CAREX
CANADA

Surveillance of environmental and occupational exposures for cancer prevention

Mining Industry

Industry Summary Package

This package serves as a summary of CAREX Canada's results on priority exposures to known or suspected carcinogens in the mining industry in Canada. Assembling various CAREX Canada data, tools, and resources, it provides an overview of the most prevalent exposures for those working in the industry, including diesel engine exhaust, crystalline silica, solar radiation, nickel compounds, and polycyclic aromatic hydrocarbons. Our aim is to provide a useful guide for those looking to better understand – and help reduce or eliminate – common carcinogenic exposures associated with the mining industry.

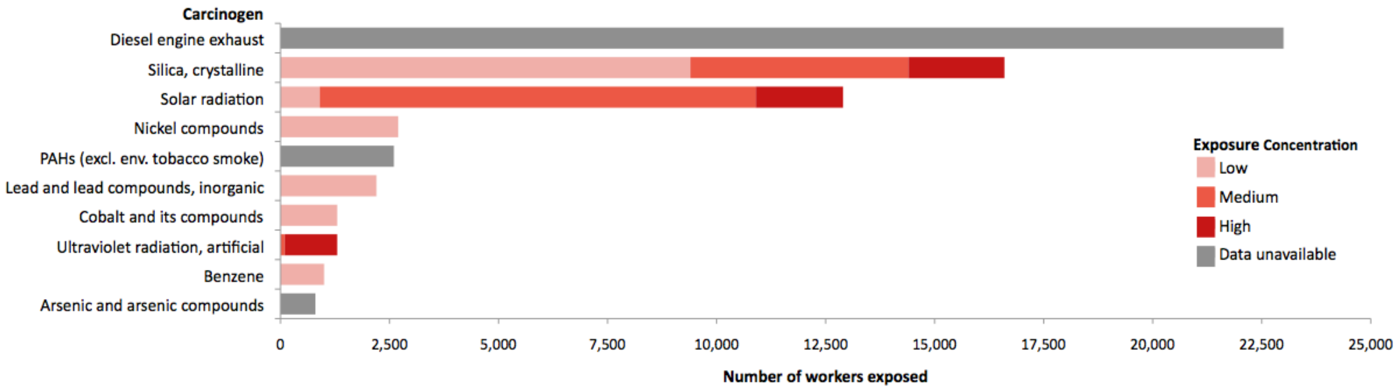
Mining industry in Canada

In 2006, the mining industry employed 63,000 workers, many of those located in Ontario (27%), Quebec (22%), and British Columbia (15%). According to the Mining Association of Canada, mining contributed $8.7 billion to Canada's gross domestic product in 2006. For the purpose of this package, the mining industry is defined herein as the set of establishments that primarily engage in mining, beneficiating or otherwise preparing metallic and non-metallic minerals (including coal), and unspecified mining. Excluded from this industry are establishments that provide support services required for mining and quarrying minerals.

Estimates of prevalent exposures

CAREX Canada estimates of the most prevalent carcinogen exposures in the mining industry are summarized in Figure 1. They include diesel engine exhaust, crystalline silica, solar radiation, nickel compounds, and polycyclic aromatic hydrocarbons (PAHs). As the shading in Figure 1 indicates, some workers are exposed to higher levels of crystalline silica, solar radiation, and artificial ultraviolet radiation.

Figure 1: Top 10 Prevalent carcinogen exposures for the mining industry, CAREX Canada Database, 2006



Note: High prevalence does not necessarily indicate a high health risk. For more information or assistance interpreting the data in this table, please contact us at info@carexcanada.ca.

Exploring the CAREX Canada estimates

eWORK

Our eWORK Tool allows users to explore CAREX exposure data by carcinogen, industry, occupation, province, sex, and exposure level. Currently, two eWORK versions are available for beta-testing: eWORK Excel and eWORK Online. eWORK Excel uses a Microsoft Excel PowerPivot interface that allows users to search for – and visualize – exposures of interest. It is available by request under the Tools tab of our website. eWORK Online, also available under the Tools tab of our website, is for users who prefer quick, accessible, yet high-quality statistics on occupational exposures to various carcinogens.

