CHRONIC RESPIRATORY DISEASE REPORT

Highlights from the Occupational Disease Surveillance System

SPRING 2022

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TABLE OF CONTENTS

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INTRODUCTION

Workers are exposed to toxic substances in the workplace primarily through inhalation of dust, fibres, fumes, and gases in the air. Thus, it is not surprising that many of the important occupational diseases occur in the lungs. Some of the most common respiratory hazards, such as asbestos, crystalline silica, and diesel engine exhaust, cause both cancer and other diseases. This report will focus on some of the most important chronic occupational lung diseases. Specifically, it will focus on long latency diseases, which are often diagnosed many years after exposure and are challenging in terms of recognition and compensation.

The goal of this report is to identify groups of workers, based on their occupation or industry, that are at increased risk of respiratory disease to promote recognition and prevention of these diseases.

High risk groups in this report are identified using the Occupational Disease Surveillance System (ODSS). The ODSS is a unique system that can identify patterns and trends in work-related disease in Ontario. It was created by linking information for over 2.3 million former workers' compensation time-loss claimants to existing provincial health databases to study their long-term risk of occupational disease. These health databases include the Ontario Cancer Registry, doctor visits (Ontario Health Insurance Plan (OHIP) eClaims Database), hospital visits (Discharge Abstract Database), and emergency room visits (National Ambulatory Care Reporting System). Together, these allow us to examine the risk of many diseases in hundreds of different occupations and industries. The ODSS was initially developed with funding from the Workplace Safety and Insurance Board of Ontario, the Ontario Ministry of Labour, Training and Skills Development, and the Public Health Agency of Canada. Ongoing activities are funded by the Ministry of Labour, Training and Skills Development and the Ministry of Health. The ODSS is part of the Occupational Disease Surveillance Program based at Ontario Health.

Most occupational diseases go unrecognized. For example, lung cancer and chronic obstructive pulmonary disease (COPD) are often assumed to be caused solely by cigarette smoking (their most common cause) and as a result, cases that are work-related face serious challenges in being recognised by the health care and compensation systems. The diseases discussed in this report often take a long time to develop and may be diagnosed many years after exposure, which further adds to the challenges of recognition. Occupational and non-occupational cases are indistinguishable in a clinical setting without a thorough history being taken by health care providers and it is challenging to identify exposures that may have occurred long ago. Without that recognition, only a small fraction of cases receives workers' compensation, and we lose one of our major incentives for prevention.

This report begins with lung cancer and COPD, which are two of the most common lung diseases and have multiple workplace causes. This is followed by three relatively rare diseases - mesothelioma, asbestosis, and silicosis – with well understood causes. The primary cause of mesothelioma is asbestos, largely through occupational exposure. Asbestosis and silicosis are, by definition, caused by asbestos and crystalline silica, respectively. Given what is known, recognition should not be challenging and yet not all people with these diseases are compensated. Lastly, we examine idiopathic pulmonary fibrosis (IPF), which is similar to asbestos and silicosis, however the word idiopathic means the causes(s) of the disease have not been identified.

LUNG CANCER

Lung cancer is the most common cancer in Canada and the leading cause of cancer death.[1] It has very poor survival; only 19% of people with lung cancer survive for 5 years after their diagnosis.[2] Smoking is the main cause of lung cancer, but workplace exposures are an important contributor to risk. An estimated 15% of all lung cancers are due to known, well-studied workplace exposures (24% of cases among men and 3.4% cases among women).[3]

The Burden of Occupational Cancer in Canada report[4] published by the Occupational Cancer Research Centre (OCRC), estimated the number of current cancers due to past exposure to workplace carcinogens. Based on this burden report, asbestos, crystalline silica, diesel engine exhaust, and welding fumes were identified as the four most important workplace lung carcinogens in Canada. Secondhand smoke, radon, and nickel are also important contributors. While exposure levels may have changed over time, exposure to these carcinogens persists in many workplaces.

In addition, the International Agency for Research on Cancer (IARC) has identified dozens of lung carcinogens based on studies of workplaces (see Table 1).[5]

In many cases, it is difficult to estimate the number of cancers caused by these exposures due to the lack of information on the number of people who were exposed and their level of exposure. Ultimately, this may lead to an underestimation of the impact of occupational exposures. Workers employed in various occupations and industries show increased risks of lung cancer.

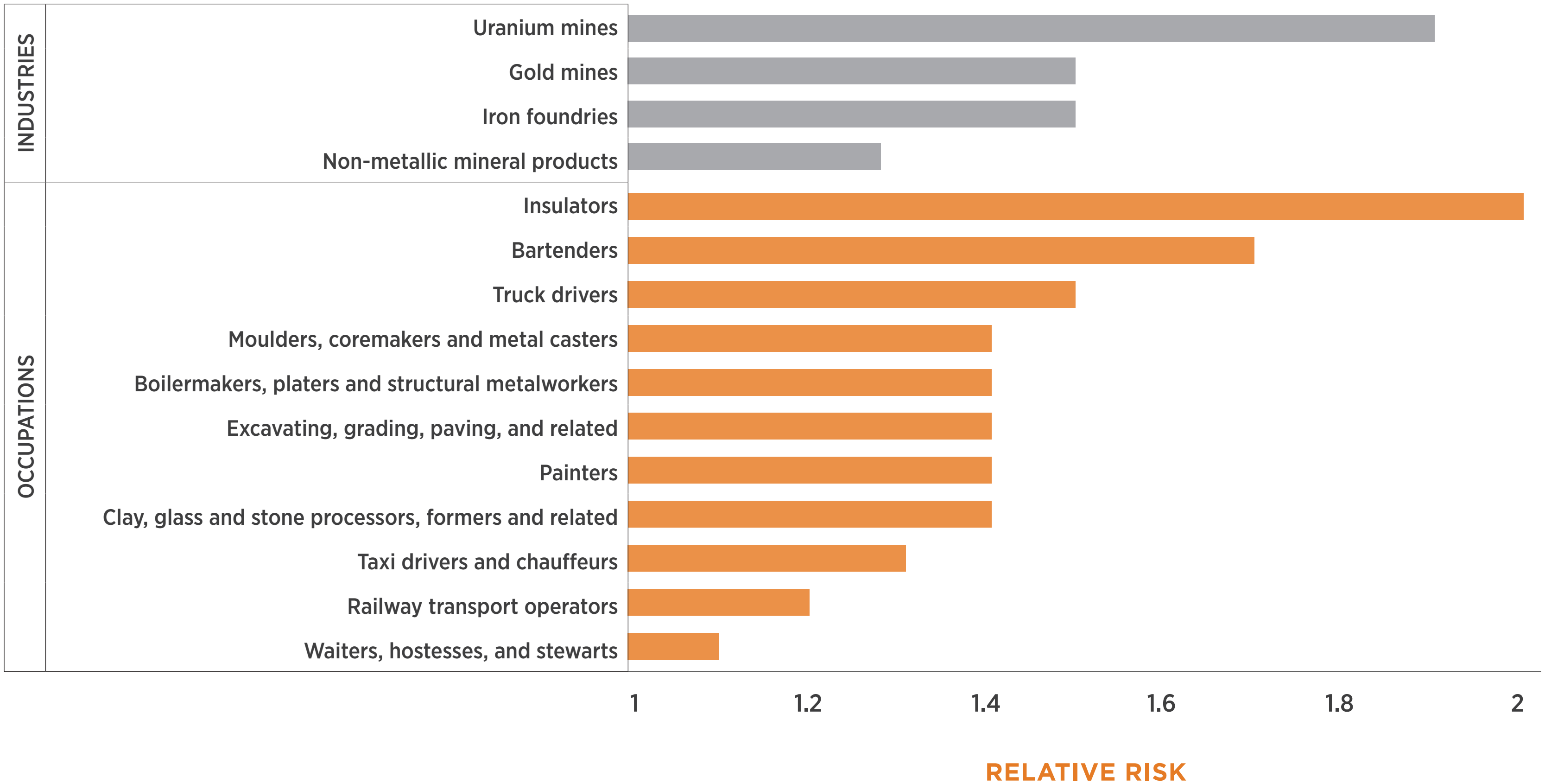


Figure 1. Risk of lung cancer in selected industry and occupation groups compared to all other workers in the ODSS.[1] Industry groups are shown in grey and occupation groups are shown in orange.

