



Ontario

Cancer Care Ontario

Action Cancer Ontario



Cancer Risk Factors in Ontario

Metals

METALS



Risk factor/exposure	Cancer	The context where high risks were reported	Magnitude of risk*	Strength of evidence ^a
Arsenic and inorganic arsenic compounds	Lung	Occupational	1.2–4.7 ^a	Sufficient
		Environmental	1.1–2.2 ^a	
	Skin	Environmental	1.1–2.1 ^{a,b}	
	Bladder	Environmental	1.1–3.3 ^{a,c}	
	Liver	Environmental	...	
	Prostate	Environmental	...	
Nickel compounds	Sinonasal	Occupational	1.1–7.8 ^d	Sufficient
	Lung	Occupational	1.2–3.8 ^a	
Beryllium and beryllium compounds	Lung	Occupational	1.2–2.0 ^{a,e}	Sufficient
Cadmium and cadmium compounds	Lung	Occupational	1.1–1.8 ^a	Sufficient
	Prostate	Occupational	...	
	Kidney	Occupational	...	
Chromium (VI) compounds	Lung	Occupational	1.2–4.0 ^{a,f}	Sufficient
	Sinonasal	Occupational	...	
				Limited

Sources: ^aIARC, 2012 ^bKaragas et al., 2001 ^cMink et al., 2008 ^dINCO Ontario (ICNCM, 1990) ^eSanderson et al., 2001 ^fCole & Rodu, 2005

* Relative risk (RR) estimate for persons exposed vs. unexposed.

... Magnitude of risk not shown in table if strength of evidence is “probable” or “limited.”

ARSENIC AND INORGANIC ARSENIC COMPOUNDS

Background

- » Arsenic is a semi-metal, with both metallic and non-metallic properties. Elemental arsenic is rare in the earth’s crust; it is usually found as inorganic arsenic compounds in complex minerals containing lead, iron, nickel and other metals.¹²⁴
- » Arsenic is currently used or has historically been used in several commercial applications, including pharmaceuticals, wood preservatives, agricultural chemicals and pesticides, the production of alloys, glass-making and in the mining industry.¹²⁴
- » Environmental sources of arsenic include volcanic activity, air emissions from mining and smelting operations, and the burning of fossil fuels. It can also leech into water sources and the soil from geologic deposits or rocks containing arsenic, mines and industrial sources.¹²⁴
- » Ingestion of food or water contaminated with arsenic is the primary route of exposure for the general population, while inhalation of airborne particles is the primary occupational exposure route.¹²⁴

- There is consistent evidence that arsenic and inorganic arsenic compounds cause cancers of the lung, bladder and skin (primarily squamous cell carcinoma).¹²⁴ The evidence for these sites comes from studies examining inhalation of arsenic and its compounds in workers and of populations who ingested high concentrations in drinking water.¹²⁴
- Workers exposed to arsenic have 1.2–4.7 times the lung cancer risk of unexposed workers.¹²⁴

- A 1.1–2.2 times greater risk of lung cancer,¹²⁴ a 1.1–2.1 times greater risk of skin cancer^{124,139} and a 1.1–3.3 increased risk of bladder cancer^{124,140} is seen among individuals exposed to arsenic in drinking water at levels similar to those found in Canada;^{139,141,142} higher risks are seen in studies of heavily contaminated areas.
- All associated cancer types show strong and consistent evidence of **dose-response** relationships with concentration, duration and cumulative exposure.¹²⁴ For lung cancer, a **synergistic relationship** exists between ingestion of arsenic in drinking water and cigarette smoking, with the risk from arsenic substantially elevated in smokers.¹²⁴
- There are several proposed biologic mechanisms including oxidative DNA damage, genomic instability and **epigenetic** effects.¹²⁴

NICKEL COMPOUNDS

Background

- » Nickel is a hard metal that is found naturally in combination with other elements in the earth's crust and soil, and is emitted from volcanoes.¹⁴³
- » Nickel and nickel compounds are used in many processes, including the production of a variety of alloys (including steels), plating, electroforming, the production of batteries and as catalysts to increase the rate of chemical reactions.¹⁴³
- » Environmental sources of nickel include emissions from natural (e.g., volcanic activity, weathering of nickel-containing rocks or soil) and industrial sources (e.g., mining, milling, smelting).¹²⁴
- » Ingestion of food contaminated with nickel, and to a lesser extent nickel in drinking water is the primary route of exposure for the general population.^{108,124} Inhalation of dust particles or fumes containing nickel and skin contact are the primary routes of occupational exposure, although ingestion is also possible.¹⁰⁸