Profile overviews

The CAREX Canada website contains detailed information on use, production and trade, exposure routes, and health effects for the top ten carcinogen exposures for the mining industry listed above. A sample of these – for the top five exposures – are summarized below. For more detail, including regulations and guidelines for each of these exposures and a list of references, please see our Profiles and Estimates tab.

Diesel Engine Exhaust

Known Carcinogen (International Agency for Research on Cancer (IARC) 1)

What is diesel engine exhaust?

The combustion of diesel fuel in engines produces diesel engine exhaust, a complex mixture of gases and particulates that can contain other known and suspected carcinogens such as benzene, polycyclic aromatic hydrocarbons (PAHs), metals, and particulate matter. The composition of the mixture depends on a number of factors including the type of engine (heavy or light duty), the type of fuel and oil, sulphur levels, speed and load of operation, and emission control systems.

Occupational exposure to diesel engine exhaust

Inhalation is the most common route of exposure. Assessing exposures to diesel engine exhaust is complex due to difficulty separating diesel exhaust exposure from other air contaminants with similar characteristics, in addition to controversies in the best practices for measuring exposure.

Occupations with the largest number of exposed workers in the mining industry include underground production and development miners, heavy equipment operators, and heavy-duty equipment mechanics.

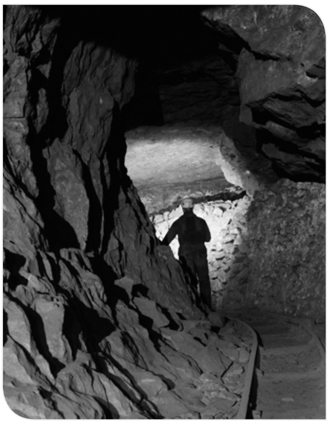
What are its health effects?

Cancer:
There is sufficient evidence linking diesel engine exhaust to lung cancer, and limited evidence for bladder cancer in humans.

Non-cancer:
Short-term exposure to diesel engine exhaust can cause irritation of the eyes, throat, and bronchi, as well as light-headedness, nausea, and respiratory symptoms such as cough and phlegm. Diesel exhaust may initiate allergic reactions or increase immunological response to other allergens.

Crystalline Silica

Known Carcinogen (IARC 1)



What is silica?

Silica is one of the most common minerals on earth and is a basic component of soil, sand, and rocks including granite and quartzite. It exists in both crystalline and amorphous (non-crystalline) forms, with conversion from amorphous to crystalline possible at high heat. Quartz is the most common form of crystalline silica and the most commonly used industrially. Quebec, Ontario, and Alberta are the primary silica producers in Canada, followed by Saskatchewan, British Columbia, and Nova Scotia.

What are the main uses of silica?

Crystalline silica is used in foundry castings, abrasives and sandblasting materials, hydraulic fracturing, silicon and ferrosilicon metal production, and as a filter for large volumes of water (i.e. in municipal water and sewage treatment plants). Flours are very fine grades of crystalline silica and are used in the ceramic and pottery industry, in manufacturing chrysotile cement, as filler in rubber and paints, and as an abrasive in soaps and cleaners.

Occupational exposure to silica

Health concerns arise when silica-containing products are disturbed by grinding, cutting, drilling or chipping, which creates respirable particles. Inhalation is therefore the most important route of occupational exposure. Occupations with the largest number of exposed workers in the mining industry include underground production and development miners, heavy equipment operators, and mining and quarrying supervisors.

What are its health effects?

Cancer:
Epidemiological studies show a relationship between occupational exposure to crystalline silica and increased risk of lung cancer, with the strongest link in quarry and granite workers and workers involved in ceramic, pottery, refractory brick and diatomaceous earth industries.

Non-cancer:
Silicosis, a non-reversible fibrotic lung disease, is caused by inhaling crystalline silica particles. Occupational silica exposure has also been linked to pulmonary tuberculosis, chronic obstructive pulmonary disease, and autoimmune disease (rheumatoid arthritis).

Solar Ultraviolet Radiation

Known Carcinogen (IARC 1)

What is solar ultraviolet radiation?

Ultraviolet radiation (UVR) is a type of ionizing radiation. The main natural source of exposure to UVR is the sun. While UVR is produced by a variety of natural and artificial sources, CAREX exposure estimates for solar UVR does not include exposures from sources other than the sun.