[1] For example, insulators had 2 times the risk for lung cancer compared to all other workers in the ODSS.

RISK OF LUNG CANCER IN ONTARIO WORKERS

Workers employed in mining are exposed to several respiratory carcinogens that increase their risk of lung cancer. Exposure to diesel engine exhaust and crystalline silica is common across the Ontario mining industry, while some mining and quarrying workers may also be exposed to nickel, radon, and arsenic.[6-8] For example, Ontario's former **uranium miners** are recognized for their exposure to radon gas,[9] and **gold miners** to arsenic.[10]

Workers in construction trades are also potentially exposed to a wide range of lung carcinogens. Elevated risks of lung cancer are seen among workers in **excavating, grading, paving and related occupations.** This may be due to exposure to diesel engine exhaust and crystalline silica dust, as well as bitumens, a suspected cause of lung cancer.[11-13] Increased risk of lung cancer is also detected among workers employed in other construction trades, such as **painters** and **insulators.** Painting is recognized as a high-risk occupation for lung cancer, possibly due to various hazardous chemicals in paint pigments, resins, and filaments.[14] Historically, insulators handled asbestos-containing materials when installing or removing insulation from buildings. Many other construction workers continue to be exposed to asbestos during renovation, repair, or demolition of older buildings.

In the transportation and equipment operating sectors, workers may be exposed to diesel engine exhaust if they work in or around diesel-powered equipment. Increased lung cancer risk is seen among **truck drivers** and **railway operating occupations,** where use of diesel engines is common.[15] **Taxi drivers** also have an increased risk of lung cancer. They may have been exposed to secondhand smoke from passengers prior to the ban on smoking in enclosed workplaces and public spaces in 2006.[16] In addition, it is important to remember that IARC has classified outdoor air pollution as a lung carcinogen.[17] Traffic is a major source of air pollution in urban areas and near major roadways, and professional drivers may have much higher exposures at work than the general population.

Workers in primary metal industries are exposed to various lung carcinogens, including silica, asbestos and metal fumes. For example, in **iron foundries**, silica is used in the metal moulds and in the bricks lining the furnaces. Furnaces and other hot operations have historically been insulated with asbestos until the 1990s. Workers in this industry showed an increased risk of lung cancer, as did workers in **moulding, coremaking, and metal casting occupations.** Other metal processing and metalworking occupations, such as **boilermakers,** also showed an increased risk of lung cancer. Asbestos was also commonly used to insulate boilers and boiler rooms and welding is common among boilermakers. Boilermakers may be employed in both the manufacturing and construction sectors.

Work related to **non-metallic mineral products manufacturing** showed an elevated risk of lung cancer due to exposure to silica and asbestos. This industry includes concrete and concrete products manufacturing and, in the past, the manufacture of asbestos containing products, including asbestos containing cement products such as pipes.[18] Asbestos exposure is also likely in asbestos and vermiculite products manufacturing. Similarly, workers in **clay, glass, and stone processing** and forming occupations are also at increased risk of lung cancer. Workers in these occupations may perform tasks such as grinding, crushing, and mixing stone and other non-metallic minerals, which releases an abundance of silica dust into the air.

In Ontario, smoking was allowed inside restaurants and bars until 2006, and on uncovered patios until 2015.[16] Prior to then, people working as **bartenders** and **waiters** may have been exposed to high levels of secondhand smoke. Emissions from high temperature frying and cooking may also contribute to risk of lung cancer.

We have highlighted key groups in this section that are important to consider for prevention. There are many other groups with elevated risks of lung cancer identified in the ODSS and these findings can be found in the Jung et al paper published in 2017.[19]

The following is a list of occupational (work-related) agents with sufficient or limited evidence of lung cancer in humans based on the International Agency for Research on Cancer (IARC) list of classifications by cancer site.[5]

This list does not include agents that are unlikely to be major workplace exposures. It also does not include exposure circumstances such as iron and steel founding, coke production, rubber production, which were classified in the past because of patterns of increased risk that could not be linked to specific exposures.

SUFFICIENT EVIDENCE FOR LUNG CANCER IN HUMANS

- Arsenic and inorganic arsenic compounds
- Asbestos (all forms)
- Beryllium and beryllium compounds
- Bis(chloromethyl)ether; chloromethyl methyl ether (technical grade)
- Cadmium and cadmium compounds
- Chromium (VI) compounds
- Coal-tar pitch
- Engine exhaust, diesel
- Nickel compounds
- Painting
- Plutonium
- Radon-222 and its decay products
- Silica dust, crystalline
- Soot
- Tobacco smoke, second hand
- Welding fumes
- X-radiation, gamma radiation

LIMITED EVIDENCE FOR LUNG CANCER IN HUMANS

- Acid mists, strong inorganic
- Benzene
- Bitumens, occupational exposure to oxidized bitumens and their emissions during roofing
- Bitumens, occupational exposure to hard bitumens and their emissions during mastic asphalt work
- Alpha-chlorinated toluenes and benzoyl chloride (combined exposures)
- Cobalt metal with tungsten carbide
- Creosotes
- Diazinon
- Fibrous silicon carbide
- Frying, emissions from high temperature
- Hydrazine
- Insecticides, non-arsenical, occupational exposures in spraying and application
- Printing processes
- 2,3,7,8-tetrachlorodibenzo-para-dioxin

CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

Chronic obstructive pulmonary disease (COPD) is a respiratory condition that causes breathing problems, including coughing, wheezing, shortness of breath, and mucus production. Chronic bronchitis and emphysema are two of the most common diseases within COPD. It is one of the most common chronic respiratory diseases in Canada and was the fourth leading cause of death in Canada in 2012.[20-21] Smoking is the most common cause of COPD, although the American Thoracic Society and European Respiratory Society estimate that 14% of all COPD cases are caused by workplace exposures to dusts, fibres, and fumes.[22] COPD has been linked to a wide range of organic and inorganic substances common in workplaces, including cotton dust, farm dust, grain dust, wood dust, welding fumes, and crystalline silica.[23] The groups presented here highlight the diversity of risk factors for COPD.

