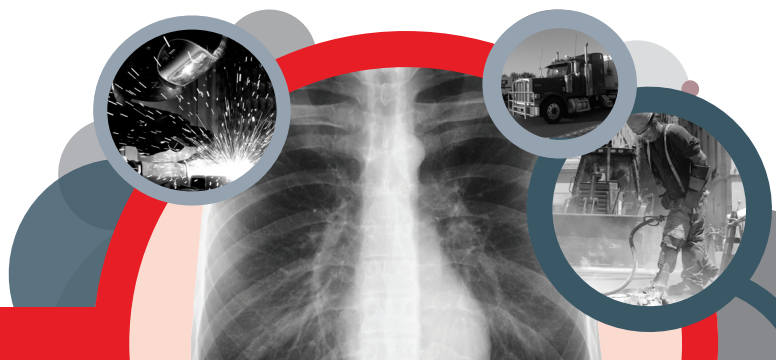




Lung Carcinogens

Occupational Exposure Summary Package

This package serves as a summary of CAREX Canada's results on priority exposures to known or suspected lung carcinogens in Canada. Assembling various CAREX Canada data, tools, and resources, it provides an overview of the most prevalent exposures that are linked to lung cancer, including diesel engine exhaust, crystalline silica, asbestos, nickel compounds, and hexavalent chromium. Our aim is to provide a useful guide for those looking to better understand – and help reduce or eliminate – common carcinogenic exposures associated with lung cancer.

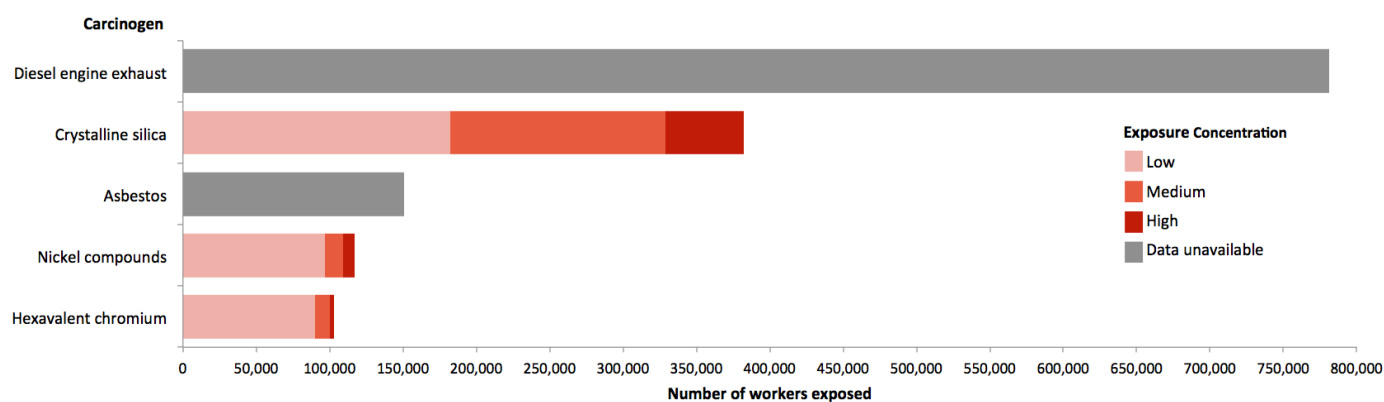
Lung cancer in Canada

Lung cancer is the second most common type of cancer among Canadians behind breast cancer in women and prostate cancer in men (this excludes non-melanoma skin cancers). According to the Canadian Cancer Statistics, an estimated 25,500 Canadians were diagnosed with lung cancer and approximately 20,200 Canadians died of the disease in 2013. Lung cancer is the leading cause of cancer mortality in Canada, resulting in approximately 27% of all cancer deaths.

Estimates of prevalent exposures

CAREX Canada estimates of the most prevalent lung carcinogen exposures in Canada are summarized in Figure 1. They include diesel engine exhaust, crystalline silica, asbestos, nickel compounds, and hexavalent chromium. As the shading in Figure 1 indicates, some workers are exposed to higher levels of crystalline silica, nickel compounds, and hexavalent chromium. Due to various challenges, exposure level data are unavailable for diesel engine exhaust and asbestos at this time. For more information, please visit the Occupational Estimate tab for [diesel engine exhaust](#) and [asbestos](#) on our website.