Occupational exposure to solar ultraviolet radiation

Exposure to solar UVR can occur via skin or eyes. Levels of solar UVR exposure vary depending on conditions related to geography, seasonality, time of day and meteorology, as well as time spent out of doors and the amount of exposed skin surface. All outdoor occupations have a potential for exposure to solar UVR. The occupations with the largest number of exposed workers in the mining industry include heavy equipment operators, heavy-duty equipment mechanics, and construction trades helpers and labourers.

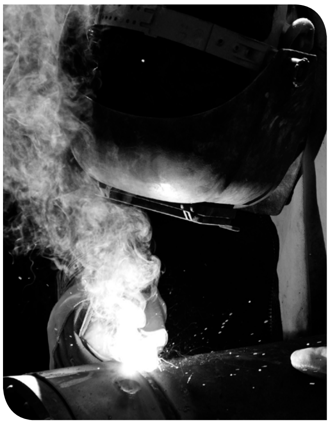
What are its health effects?

Cancer:

Solar UVR is the most important cause of skin cancer, the most common cancer worldwide. Additional studies have found associations between solar UVR and melanoma of the eye and non-Hodgkin's lymphoma.

Nickel

Multiple Classifications (IARC 1, 2B)



What is nickel?

Metallic nickel is a silvery, hard metal or a gray powder not commonly found in nature. It typically exists as a trace constituent in many minerals, particularly those containing magnesium and iron. Nickel's properties of corrosion, heat resistance, hardness, and strength, make it an ideal component of alloys.

What are the main uses of nickel?

Nickel is largely used in stainless steel production, nickel-based alloys, electroplating, casting and alloy steels, and rechargeable batteries. Pure nickel is also used as a catalyst in magnets, electrical contacts and electrodes, spark plugs, and machinery parts.

Occupational exposure to nickel

Inhalation of particles and fumes and dermal contact are the main routes of occupational nickel exposure. Occupations with the largest number of exposed workers in the mining industry include underground production and development miners, welders and related machine operators, and construction millwrights and industrial mechanics.

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What are its health effects?

Cancer:
There is a definite link between exposure to nickel compounds and human lung, nasal, and paranasal cancer. Animal studies have also shown metallic nickel to cause lung cancer and local sarcomas, but there is insufficient epidemiological evidence in humans.

Non-cancer:
Working with nickel (e.g. in nickel refining or welding) can cause chronic bronchitis and decreased lung function, as well as immunological and kidney effects. Nickel exposure is also a common cause of allergic contact dermatitis. Those who are sensitized to nickel may have asthma related to their nickel exposure.

Polycyclic Aromatic Hydrocarbons

Multiple Classifications (IARC 1, 2A, 2B, 3)

What are polycyclic aromatic hydrocarbons?

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 chemicals formed during the incomplete burning of coal, oil, gas, wood, garbage, and other organic substances such as tobacco and charbroiled meat. PAHs occur naturally and generally exist as complex mixtures (i.e. in combustion products). They can also be individually manufactured.

What are the main uses of PAHs?

PAHs are primarily by-products of incomplete combustion and petroleum product production and processing. PAHs are present in coal tar and other products derived from coal tar such as coal tar pitch, creosote, bitumen, and asphalt. Coal tar and associated coal tar products may be used as a fuel, in road and roof paving, in carbon electrode manufacturing, and in wood preservation.

Occupational exposure to PAHs

Inhalation and dermal contact are the main routes of occupational exposure to PAHs. Occupations with the largest number of exposed workers in the mining industry include heavy-duty equipment mechanics, automotive service technicians, truck and bus mechanics and mechanical repairers, and cooks.

What are their health effects?

Cancer:
Due to the fact that PAHs are often found in complex mixtures, the carcinogenic effects of individual PAHs are difficult to assess. Based on evidence from occupational studies of exposed workers, cancers associated with exposure to PAH-containing mixtures occur predominantly in the lungs and skin. Animal studies have shown that a number of pure PAHs are carcinogenic following inhalation, oral, and dermal exposure.

Non-cancer:
PAH exposure is associated with reduced lung function, skin inflammation and lesions, and decreases in immune function.

Exposure control strategies

As outlined by the CCOHS, a variety of strategies can help protect workers from exposures to harmful substances such as carcinogens. These strategies are listed in order of effectiveness in controlling a risk.