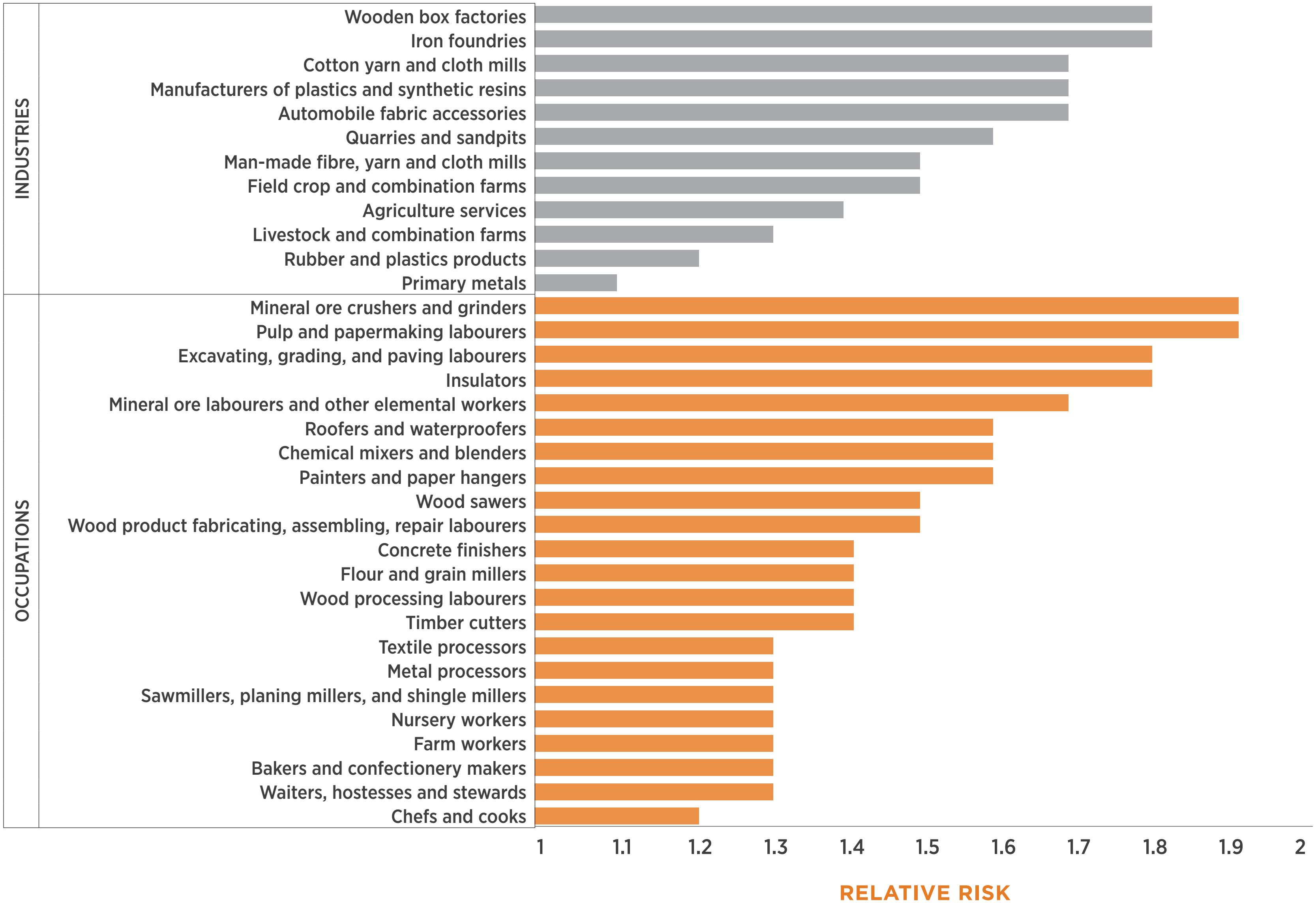


Figure 2. Risk of COPD in selected industry and occupation groups compared to all other workers in the ODSS.[2] Industry groups are shown in grey and occupation groups are shown in orange.

[2] For example, mineral ore crushers and grinders had 1.9 times the risk for COPD compared to all other workers in the ODSS.

RISK OF COPD IN ONTARIO WORKERS

Farming and agricultural work may involve exposure to organic dusts (including grain dusts, and mixtures of plant, animal and microbial dusts) which contain endotoxins, a pro-inflammatory agent, that can induce bronchitis and other respiratory concerns leading to increased risk of COPD.[24] Farmers and farm workers may also be exposed to diesel engine exhaust while driving diesel-powered tractors and using other diesel-powered equipment. **Farm workers** have an elevated risk of COPD, as do other groups of agricultural workers, such as those in **nursery and related occupations, services incidental to agriculture,** or those working on **field crop** or **livestock farms. Field crop and livestock farmers** may be exposed to organic and inorganic dusts, ammonia, and hydrogen sulfide that play a role in risk of COPD.[25]

Flour and grain dusts are common exposures among workers in **flour and grain milling** and **baking** occupations, who have an increased risk of COPD in the ODSS. Flour dusts can contain various contaminants including fungi, chemical additives, endotoxins, and insects and mites.[26] There may also be a higher risk for respiratory symptoms in bakery and mill workers with sensitizations to allergens, especially for fungal amylase found in flour improvers.[26-28]

Some food service occupations, such as **chefs** and **waiters,** also show an increased risk of COPD. Flour and grain dusts may be risk factors for chefs and cooks, and they are also exposed to polycyclic aromatic hydrocarbons (PAHs) in cooking fumes. Waiters may have been exposed to second-hand smoke prior to bans on smoking in restaurants and patios.

Some sectors of the textile industry also have an increased risk of COPD, especially in establishments that make cloth and yarn from **cotton** or **man-made fibres,** as well as those that make **automobile fabric accessories.** Workers in these industries may be exposed to cotton and other organic dusts as well as synthetic fibres, although the strongest evidence exists for cotton dust, due to contamination from endotoxins.[29-30] Similarly, workers in **textile processing occupations** also show an increased risk of COPD.

Several industries and occupations with exposure to wood dust have elevated COPD risks. For example, workers in wood manufacturing industries such as **sawmills** and **wooden box factories** have likely to have high exposure to wood dust. Similarly, workers in **wood sawing occupations** and **labourers in wood products fabricating, assembling, and repair** and **wood processing** are at increased risk of COPD. Workers in forestry jobs, such as **timber cutting occupations,** often cut wood causing exposures to wood dust and potentially mould and diesel engine exhaust. **Labourers in pulp and papermaking** may be exposed to wood and paper dust, as well as asbestos used to insulate the high-temperature processes. Pulp mill workers involved in bleaching may also be exposed to ozone and chlorine dioxide/sulphur dioxide, which have both been shown to be respiratory irritants.[31]

Construction trades workers are exposed to several possible risk factors, including asbestos, crystalline silica, diesel engine exhaust, cement and concrete dusts, wood dust, welding fumes, asphalt fumes, and molds/spores, depending on the tasks they perform.[24, 32-33] There is an elevated risk of COPD in the construction trades overall, and certain trades have even higher risks. For example, **insulators** may be exposed to asbestos, fiberglass, and other man-made fibres when handling insulation.[24, 34] **Labourers in excavating, grading and paving occupations** may be exposed to a number of risk factors such as crystalline silica and asphalt fumes. Other groups with high risk of COPD include **painters and paperhangers, roofers, and concrete finishers.** Construction sites often have multiple trades working simultaneously and workers can also be exposed to agents that are not directly related to their trade, known as exposure drift.