Figure 1: Top 5 prevalent lung carcinogen exposures for workplaces in Canada, 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.

Radon, the second leading cause of lung cancer in Canada, is an important occupational exposure that has not yet been characterized in Canada. For this reason, it is not included in Figure 1. For more information on radon, please see the profile below.





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 five lung carcinogens listed above. A sample of information from the profiles is summarized below. For more detail, including regulations and guidelines for each of these exposures and a list of references, please see the [Profiles and Estimates](#) tab of our website.

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.

Of those exposed to diesel engine exhaust, the transportation and warehousing, construction, and manufacturing sectors have the largest number of exposed workers in Canada. Occupations with the largest number of exposed workers include truck drivers, heavy equipment operators, and transit operators.

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, BC, 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.

Of those exposed to crystalline silica in Canada, the construction sector has the largest group of exposed workers. Occupations with the largest number of exposed workers include construction trades helpers and labourers, heavy equipment operators, as well as plasterers, drywall installers and finishers, and lathers.

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).



Asbestos

Known Carcinogen (IARC 1)



What is asbestos?

Asbestos is a commercial term for six naturally occurring, fibrous silicate minerals. There are two main classes of asbestos: serpentine and amphibole. The only serpentine variety, chrysotile is the most abundant form and is the most common asbestos fibre used commercially. The five amphibole varieties include amosite, crocidolite, actinolite, tremolite, and anthophyllite.

What are the main uses of asbestos?

Asbestos has been useful for many commercial applications because of its heat resistance, tensile strength, insulating and friction characteristics, as well as its ability to be woven. It has been used primarily for roofing, thermal and electrical insulation, cement pipe and sheets, flooring, gaskets, friction materials, coatings, plastics, textiles, paper, and other products. However, the manufacturing and use of asbestos-containing products is banned or severely restricted in most western countries, including Canada.

Occupational exposure to asbestos

Inhalation is the most important route of occupational exposure. Asbestos fibers vary in length, diameter, and chemical composition, which impacts their ability to enter the body and influences the body's ability to clear the substance.

Workers exposed to asbestos may be involved in mining asbestos-contaminated minerals, manufacturing or using asbestos-containing products, maintaining and repairing brakes, maintaining or demolishing buildings, and asbestos abatement. Of those exposed to asbestos in Canada, the construction industry has the largest group of exposed workers. Occupations with the largest number of exposed workers include carpenters, construction trades helpers and labourers, and electricians.

What are its health effects?

Cancer:

Asbestos has well-established links to mesothelioma, a cancer of the protective lining that covers many of the internal organs of the body, and to lung cancer. A strong synergistic effect exists between tobacco use and asbestos exposure, further increasing the risk of lung cancer. There is also sufficient evidence in humans for laryngeal and ovarian cancer, and limited evidence for colorectal and stomach cancer.

Non-cancer:

Asbestosis, a disease characterized by scar tissue in the lungs and in the pleural membrane, is caused by exposure to high concentrations of asbestos. Symptoms include difficulty breathing, coughing, and in severe cases, heart enlargement, disability, and death.



Nickel and Nickel Compounds

Multiple Classifications (IARC 1 (Nickel Compounds), 2B (Metallic Nickel))



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, and casting and alloy steels. Pure nickel is also used as a catalyst, in magnets, electrical contacts and electrodes, spark plugs, machinery parts, and surgical and dental prostheses.

Occupational exposure to nickel

Inhalation of particles and fumes and dermal contact are the main routes of occupational nickel exposure. Of those exposed to nickel in Canada, the manufacturing sector has the largest group of exposed workers. Occupations with the largest number of exposed workers include welders and related machine operators, machining tool operators, and construction millwrights and industrial mechanics.

What are its health effects?

Cancer:

There is a definite link between exposure to mixtures that include nickel compounds and nickel metal and cancers of the lung, nasal cavity, and paranasal sinuses in humans. Animal studies have shown specifically that nickel monoxide, nickel hydroxides, nickel sulfides, nickel acetate, and metallic nickel cause cancer.