Elimination	is the most effective way to control a risk; it involves removing the hazard from the workplace. This process may also involve substitution; an example of a substitution includes using lead-free paints and glazes instead of those that contain lead.
Engineering controls	minimize risk of exposure through strategic modifications or designs of the source of the exposure, such as the plant, equipment, and process. The three types include process, enclosure and/or isolation of an emission source, and ventilation. An example of a process control is using wet methods instead of dry when grinding or drilling to reduce dust.
Administrative controls	alter the way the work is done through rules or policies, such as shorter work times in areas where exposure may occur, as well as implementing safe work practices.
Personal protective equipment (PPE)	provides a barrier between the worker and the hazard. This may include respirators, eye protection, face shields, gloves, and footwear.

For more information on these strategies and which one is appropriate for a situation, please visit the hazard control page of the Canadian Centre for Occupational Health and Safety website. We have also compiled a list of key publications and resources from a detailed scan of exposure reduction resources, which is available on our website.

Methods

The goal of the CAREX Canada project is to estimate Canadians' potential exposures to known and suspected carcinogens in the workplace. CAREX Canada classifies carcinogens based on evaluations made by the International Agency for Research on Cancer (IARC), prioritizing IARC agents that are most relevant to Canadians. Estimates of the numbers of workers exposed to these agents are calculated by industry, occupation, province and sex for 2006 (using the 2006 Census of Population, the most recent census that includes detailed information on industry and occupation). Where data are available, levels of exposure expected in Canadian workplaces are also estimated. CAREX Canada's general approach to producing occupational prevalence and exposure level estimates is summarized in Figure 2.

Data sources

Data used in developing the occupational estimates for crystalline silica, nickel, and PAHs were collected from several sources, including the Canadian Workplace Exposure Database (CWED), which contains approximately 7,600 measurements for crystalline silica exposure, 4,800 measurements for nickel exposure, and 4,200 measurements for exposure to PAHs. These measurements were collected between 1981 and 2004 in Ontario and British Columbia workplaces.

Data for occupational exposures to diesel engine exhaust, crystalline silica, nickel, and PAHs was also collected from scientific peer reviewed publications that addressed exposure in Canada and the United States, as well as technical reports from governments and international bodies.

To develop estimates of both the prevalence and levels of solar ultraviolet radiation exposure, we used a skin cancer prevention workbook developed by the SunSmart program at Cancer Council Australia to identify

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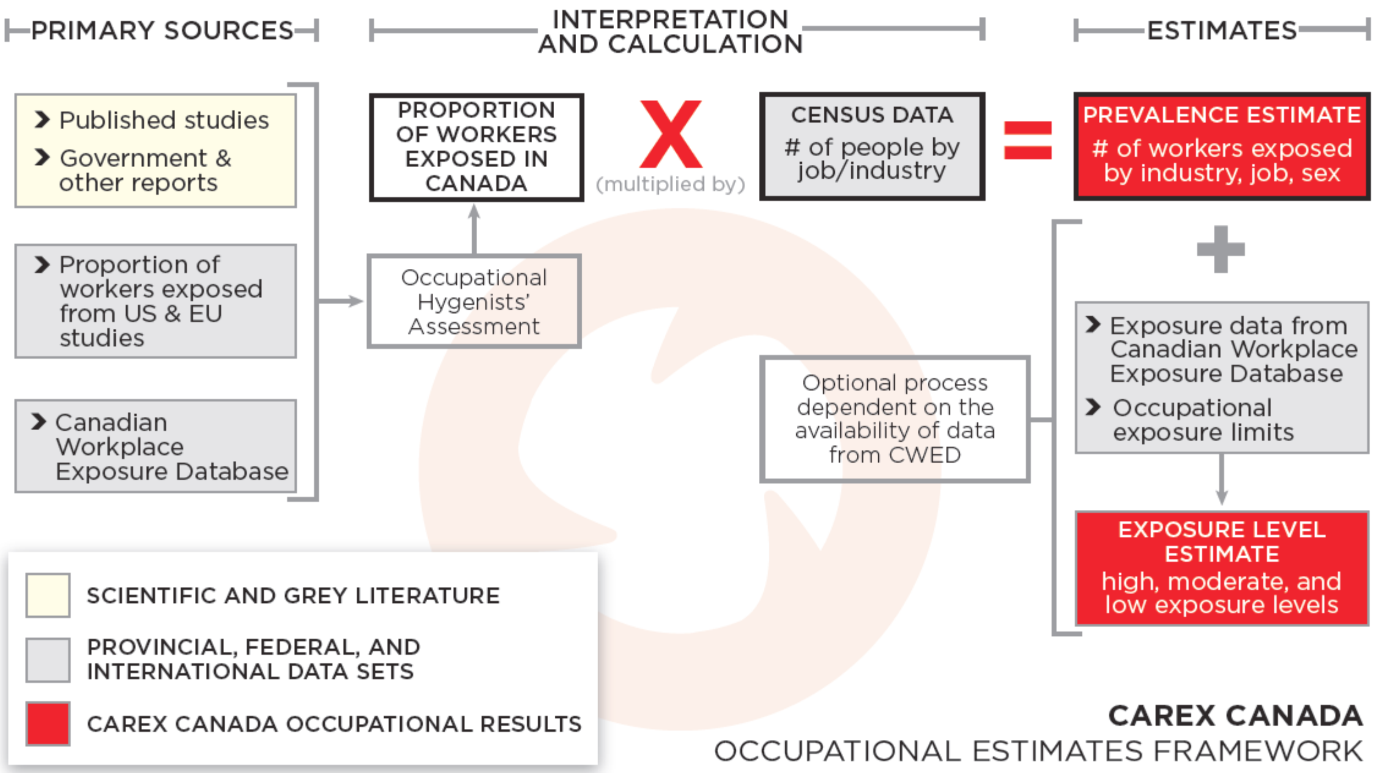
jobs at high risk of exposure. To create the low and moderate categories of exposure, we used websites that describe tasks by job title and include information on whether or not the job includes outdoor work (and how much).