Silica exposure is a major risk factor for COPD in the mining industry. Mining workers may also be exposed to high levels of other inorganic dusts, as well as diesel engine exhaust from heavy equipment.[24, 35-37] Tasks such as drilling, blasting, and cutting rock and stone can create large amounts of dust. Occupations related to **crushing and grinding mineral ores** have a particularly high risk of COPD as they are exposed to increased levels of dusts. **Labouring and other elemental work** also had an elevated risk of COPD.

By industry, risk of COPD was particularly elevated in **quarries and sandpits** where workers can be exposed to dusts.

Metal processing workers can be exposed to metal fumes and dusts when performing tasks such as melting, heat-treating, rolling, moulding, casting, extruding, plating metal, or welding. Many workers in the **primary metal industries** were at increased risk of COPD including those working with copper and iron. Metal fumes, consisting of iron and other additive metals, can lead to respiratory disfunction and suppress immune responses.[38-39]

Within the ODSS, workers in the **plastics and synthetic resins manufacturing** industry had elevated risks of COPD, as did workers in **rubber and plastic products manufacturing,** although studies in the literature are sparse.[40] By occupation, workers who **mix and blend chemicals and related materials** are at increased risk of COPD. Workers in these types of groups may be exposed to a variety of chemical dusts and fumes that increase their risk of COPD.

ASBESTOSIS AND MESOTHELIOMA

Asbestosis and mesothelioma are chronic diseases caused by exposure to asbestos and asbestos-like fibres.[41] Asbestosis is a serious disease that involves scarring and stiffening of lung tissue, causing shortness of breath, coughing, and difficulty breathing. It is generally associated with high levels of asbestos exposure.[42] Mesothelioma is an aggressive cancer of the tissue lining the lungs and other organs and may be associated with even low levels of exposure.[43] Both diseases generally take decades to develop after exposure, although this "latency period" can be even longer for mesothelioma than asbestosis[44]. Mesothelioma has very poor survival and according to the recent mesothelioma surveillance and prognosis research brief published by OCRC, only about 40% of people survive one year after diagnosis in Ontario.[45] It is estimated that 80-85% of all mesothelioma cases are associated with occupational asbestos exposure[43,46] and the remainder is likely due to environmental exposure to asbestos.

Although levels of exposure to asbestos have been regulated for many decades, more specific regulations in Ontario came into effect when the Regulation Respecting Asbestos (Ontario Regulation 570/82) and the Regulation Respecting Asbestos on Construction Projects and in Building Repair Operations (Ontario Regulation 654/85) were filed, in 1982 and 1985 respectively. Canada banned almost all new use of asbestos in 2018. However, due to the long latency of both asbestosis and mesothelioma, and the presence of asbestos in older products and building materials, these diseases will continue to occur for many decades.

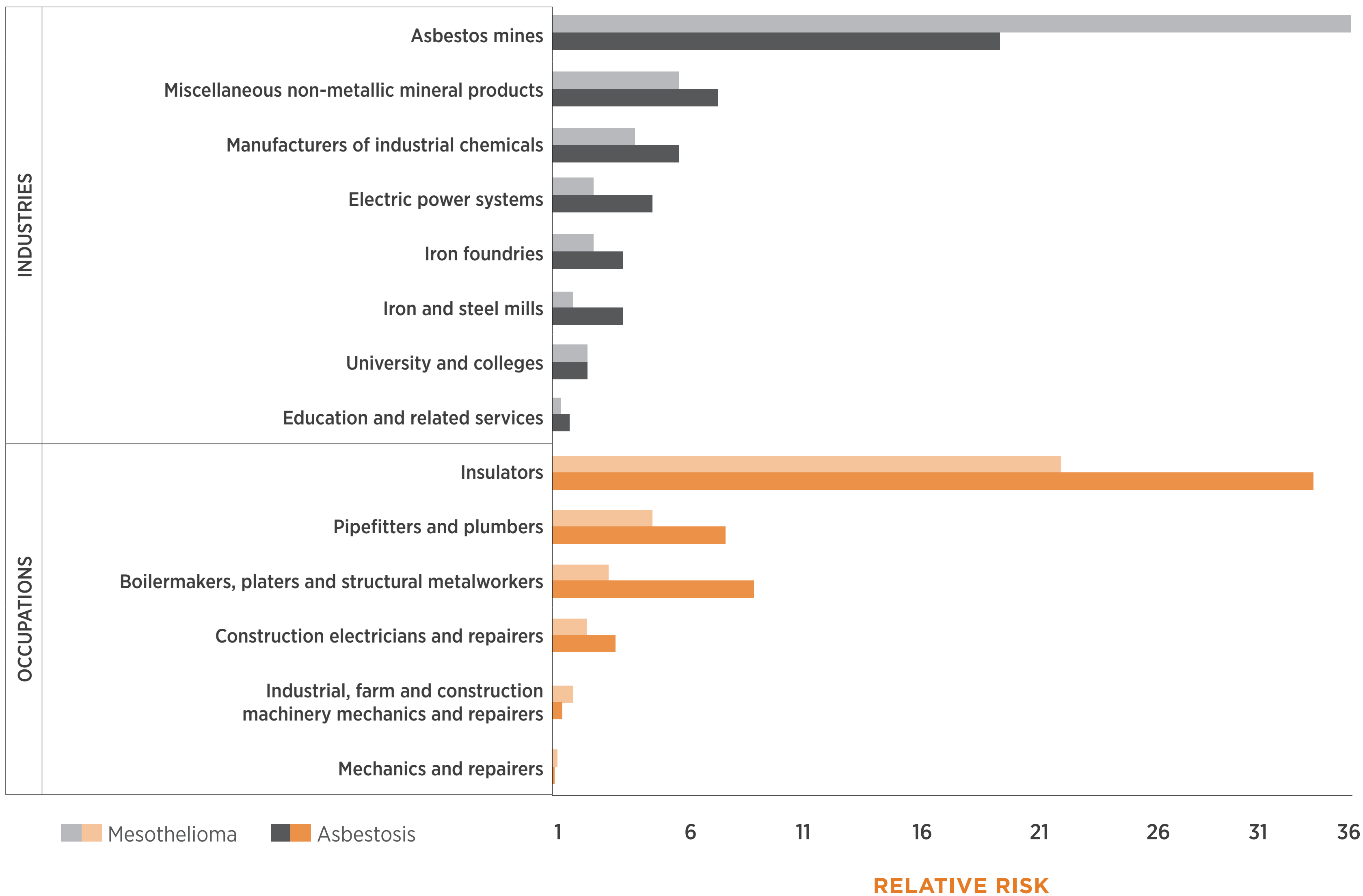


Figure 3. Risk of mesothelioma and asbestosis in selected industry and occupation groups, compared to all other workers in the ODSS.[3] Industry groups are shown in grey and occupation groups are shown in orange.

[3] Although the horizontal axis is limited to 36 to show the different levels of risk in each group, the risk of mesothelioma was highest in asbestos mine workers, 211 times the risk compared to all other workers in the ODSS.