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.

Hexavalent Chromium Compounds

Known Carcinogen (IARC 1)



What are hexavalent chromium compounds?

Hexavalent chromium compounds are most often products of industrial processes. Canada has not mined chromium ores since the early 1900s, although there are deposits across the country. Recent exploration has taken place in Ontario, Manitoba, Quebec, and Newfoundland.

What are the main uses of hexavalent chromium?

Hexavalent chromium is used to manufacture stainless steel and other alloys, pigments, wood preservatives, and to tan leather and finish metal (chrome plating). Chromated copper arsenate (CCA) is a widely used wood preservative that contains hexavalent chromium. The use of CCA-treated wood for residential purposes was voluntarily phased out by the industry at the end of 2003, however CCA is still used for wood preservation in industrial applications such as utility poles, pilings, and highway construction.

(continued on page 6)



Occupational exposure to hexavalent chromium compounds

Inhalation and dermal contact are the most important routes of occupational exposure to hexavalent chromium. Of those exposed to hexavalent chromium in Canada, the manufacturing sector has the largest group of exposed workers. Occupations with the highest prevalence of exposure include welders and related machine operators, printing press operators, and construction millwrights and industrial mechanics.

What are its health effects?

Cancer:

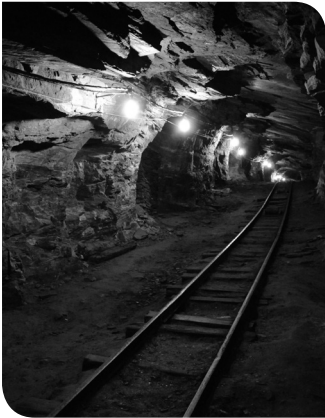
There is a well-established link between hexavalent chromium and lung cancer. Several epidemiological studies have also found increased risks of cancer in the nasal region.

Non-cancer:

Acute inhalation exposure to hexavalent chromium may cause irritation and damage to the nose, throat, and lungs. Dermal exposure may also cause allergic contact dermatitis and skin sensitization.

Radon

Known Carcinogen (IARC 1)



What is radon?

Radon is a naturally occurring radioactive gas found in several isotopic forms. It is produced from the natural breakdown of uranium in soils and rocks and is colorless, tasteless, and odourless.

Occupational exposure to radon

Inhalation is the most important route of occupational exposure. Radon in groundwater, soil, or building materials may enter the working environment and then decay, emitting ionizing radiation. Levels of radon in confined spaces or underground are often significantly higher than outdoor air levels.

The workers with the highest risk of exposure are those involved in underground mining, especially for uranium. Other workers who spend time underground (i.e. subway and utility tunnel workers) are also at increased risk in areas where radon is present. Indoor workers of any type may also be exposed, especially if they work in areas and rooms with higher concentrations of radon (e.g. basements).

What are its health effects?

Cancer:

There is a well-established link between exposure to radon gas and lung cancer, with concurrent exposure to radon and cigarette smoke showing a synergistic effect on the development of lung cancer. In Canada, radon is estimated to account for ~16% of lung cancer deaths every year.



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.

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.

