer has increased because of an increase in life expectancy and a gradual reduction in other causes of death, such as infectious diseases and injuries [8, 25]. Ten major risk factors for occupational oncogenesis is responsible for around 85% of all occupational cancers [10]. Oncogenic agents in the workplace may include chemicals such as anilines, chromates, dinitrotoluene, arsenic and its inorganic compounds, beryllium and its compounds, cadmium and nickel compounds, wood dust, asbestos, crystalline silica, brown coal phosphors, smoke of furnaces, pollution of diesel instruments, cigarette smoke, sunlight, radon gas, and ionizing and non-ionizing radiation [19, 31, 35,36,37]. Some of the chemicals used in paint, rubber, and other chemical industries are all related to bladder cancer. Fortunately, these

chemicals are now banned [38,39]. Some industrial processes that are related to cancer includes the production of aluminum, iron and steel and underground mines that may cause cancer by exposure to uranium or radon [40]. Also, the shift work, which can disrupt the daily rhythm, is recognized as a risk factor for different types of cancer, especially breast cancer [41,42,43]. Table shows different types of occupational cancers and risk factors, which develop them in different industries [24, 44,45,46,47,48,49,50,51,52,53,54].

## Asbestos

Asbestos is a natural mineral that can damage the lungs [55]. According to survey, nine out of ten people with mesothelioma have been exposed to asbestos [38]. People who work in industries such as shipbuilding and construction may contact asbestos [31, 55]. Since June 1, 2005, the use of asbestos was banned in Europe [56]. Lung cancer is responsible for 54 to 75 percent of all occupational cancers. Epidemiological studies show that exposure to occupational risk factors can result to 8.4% to 5.3% of all cancers, as well as 17 to 29% of total mortality among men due to lung cancer. Asbestos is the cause of 55-85% of lung cancers, which could be prevented previously [10]. Asbestos in 2004 caused the death of 59,000 cases of mesothelioma [57]. Fig. 2 shows environmental and occupational risk factors [58].

## Chemicals

Different chemicals have different toxicities [13]. Overexposure to these materials in the workplace can lead to various illnesses [32]. Also, chemicals or their compounds can cause cancer in high risk people [13]. These materials can be classified as oncogene by scientists. The most important organizations in this field are the International Agency for Research on Cancer (IARC) and the World Health Organization [59]. Chemicals are known causes of occupational cancers [38]. In a limited number of studies, the correlation between chemical exposure and cancer has been thoroughly investigated, and many studies also should be done to assess other hazards, such as physical, pharmaceutical and biological factors [59]. Scientists have proved the association between exposure to endocrine disrupting compounds (EDCs) and the increased incidence of certain cancers such as breast, endometrial, ovarian, testicular, prostate, and thyroid cancers, which have increased during last 40-50 years [60]. The authors mention that exposure to pesticides, some of biphenyl polyphenols (PCBs), and arsenic are the cause of prostate cancer [59, 61,62]. In 2004, exposure to leukaemogens (including benzene, ethylene oxide and ionizing radiation) approximately caused 7,400 deaths due to leukemia [57].

**Fig. 2** *Exposure network of occupation and environment induced lung cancer* \*Solid circles (exposure sources) indicate human carcinogens; Dotted circles indicate human probable carcinogens. Hubs, ETS (environmental tobacco smoking), steel founding, asbestos, PAHs (polycyclic aromatic hydrocarbons), cadmium, and welder were identified as having more than 5 connections within the network\*

## Nano-materials

Nanomaterials can be introduced as emerging cancer risk factors; for example carbon nanotubes and endocrine disruptor components (EDCs) [63]. Some types of carbon nanotubes may cause effects similar to asbestos. A long-term animal study showed that internal injection of all studied Nano materials including black carbon, aluminum oxide, aluminum silicate, titanium dioxide and amorphous silicon dioxide resulted to tumors formation. Nanomaterial power was also calculated to be 5 to 10 times higher than other materials [59].