RISK OF ASBESTOSIS AND MESOTHELIOMA IN ONTARIO WORKERS

The vast majority of **asbestos mining** in Canada took place in Quebec; however, historically, Ontario did have a small asbestos mining sector between 1950 and 1978.[47] High levels of asbestos exposure are likely to have occurred among asbestos miners in Ontario. Those who worked in Ontario's asbestos mining industry have the highest mesothelioma risk of any group in the ODSS, as well as a dramatically increased risk of asbestosis.

Another industry with primarily historical heavy exposure to asbestos in Ontario is the **non-metallic mineral products manufacturing industry.** Workers in this industry manufactured asbestos products such as insulation, asbestos cement, and brake and clutch pads.[19] In addition, large amounts of asbestos-contaminated vermiculite from Libby, Montana were imported into Ontario between 1964 and 1990, and reprocessed in Ontario for use as insulation.[41] These types of manufacturing were largely phased out in Ontario as the health risks of asbestos and the contamination of Libby vermiculite became known, but the long-term impact of those exposures remains.

Almost all construction trades occupations within the ODSS showed an increased risk of asbestosis and mesothelioma. The highest risks were among **insulators,** followed by plumbers and pipefitters and boilermakers. This is likely due to the widespread use of asbestos in insulation and asbestos-cement pipes prior to 1990.[48] During that time period, other construction trades may have also worked with or near asbestos-containing materials, but exposure was likely lower and less frequent. Groups such as **plasterers, electricians, brick and stone masons, and carpenters** all have increased risks of mesothelioma and asbestosis.

As use of asbestos in building materials was phased out in Canada, these exposure patterns have changed. Currently, construction trades workers are most likely to be exposed during the repair, maintenance, and demolition of older buildings. Construction is one of the most important industries in terms of current exposure to asbestos in Ontario and will remain so until asbestos-containing building materials have been safely removed from older buildings.

Many industries that involve high-temperature processes also have high risks of asbestos-related disease. **Iron foundries, iron and steel mills, and industrial chemical manufacturing** all showed elevated risks of both asbestosis and mesothelioma. In these industries where high temperatures were common, asbestos was often used for insulation in heating apparatuses, pipes, machinery, and protective clothing due to its heat, fire, and chemical resistant properties. Related occupations showed similar patterns. For example, **boilermakers, platers and structural metalworkers** also have increased risk of both diseases. Asbestos was often used to line the inside and outside of boiler tanks, as insulation for pipes, in gaskets, and to protect the floors and walls in boiler rooms, leading to high exposures for these workers.

The impact of asbestos exposure in these industries can also be seen when mesothelioma rates are examined geographically by census division. For example, Lambton County had the highest incidence rate of mesothelioma in Ontario over the period 1993-2017.[45]

Sarnia, located in Lambton County, was a hub for the chemical industry, as well as the site of the Holmes Foundry and Insulation plant, which manufactured engine casting blocks, brake linings, and asbestos insulation and had a notoriously poor health and safety record.

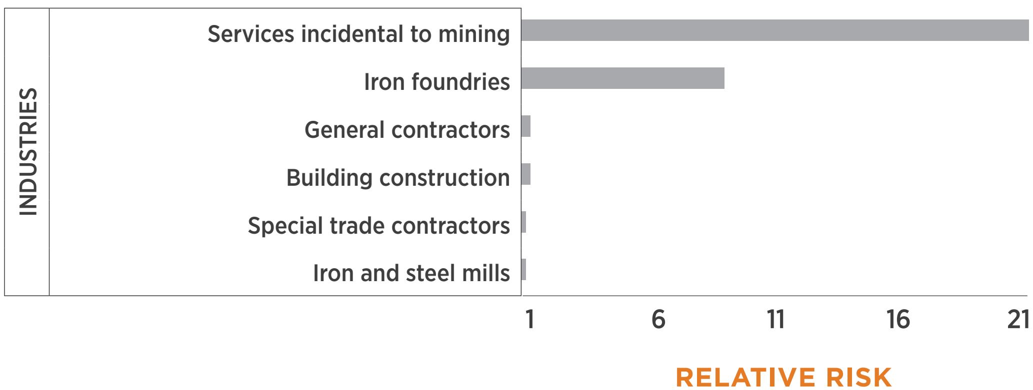
In the **electric power industry,** asbestos was used for its non-conductive properties as well as its heat and fire resistance.[49] Asbestos was used in many applications including coatings for electrical wires and cables, in transformer housings, and as protection for electrical panels and breakers. In the power generating stations, asbestos was also used as insulation and fireproofing in boilers and steam rooms. Workers in this industry have an increased risk of asbestos-related disease. Similarly, workers in **electrical power, lighting and wire communications equipment erecting, installing and repairing occupations,** including **construction electricians and repairers,** also have increased risks of mesothelioma and asbestosis.

Mechanics maintain and repair machinery and vehicles, which often involves removing parts for cleaning or replacement. Asbestos was widely used in many of these automotive parts, including gaskets, brake pads, clutches and hoodliners. It may still be present in older vehicles and machinery, leading to exposure during repair and maintenance.[50] **Mechanics and repairers** have an increased risk of mesothelioma, although their risk of asbestosis was not elevated in the ODSS. When looking at specific types of mechanics, those that repair **industrial, farm and construction machinery** had increased risks of both mesothelioma and asbestosis.

Workers in the **education industry** demonstrated increased risks of mesothelioma and asbestosis. The risk was highest among workers in universities and colleges, followed by education and related services, then elementary and secondary schools. Many historical educational buildings used asbestos-containing materials during their construction including for fireproofing or insulation. Like many worker groups noted above, exposure now primarily comes from the maintenance or repair in areas with historical asbestos. Within the education industry, the highest number of mesothelioma and asbestosis cases came from those working in **service and building trades such as janitors, pipefitters and plumbers, and carpenters.**

SILICOSIS

Silicosis is a disease caused by inhaling crystalline silica,[51] resulting in scarring of the lungs. Silicosis reduces lung capacity and can cause symptoms such as chronic cough, shortness of breath, and fatigue. Silicosis can be described as chronic, acute, or accelerated. Chronic silicosis, the most common type, may not show symptoms until decades after exposure to low or moderate concentrations of silica. Acute silicosis is rare but highly fatal and involves symptoms appearing within a short period of time (weeks to months) after immense exposure to silica.[52] Accelerated silicosis also involves high exposure to silica over a short period but symptoms take longer to appear (e.g., 5-10 years after exposure) and worsen quicky.[52] Crystalline silica is a natural occurring mineral of rocks, sand, and soil,[51] and is a common exposure in a range of industries,[53] such as mining, manufacturing, and construction. In part because silicosis is a rare disease, many of the estimates presented here are based on a small number of cases and should be interpreted with caution. We were also unable to look at the risks for various groups because they did not have enough people who had silicosis.



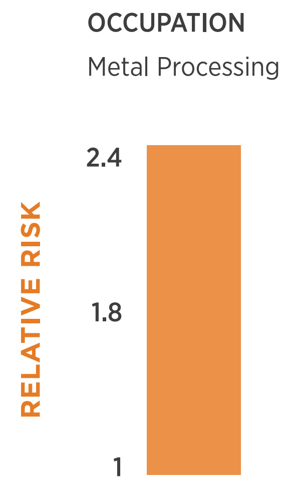


Figure 4. Risk of silicosis in selected industry and occupation groups compared to all other workers in the ODSS.[4] Industry groups are shown in grey and the occupation group is shown in orange.