More information on the sources of data can be found online in the Data Sources and Methods tab for each carcinogen.

Figure 2: CAREX Canada's general approach to identifying occupational exposure level and prevalence estimates



Strengths and limitations

One of the key strengths of CAREX Canada's approach is the transparent, systematic, and scientifically rigorous methods used to develop estimates of occupational carcinogen exposures. A challenge that we face is a general lack of current occupational exposure data. Since the 1990s, workplace exposure sampling by regulatory agencies across Canada has significantly decreased. Varied record retention and archiving policies, as well as reduced accessibility to non-electronic data also limit the availability of occupational exposure data. This lack of data may affect both our prevalence estimates and levels of exposure estimates, especially when use of a substance has changed substantially since the 1990s. Another limitation is the lack of information about particular work environments, which can make it difficult to determine appropriate exposure proportions for some occupations and industries. These instances are noted in our documentation.

Where can you learn more?

To learn more about our data sources, methods, and results, and to use our interactive tools, please visit our website at www.carexcanada.ca, email us at info@carexcanada.ca, or follow us on Twitter @CAREXCanada.

For resources on how individuals can reduce their exposures, visit:
CAREX Canada's compilation of exposure reduction resources at
http://www.carexcanada.ca/en/exposure_reduction/
Canadian Centre for Occupational Health and Safety at http://www.ccohs.ca/
Canadian Cancer Encyclopedia at http://info.cancer.ca/cce-ecc/

To learn more about Canadian policies and regulations relating to carcinogens, visit the Canadian Partnership Against Cancer's Prevention Policies Directory at: http://www.cancerview.ca/preventionpolicies.

Relevant publications and reports

IARC Monographs Volume 105: Diesel and Gasoline Engine Exhausts and Some Nitroarenes
International Agency for Research on Cancer, 2013.

IARC Monographs Volume 100C: A Review of Human Carcinogens: Arsenic, Metals, Fibres, and Dusts
International Agency for Research on Cancer, 2012.

IARC Monograph Volume 100D: A Review of Human Carcinogens: Radiation
International Agency for Research on Cancer, 2012.

IARC Monograph Volume 92: Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons and Some Related Exposures
International Agency for Research on Cancer, 2010.

Prevalence of exposure to solar ultraviolet radiation (UVR) on the job in Canada
Peters CE, Nicol AM, Demers PA. Can J Public Health 2012;103(3):223-26.

Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts
Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. Environ Health Perspect. 2014;122(2):172-177.

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