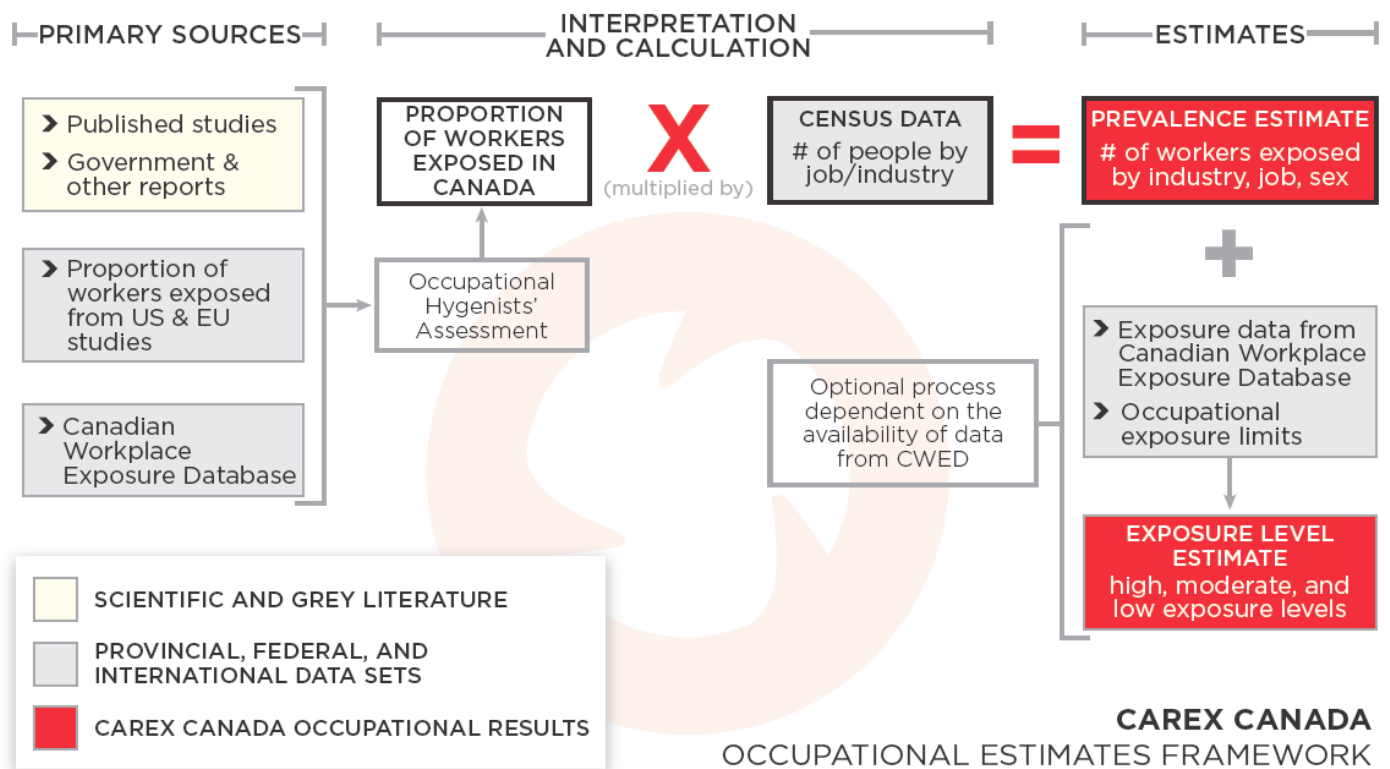
Data sources

Data used in developing the occupational estimates for crystalline silica, asbestos, nickel compounds, and hexavalent chromium were collected from several sources, including the Canadian Workplace Exposure Database (CWED), which contains approximately 7,600 measurements for crystalline silica exposure, 6,700 measurements for asbestos exposure, 4,800 measurements for nickel exposure, and 4,400 measurements for hexavalent chromium exposure. These measurements were collected between 1981 and 2004 in Ontario and British Columbia workplaces.

Data for occupational exposures to diesel engine exhaust, crystalline silica, asbestos, nickel compounds, and hexavalent chromium 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.



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, regulatory agencies across Canada have significantly decreased workplace exposure sampling. Varied record retention and archiving policies, as well as reduced accessibility to non-electronic data also limit occupational exposure data available to CAREX Canada. This lack of data may affect both our prevalence estimates and levels of exposure estimates, especially when the 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](https://twitter.com/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

[Occupational and environmental causes of lung cancer](#)

Field RW, Withers BL. Clin Chest Med. 2012;33(4):681-703.

[CAREX Canada's priority carcinogens – Lung cancer](#)

CAREX Canada Website, 2013.

[IARC Monographs List of Classifications by Cancer Site](#)

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.

[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.

[Lung cancer risk from radon in Ontario, Canada: how many lung cancers can we prevent?](#)

Peterson E, Aker A, Kim J, Li Y, Brand K, Copes R. Cancer Causes Control. 2013;24(11):2013-2020.

CAREX Canada is funded by the Canadian Partnership Against Cancer