## Biological agents

Biologic agents can cause cancer development via direct effect (such as hepatitis) or toxic

substances (such as aflatoxins, one of the most powerful toxins) [64]. Chronic B and C hepatitis virus infection can progress to severe long term liver damage such as cirrhosis and hematocritin. In 2000, 656,000 Hepatitis B virus infections in health care workers was reported to be developed due to injuries caused by contaminating activities; And about 16,400 hepatitis C infections have included about 40% of all infections in health care workers. HIV can also be an occupational transmitted agent, and it has been estimated that in 2000, 1,000 HIV infection cases occurred in health care workers. HIV opportunistic infections include cancers such as Kaposi-sarcoma and lymphoma [65]. Some infectious agents, such as Helicobacter pylori (gastric cancer), can be transmitted through contaminated water or food [66].

## **Ionizing radiation**

Ionizing radiation can cause lethal mutations [35]. X-ray is the most well-known ionizing radiation [67]. Nowadays, the use of ionizing radiation has spread, such as rays from radioactive decay, cosmic rays, etc. [68].

## **Non ionizing radiation**

There are many documents show that non-ionizing radiation can cause cancer [69]. For many years, the cancer-causing effect of non-ionizing radiation has been the subject of scientific research. Clapp and colleagues in 2007 explained their new documents regarding environmental and occupational causes of cancer [70]. Ultraviolet Radiation (UVR) of sunlight or artificial sources (such as welding) can cause skin cancer [71]. Exposure to arc welding is associated with an increased risk of eye melanoma [72]. IARC has mentioned this type of radiation in relevant publications (IARC, 2012b) [59]. Other sources of artificial light radiation include the use of sunlight for tanning and solar lamps, as well as exposure to fluorescent lamps at workplace [73].

## **Heat shock**

There are evidences that heat shock leads to damage to Deoxyribonucleic acid [74], which ultimately leads to cancer [75]. Heat shock may occur in furnace workers and melting operators in casting industries and so on [76].

## **Work shift**

Work shift causes daily disorders, which were evaluated for the first time in 2007, and now, as an oncogene agent may be listed by IARC [77]. Workers of shift works may suffer from a rhythm of sleep and awakening and a lack of melatonin [78]. Exposure to light at night causes disturbances in the circadian cycle, possibly due to the combination of melatonin and clock genes, as an important factor in the development of breast cancer [77,78].

## **Stress**

Work-related stress may indirectly lead to cancer, as workers may use coping strategies that include smoking and drug use. In 2003, Fox in his study concluded that stress, regardless of the type, severity or duration of exposure, has little effect on the incidence of cancer [59]. However, few studies have performed to reach any conclusion - even basic- about stress causing factors. However, strong social support may reduce the incidence [79]. However, it should be noted that as stress may increase smoking, drinking, eating or consuming narcotic drugs, could enhance the risk of cancer [80].

## **Sedentary work**

Boyle et al. performed a case-based study and on a population of colorectal cancer patients at West Australia in 2005 to 2007, and found that long-term sedentary work may increase the risk of colon cancer and rectal cancer [81]. A research that has performed using recorded data showed an increased risk of testicular cancer for office workers [82]. Researchers have described the socio-economic status and lifestyle that is without mobility as two main causes of this type of cancer [83]. However, the incomplete occupational data, and the difficulty in finding an appropriate control group for comparing, are the main challenges in assessing these risk factors [84,85]. A part of 256,000 cases of liver, colon, and rectal cancers which are caused by lack of physical activity, can be prevented through transportation policies to encourage biking and walking [57, 86].