- Nickel compounds increase lung and sinonasal cancer risk in nickel refinery workers and lung cancer risk in nickel smelter workers.¹²⁴
- Workers exposed to nickel compounds have a 1.2–3.8 times greater risk of lung cancer than unexposed workers.¹²⁴ Specific forms of nickel such as nickel chloride, nickel sulfate, water-soluble nickel compounds in general, insoluble nickel compounds, nickel oxides, nickel sulfides and mostly insoluble nickel compounds, demonstrated increased risks of lung cancer in humans.¹²⁴ The strongest evidence for a **dose-response** relationship is with cumulative exposure to water-soluble nickel compounds.¹²⁴
- Workers exposed to nickel compounds have a 1–8 times higher risk of sinonasal cancer than unexposed workers,^{124,144} with even higher risks seen in some studies of this rare and therefore challenging to study cancer. A **dose-response** relationship exists for cumulative exposure to water-soluble nickel and nickel oxide compounds.¹²⁴
- There are many established biologic mechanisms for **carcinogenesis**, including DNA damage, chromosome aberrations and inhibition of DNA-repair mechanisms.¹²⁴

BERYLLIUM AND BERYLLIUM COMPOUNDS

Background

- » Beryllium is a metal occurring naturally in rocks, coal, oil, soil and volcanic dust.¹²⁴
- » Most beryllium is converted into alloys, which are used in automobiles, computers, sports equipment and dental bridges.¹⁴⁵ Other industries that use or produce beryllium and beryllium products include aerospace, defence, energy and electrical, fire prevention, consumer products (eg., camera shutters, bellows, computer disk drives), manufacturing and telecommunications.¹⁴⁶
- » Occupational exposure accounts for the majority of human exposure to beryllium, with inhalation of dust and dermal contact the main routes of exposure for this group.¹⁰⁸ Ingestion of food or water contaminated with beryllium is the primary route of exposure for the general population.^{108,124}

- The evidence for an increased risk of lung cancer is primarily based on workers in beryllium processing plants, with the highest risk seen in workers hired before 1950 when exposures were the highest.¹²⁴
- There is a 20% increased risk to as much as a 2 times increased risk of lung cancer among workers exposed to beryllium,^{124,147} with evidence for a [dose-response](#) relationship that was strongest for the 10-year lag average-concentration exposure metric.¹²⁴
- The established biologic mechanisms include chromosome aberrations, aneuploidy and DNA damage.¹²⁴

CADMIUM AND CADMIUM COMPOUNDS

Background

- » Pure cadmium is a soft metal found in the earth's crust.¹²⁴
- » The primary use of cadmium is in electrodes for nickel-cadmium (Ni-Cd) batteries in the form of cadmium hydroxide.¹²⁴ Cadmium compounds are also used in many other applications, including pigments, coatings and platings.¹⁴⁸
- » Inhalation is the primary route of exposure in occupational settings.¹⁴⁸ The highest potential exposures occur in occupations such as cadmium production and refining, Ni-Cd battery manufacturing, cadmium pigment manufacturing and formulation, cadmium alloy production, mechanical plating, zinc smelting, brazing with a silver-cadmium-silver alloy solder, and polyvinylchloride compounding.¹²⁴
- » The most common source of exposure to the general population is ingestion of contaminated food and inhalation of cigarette smoke.¹²⁴

- Increased risks for lung cancer have been observed largely in studies of workers in cadmium plants and in a population-based study of residents in Belgium living near polluted areas.¹²⁴

- Workers exposed to cadmium have a 10%–80% increased risk of lung cancer;¹²⁴ some studies demonstrated increased **relative risks** as high as 2.2–2.7 for the highest exposure categories.¹⁴⁹ The strongest evidence for **dose-response** relationships is with duration of employment and intensity of exposure. There is also some evidence of increasing risk with cumulative exposure.¹²⁴
- The biologic mechanisms by which cancer risk is increased include DNA-repair inhibition and disturbance of tumour-suppressor proteins leading to genomic instability.¹²⁴

CHROMIUM (VI) COMPOUNDS

Background

- » Chromium is a metal occurring naturally in rocks, animals, plants and soil. There are three main forms of chromium: chromium (0), chromium (III) and chromium (VI).¹⁵⁰
 - » Chromium (VI) compounds, known as hexavalent chromium, are rarely found in nature, but are manufactured to be used in a variety of processes and applications, including pigment for textile dyes, paints, inks, plastics, corrosion inhibitors, wood preservatives and metal finishing. They can therefore be found in several consumer products, such as stainless steel cookware.¹⁵⁰
 - » Occupational exposures are the most likely source of high human exposure to chromium (VI) compounds, with inhalation of dusts, mists or fumes and skin contact with these compounds as the main routes of exposure.¹⁵⁰
 - » Environmental exposure can occur through inhalation of contaminated outdoor and indoor air or ingestion of contaminated water.¹⁵⁰
- Chromium-exposed workers have an increased risk of lung cancer, which was demonstrated in the 1980s. Evidence comes mainly from studies of workers in the production of chromate and chromate pigment production, and in chromium electroplating.¹²⁴
 - A recent **meta-analysis** found a 20% increase in lung cancer risk from exposure to chromium (VI) when controlling for smoking;¹⁵¹ some studies have found up to a 4 times higher risk in chromium-exposed workers.¹²⁴
 - The biologic mechanisms of **carcinogenicity** include direct DNA damage after the reduction of chromium (VI) to chromium (III), mutation, genomic instability, aneuploidy and cell transformation.¹²⁴