[4] For example, workers in services incidental to mining had 21 times the risk for silicosis compared to all other workers in the ODSS.

RISK OF SILICOSIS IN ONTARIO WORKERS

Silica is a common exposure in **mining,** which involves excavating (i.e., digging) and moving large amounts of rock and soil. Miners often perform tasks such as drilling, crushing or blasting rock and stone that result in silica becoming airborne.[51] In underground mines, the enclosed work environment can lead to extremely high levels of exposure. Mining-related groups have the highest risks of silicosis across the ODSS.

Silica exposure is also common in primary metal manufacturing, such as **iron and steel mills** and **iron foundries.** Silica-containing bricks line the furnaces used in the manufacturing processes, and workers may be exposed when installing, maintaining or repairing the furnaces. Foundry moulds are often made using silica, and workers may be exposed during casting, when removing the molds (i.e., shakeout), and during cleaning and abrasive blasting of the new metal pieces. Workers in **metal processing and related occupations** also have an increased risk of silicosis. This group includes tasks such as melting, heat-treating, moulding, and casting metal, although there were not enough silicosis cases in the ODSS to look at the risk of these individual jobs.

Crystalline silica is found throughout the construction industry due to its prevalence in various construction materials such as concrete, granite, asphalt, brick, and sand. Silica dust is released into the air during various activities including demolition or repairing buildings, crushing, drilling, blasting, or grinding stone or similar materials.[53] Increased risks were seen across the construction industry in both the **general and special-trade contractors.** Specifically, we see increases in the **building construction industry.**

IDIOPATHIC PULMONARY FIBROSIS

Idiopathic pulmonary fibrosis (IPF) is a chronic interstitial lung disease with an unknown cause associated with an irreversible decline in lung capacity.[54] In many ways it is similar to silicosis, asbestosis, or hypersensitivity pneumonitis (associated with organic dust or other allergens), but the word idiopathic means that the cause of these cases of fibrosis is not known. IPF has limited treatment options associated with poor long-term survival. The risk increases with age and it is more common in males.

Although the causes of individual IPF cases may not be recognized by the healthcare system as occupational, studies have found on average that 26% of cases are attributable to exposure to vapours, gases, dusts and fumes in the workplace.[55] Some studies have specifically linked IPF to metal dust, wood dust, mineral dust, asbestos, and organic dusts from livestock, agriculture, and farming. A Korean National Health and Nutrition study observed that people with exposures to occupational and environmental dusts were diagnosed with IPF at a younger age, had a longer symptomatic period, and had increased mortality.[56] A recent systematic review and meta-analysis was conducted aiming to explain the relationship between occupational and environmental risk factors and IPF found the greatest increased risks associated with pesticides, metal dusts, and wood dusts.[57] Risk of IPF was identified in few groups in the ODSS that are highlighted here.

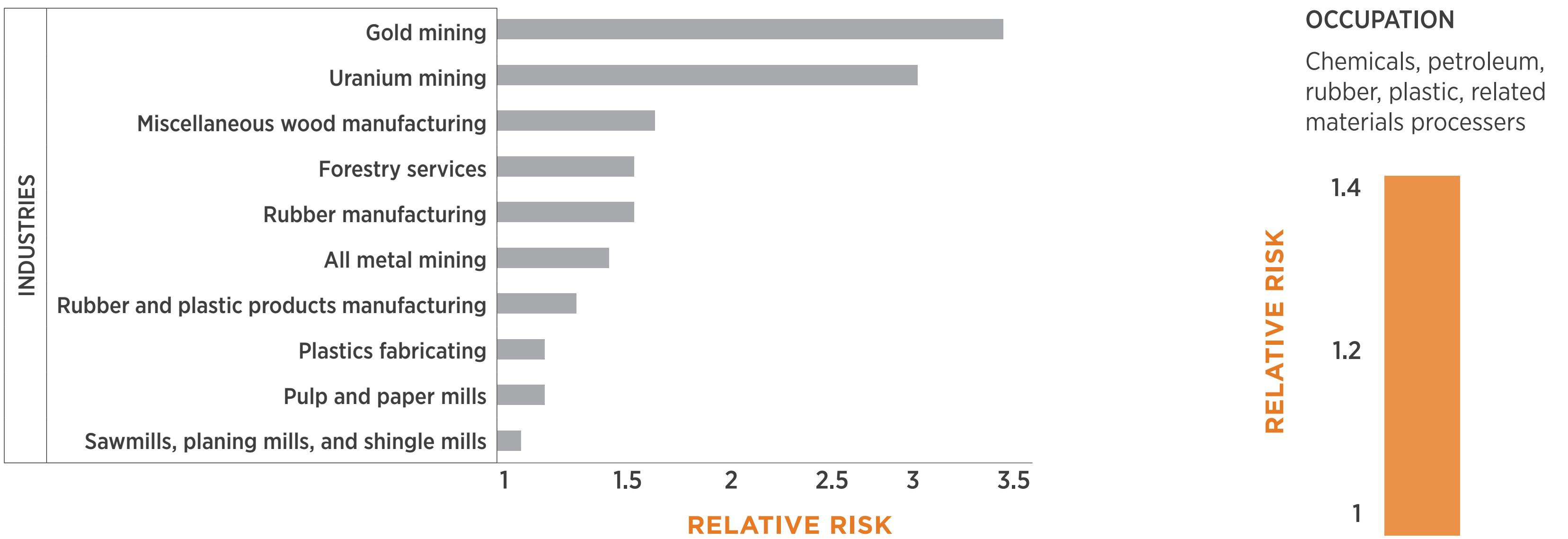


Figure 5. Risk of IPF in selected industry and occupation groups compared to all other workers in the ODSS.[5] Industry groups are shown in grey and the occupation group is shown in orange.

Various occupations and industries with dusty environments demonstrated elevated risks of IPF in the ODSS. **Metal mining**, particularly **gold and uranium mining** demonstrated increased risks. Workers are exposed to silica, metal dusts, as well as diesel engine exhaust which can impact their risk for developing IPF. Those working in **forestry, pulp and paper, sawmills and related** and other **wood manufacturing industries** also had higher risks of IPF which may be attributed to their exposures to wood dusts.

Similarly, **rubber products and plastics industries** also reported elevated risks of IPF. **Rubber products manufacturing and plastics fabricating industries** is complex and can include processes such as mixing, milling, molding, and finishing.[58] In addition to exposure to rubber dusts, workers can potentially be exposed to gases and vapors such as amines and polycyclic aromatic hydrocarbons (PAH) which have been associated with increased cancer risks.[58]

[5] For example, workers in gold mining had 3.3 times the risk for IPF compared to all other workers in the ODSS.

PREVENTION OF OCCUPATIONAL RESPIRATORY DISEASE

Occupational lung disease, by its nature, is preventable and can be achieved by eliminating or reducing exposures. In addition, although the lung diseases described in this report are not generally curable, early identification can lead to early treatment and improved prognosis. Often, workers' compensation statistics are utilized to understand the impact of occupational disease, which grossly under-represent the impact of occupational disease.[59] Thus, studies like the Burden of Occupational Cancer in Canada[4] that estimate the true number of cancers caused by occupational exposures, and ongoing surveillance efforts like the Occupational Disease Surveillance System[60] are important in providing scientific evidence representing the magnitude of occupational respiratory diseases and workplace exposures.