## Environmental cancer

The WHO defines the environment as "all the physical, chemical and biological factors external to the human host, and all related behaviors, but excluding those natural environments that cannot reasonably be modified". This definition is actually limited to those parts of the environment that can be controlled, including environmental health impacts such as air, water and soil pollution, electromagnetic fields, occupational, agriculture, behavior and lifestyle hazards (such as alcohol and tobacco consumption, diet, Personal habits and behaviors related to the social and cultural environment) which can be controlled [86]. Therefore, environmental interventions such as elimination or reduction of exposure to oncogene agents in the environment are key to reduce the incidence of cancer-related mortality [66]. The patterns of environmental pollution and the diseases that cause it in the country are very different, and national income and development levels appear to be main responsible for these differences [5]. The most important environmental cancer risk factors are described below:

### Sunlight

One of the main environmental causes of cancer is natural radiation, including the sun [87]. The cause of most skin cancers is prolonged exposure to the sun [88]. The mortality due to ultraviolet radiation in 2000 were estimated approximately 60,000 people, of which 48,000 were melanoma and 12,000 others had scaled skin cancer [89]. Surdu and colleagues performed a study on the effect of UV exposure occupational protection, and found that its results were completely unexpected and limited to people with light skin [74].

### Air pollution

Air pollution caused 108,000 deaths due to lung cancer in 2009 [57]. Solid fuel, which is used for more than half of the population in developing countries for cooking and heating, created 36,000 mortality from lung cancer [57, 90]. Second-hand smoke has resulted in 21,000 mortality due to lung cancer [91]. This was the second most common environmental oncogene in the Europe Union. It is estimated that lung oncogene factors (such as arsenic, asbestos, beryllium, cadmium, chromium, etc.) caused to 111,000 deaths due to lung cancer [57].

### Radon

Environmental risk factors are main factors that are related to cancer, but internal radon plays a decisive role in the causes of cancer in China [92]. Radon is related to the progression of lung cancer [93]. Many of biohazardous agents are related to life style that is also controllable [94]. Radon is the second important factor in lung cancer in many countries, so that 3-14% of all lung cancers (equal to 70-220 million mortality) is determined regarding to Radon mean level in a country [95].

On the other side, gradually, with the increase in the world's population, factors associated with lifestyle (tobacco use, vitality, unhealthy diets, etc.) have become very important [96]. The most



important risk factors related to life style are:

## **Cigarette smoking**

It has been proved that smoking increases the chance of cancer development, so reduction or contradiction with smoking, may decrease the chance of cancer development. Smoking is one of the main causes of lung cancer worldwide [16]. 85% of cases of lung cancer in men are related to smoking [97]. In 2004, lung cancer includes 18% of all types of cancers, of which 938,000 mortality (71%) were related to smoking [57]. In the past years, 17 countries of Europe Union have introduced laws to ban cigarette smoke in public places [59].

## **Nutrition**

Nutrition and diet style is another important risk factor for cancer. The type of nutrients, which is consumed, varies according to geographic regions [98]. Approximately 200 studies have examined the relationship between fruit and vegetable intake and cancers of lung, colon, breast, cervix, esophagus, oral cavity, stomach, bladder, pancreas and ovaries. Consumption of fruits and vegetables has shown a significant protective effect, so that people who consume little fruit and vegetable (at least a quarter of the usual) have a two-fold increase in the risk of cancer [99]. Salt consumption is also highly related to mortality from stomach cancer and brain stroke [100].

## **Social and economic status**

The socio-economic status (and, therefore, probably lifestyle) is described as a risk factor for skin melanoma. Martinsen et al. assessed the diversity in the prevalence of skin melanoma, in five North African countries regarding occupation and socioeconomic status. They compared the data of occupation of 15 million workers to the recorded national mortality. The highest risk was found in dentists, while the risk was increased in managers. The least risk was found in anglers and all non-expert workers also had a lower risk [59].

## **Conclusion**

The data presented in this report shows that exposure to environmental harmful factors is one of the major causes of illness, death and disability worldwide [5, 96]. Almost one third of all cancers can be prevented [34]. More than 75% of mortality due to cancer can be prevented by avoiding risk factors such as: tobacco, overweight /obesity, inadequate diet, physical inactivity, alcohol, sexually transmitted infections, and air pollution [101]. Most of caused by environmental, occupational or non-genetic factors, and are potentially preventable [92]. Because of the sharp increase in the incidence of occupational and environmental cancers, there is a strong need for planning and performing scientific interventions, to minimize the thousands of deaths due to occupational cancer [19]. The health consequences of exposure to environmental harmful agents are major and growing problems, but enough attention has not been paid to them; and it is now the time to pay a global attention to the big problem of environmental pollution problem [5]. It's the time to determine numerical and applicable targets for pollution control. Therefore, the world's response to pollution requires the same degree of difficulty that is performed for AIDS, tuberculosis and malaria. The international community's focus on environmental pollution can save millions lives [5, 102]. The incidence of cancers varies between different countries; so, cancer control programs should be relied on the prevalence of cancer in each country [96]. For example, the prevalence of cancer in Asian countries is very diverse due to the great difference in lifestyle [26]. With industrial progress and economic development, air quality in Asian countries has become worse than past, and air pollution in open air has become a concern. For example, levels of (PAHs) in large Asian large cities, is higher than western countries [103]. Income and developmental level are the main factors for determination of various patterns of environmental pollution and disease [28]. Therefore, research in less developed countries is required, as each country faces unique challenges in which,

there is a cultural, political and economic context [104]. Programs of improving public health and environmental protection are required in all countries at every levels of economic development, and pollution control strategies and technologies that have been successfully developed in developed countries should be transferred to low-income and middle-income countries [5]. Personal protective equipment, engineering and management controls Preventing workplace exposure and employee training, can prevent exposure to oncogenes in the workplace [105]. The prevention of global cancer is an important goal for its application to large populations via promotion of performance and predicted health behaviors, effectiveness and affordability for all socioeconomic groups [37]. Twenty-five years ago, the European Union introduced its first global instruction to improve cancer prevention at the workplace, which at that time the modern law was an important help for protecting workers [10]. For many stakeholders, it's time to adapt laws and policies to new knowledge and emerging risks. It is assumed that occupational and environmental cancers can be eliminated, and this can save many people's lives and significantly is related to overall health. Through the Monographs program, IARC wants to prevent occupational and environmental cancers [106]. On the other hand, all the environmental factors of the cancer, including the background radiation of the sun, can not be controlled, and they cause cancer through inherited genetic disorders. In the future, developing gene modification techniques may serve as preventative measures [39]. For detection of cancer preventative chances in occupational environment, the most common causes of cancer s should be identified, and the relationship between exposure to the agent and development of cancer, should be determined by estimating the risks of exposure to a certain level of exposure. But the important point is that exposure to less than the limit range of oncogenic agents, is one of the most important concerns due to the lack of exposure information (including the duration and number of unexpected exposures and the number of people who may be exposed) [66]. Therefore, quantitative risk assessment is a very important step for making decision in this field [32, 107,108]. To reduce the risk of cancer in workers, preventative strategies should be used at high-risk working environments [13]. Effective Prevention of Occupational Cancer requires knowledge of oncogenes. Professional health is influenced by IT solutions to improve prevention, early diagnosis, treatment, and, ultimately, efficacy and preventative systems. So, IT solutions are important health care issues. Occupational cancer information is important for policy makers, managers, doctors, patients, and researchers, in information systems. Since, information about occupational cancers and their causes can determine labor groups that require special attention. For example, workers exposed to harm can be assessed and considered for preventive interventions [34,109]. Other steps should be taken include: reducing tobacco use, controlling respiratory infectious diseases, and replacing inefficient energy sources with renewable energy sources [104]. In order to assess future occupational cancer, further researches should be focused on assessment of lifestyle factors in occupational environments [94]. So, it is recommended that more studies to be performed in this field to not only determine the number and type of cancers due to occupational and environmental risk factors, but also effective scientific and their preventative methods could be determined.

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