Increased awareness to address the impact of occupational lung diseases is important although not sufficient. For example, evidence of the harmful effects of asbestos has existed for many years. Evidence of asbestosis among asbestos-exposed workers was first published in the 1920s[61] and by the 1950s asbestos had been identified as a lung carcinogen.[62] However, considerable efforts to reduce the use of asbestos in Canada did not commence until the 1970s. Increased awareness needs to lead to regulatory policies such as exposure limits or voluntary actions initiated by employers to reduce or eliminate workplace exposures.

HIERARCHY OF CONTROLS

When speaking about prevention in the workplace, occupational health professionals often refer to the "hierarchy of controls" (see Figure 1).[63] At the top of the hierarchy are the most effective approaches: **elimination**, total removal of the toxic exposure, and **substitution**, replacing the exposure with something less toxic. Examples of this include the ban on asbestos or replacing diesel equipment with electric. Next are **engineering** controls which involves modifications to the process flow or equipment that helps reduce exposures at the source or in the path between the source and worker. Some examples include use of ventilation, filters on engine/machine exhaust, barrier screens, and/or fuel additives to reduce emissions. Engineering controls may be dependent on the worker, for example if the worker needs to attach the exhaust hose to their vehicle to use a local exhaust system to prevent exposure to diesel engine exhaust. Engineering controls can also be built into the system to increase use (e.g., in a fume hood the ventilation starts when the hood light is turned on). **Administrative** controls involve policies, procedures, and practices to prevent or reduce exposure. **Personal protective equipment (PPE)**, which for respiratory disease is some form of face shield, mask, or respirator, is the weakest tier in the hierarchy because it relies on user adherence which can be compromised in many ways.

There are several other lenses through which prevention measures can be evaluated. For example, control measures can be considered proactive if they prevent a contaminant from entering the workplace air, or reactive if they help reduce the level of a toxic substance that has already entered the air or reduce the likelihood that workers will be exposed. Elimination and substitution prevent toxic substances from ever entering the air, so are always proactive. Innovative approaches, such as the BC Construction Safety Alliance's silica control tool to predict exposure levels before a job begins and identify appropriate control measures are another proactive approach, which is being piloted in Ontario.[64] Use of personal protective equipment is always reactive, given that it is only used when there are contaminants in the air. On the other hand, some engineering and administrative controls can be proactive while others are reactive.

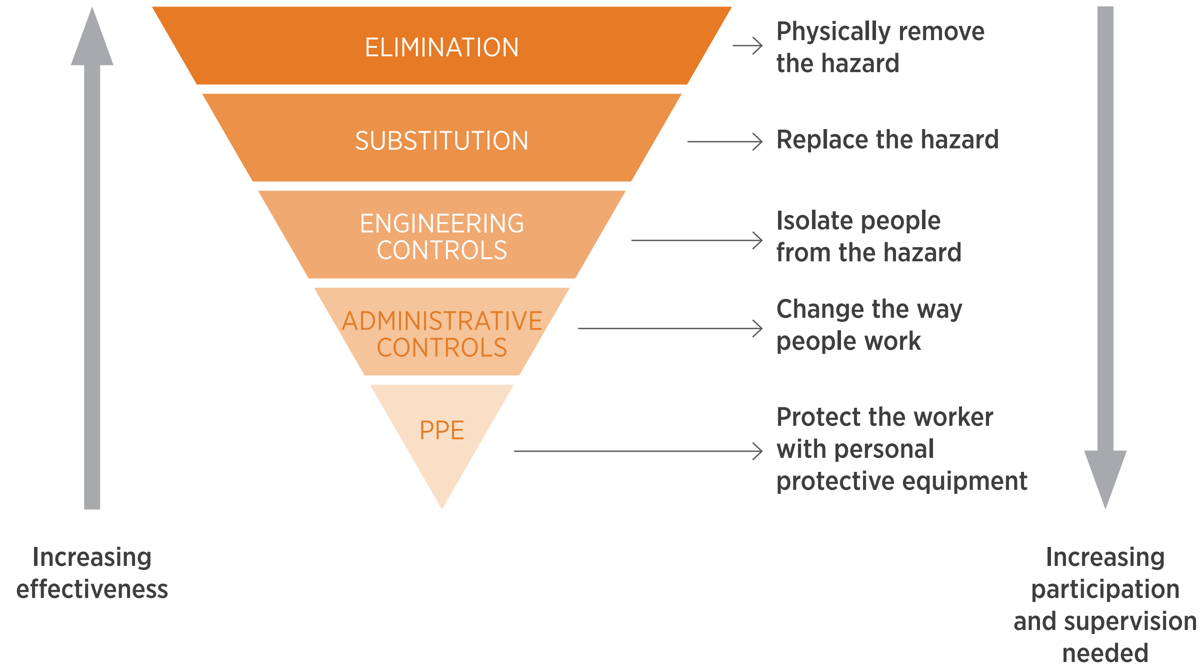


Figure 1. Hierarchy of controls demonstrating the most effective and protective control methods from top to bottom, modified to include worker participation.[63]

RECOGNITION OF OCCUPATIONAL RESPIRATORY DISEASES

Workers' compensation also plays an important role in prevention. Compensation is important to the individual and provides benefits beyond those provided by our universal healthcare system. However, workers' compensation is also one of the primary drivers of prevention, both in terms of the cost to employers and because compensated cases are still the most widely used source for occupational disease statistics. It is important to recognize that only a very small fraction of occupational diseases is recognized and compensated.[59] For example, based on the Burden of Occupational Cancer study and data from the WSIB, in Ontario only 5% of occupational cancers due to the most common, well-recognized workplace carcinogens are compensated. Even diseases such as mesothelioma that are almost entirely occupational are not well-compensated, principally because claims are not filed.[65] The increased recognition of occupational diseases by workers and health care providers can help to increase workers' compensation claims which can reiterate the importance and increase workplace prevention efforts.

The diseases identified in this report generally develop decades after workers are first exposed. If prevention of exposure fails, then early recognition, or secondary prevention of disease may improve the treatment and outcomes of people with occupational illnesses. Early recognition of disease onset before serious symptoms develop requires that individuals or their health care providers to suspect they are at higher risk, or that they undergo routine screening. Health care providers can help increase early recognition of occupational lung disease by collecting a work history to identify people who may be at increased risk. Another approach to identifying workers at high risk is to create exposure registries, such as Ontario's Asbestos Workers Registry (AWR) created in 1986. The OCRC recently completed a study linking the AWR to Ontario's health records and found that the workers registered had a higher risk of lung cancer and a much higher risk of mesothelioma, asbestosis, and IPF than the general population.[66]

In recent years, lung cancer screening programs have been launched in Ontario and in other parts of Canada and the world. Currently the criteria for screening are limited to smoking and other lifestyle-related or demographic factors, but the addition of occupational exposure criteria is being considered. An added potential benefit of lung cancer screening is that the tests may also identify the presence of other occupational lung diseases such as asbestosis, silicosis, and mesothelioma, although they are not designed to identify diseases other than lung cancer.

The lung diseases in this report are preventable and are caused by a similar set of exposures. Thus, reduction of these exposures will have a positive impact on reducing the risk of multiple occupational lung diseases. Measuring or estimating exposure in the workplace and taking steps to reduce exposure to safe levels is the most effective way lower the burden of occupational respiratory disease.

REFERENCES

1. Canadian Cancer Statistics Advisory Committee in collaboration with the Canadian Cancer Society, Statistics Canada and the Public Health Agency of Canada. Canadian Cancer Statistics 2021. Toronto, ON: Canadian Cancer Society; 2021. https://cdn.cancer.ca/-/media/files/research/cancer-statistics/2021-statistics/2021-pdf-en-final.pdf
2. Statistics Canada. Progress in net cancer survival in Canada over 20 years. Ottawa, ON: 2018. https://www150.statcan.gc.ca/n1/pub/82-003-x/2018009/article/00002-eng.htm
3. Labrèche F, Kim J, Song C, Pahwa M, et al. The current burden of cancer attributable to occupational exposures in Canada. Prev Med. 2019 May;122: 128-139. doi: 10.1016/j.ypmed.2019.03.016.
4. Occupational Cancer Research Centre. Burden of occupational cancer in Canada: Major workplace carcinogens and prevention of exposure. Toronto, ON: 2019: https://www.cancercareontario.ca/sites/ccocancercare/files/assets/OCRCBurdenofOccupationalCancerReport.pdf
5. International Agency for Research on Cancer. List of classifications by cancer sites with sufficient or limited evidence in humans, IARC Monographs Volumes 1-130. IARC 2021: https://monographs.iarc.who.int/wp-content/uploads/2019/07/Classifications_by_cancer_site.pdf
6. Verma DK, Rajhans GS, Malik OP, et al. Respirable dust and respirable silica exposure in Ontario gold mines. J Occup Environ Hyg. 2014;11(2):111-6. doi: 10.1080/15459624.2013.843784.
7. Lightfoot NE, Pacey MA, Darling S. Gold, nickel and copper mining and processing. Chronic Dis Can. 2010;29(Suppl 2):101-24. doi: 10.24095/hpcdp.29.S2.03
8. Silverman DT, Samanic CM, Lubin JH, et al. The Diesel Exhaust in Miners study: a nested case-control study of lung cancer and diesel exhaust. J Natl Cancer Inst. 2012 Jun 6;104(11):855-68. doi: 10.1093/jnci/djs034.
9. Navaranjan G, Berriault C, Do M, et al. Cancer incidence and mortality from exposure to radon progeny among Ontario uranium miners. Occup Environ Med. 2016 Dec;73(12):838-845. doi: 10.1136/oemed-2016-103836.
10. Kusiak RA, Springer J, Ritchie AC, et al. Carcinoma of the lung in Ontario gold miners: possible aetiological factors. Br J Ind Med. 1991 Dec;48(12):808-17. doi: 10.1136/oem.48.12.808
11. Verma DK, Kurtz LA, Sahai D et al. Current chemical exposures among Ontario construction workers. Appl Occup Environ Hyg. 2003 Dec;18(12):1031-47. doi: 10.1080/714044193.
12. Ge C, Peters S, Olsson A, et al. Diesel Engine Exhaust Exposure, Smoking, and Lung Cancer Subtype Risks. A Pooled Exposure-Response Analysis of 14 Case-Control Studies. Am J Respir Crit Care Med. 2020 Aug 1;202(3):402-411. doi: 10.1164/rccm.201911-2101OC.
13. Lacourt A, Pintos J, Lavoué J, et al. Lung cancer risk among workers in the construction industry: results from two case-control studies in Montreal. BMC Public Health. 2015 Sep 22;15:941. doi: 10.1186/s12889-015-2237-9.
14. International Agency for Research on Cancer (IARC). Chemical agents and related occupations. IARC monographs on the evaluation of carcinogenic risks to humans volume 100F. Lyon, FR: 2022. https://publications.iarc.fr/123
15. Steenland K, Deddens J, Stayner L. Diesel exhaust and lung cancer in the trucking industry: exposure-response analyses and risk assessment. Am J Ind Med. 1998 Sep;34(3):220-8. doi: 10.1002/(sici)1097-0274(199809)34:3.

REFERENCES CONT'D

16. Ontario. Smoke-free Ontario Act, S. O. 1994, c. 10. 2018. https://www.ontario.ca/laws/statute/94t10/v4
17. International Agency for Research on Cancer (IARC). Outdoor air pollution. IARC monographs on the evaluation of carcinogenic risks to humans volume 109. Lyon, FR: 2022. https://publications.iarc.fr/538
18. Rajhans GS, Bragg, GM, Morton JS. A review of asbestos exposures in Ontario. Am Ind Hyg Assoc J. 1978;39:9,767-771, doi: 10.1080/0002889778507849
19. Jung JKH, Feinstein SG, Palma Lazgare L, et al. Examining lung cancer risks across different industries and occupations in Ontario, Canada: the establishment of the Occupational Disease Surveillance System. Occup Environ Med. 2018;75(8):545-552. doi: 10.1136/oemed-2017-104926.
20. Government of Canada. Chronic obstructive pulmonary disease (COPD). 2019. https://www.canada.ca/en/public-health/services/chronic-diseases/chronic-respiratory-diseases/chronic-obstructive-pulmonary-disease-copd.html
21. Najafzadeh M, Marra CA, Lynd LD, et al. Future Impact of Various Interventions on the Burden of COPD in Canada: A Dynamic Population Model. PLoS One. 2012;7(10). doi: 10.1371/journal.pone.0046746
22. Blanc PD, Annesi-Maesano I, Balmes JR, et al. The Occupational Burden of Nonmalignant Respiratory Diseases. An Official American Thoracic Society and European Respiratory Society Statement. Am J Resp Crit Care. 2019;199(11):1312–34. doi: 10.1164/rccm.201904-0717ST
23. Omland O, Würtz ET, Aasen TB, et al. Occupational chronic obstructive pulmonary disease: a systematic literature review. Scand J Work Environ Health. 2014;40(1):19-35. doi: 10.5271/sjweh.3400
24. Mastrangelo G, Tartari M, Fedeli U, et al. Ascertaining the risk of chronic obstructive pulmonary disease in relation to occupation using a case-control design. Occup Med-C. 2003;53(3):165–172. doi: 10.1093/occmed/kqg041
25. Eduard W, Pearce N, Douwes J. Chronic bronchitis, COPD, and lung function in farmers: the role of biological agents. Chest. 2009;136(3):716–725. doi: 10.1378/chest.08-2192
26. Stobnicka A, Gorny RL. Exposure to flour dust in the occupational environment. Int J Occup Saf Ergo. 2015;21(3):241-249. doi: 10.1080/10803548.2015.1081764
27. Pahwa P, Senthilselvan A, McDuffie HH, et al. Longitudinal estimates of pulmonary function decline in grain workers. Am J Resp Crit Care. 1994;150(3):656–662. doi: 10.1164/ajrccm.150.3.8087334
28. Baur X, Degens PO, Sander I. Baker's asthma: still among the most frequent occupational respiratory disorders. J Allergy Clin Immunol. 1998;102(6 Pt 1):984–997. doi: 10.1016/S0091-6749(98)70337-9
29. Lai PS, Christiani DC. Long-term respiratory health effects in textile workers. Curr Op Pul Med. 2013;19(2):152–157. doi: 10.1097/MCP.0b013e32835cee9a
30. Mayan O, Torres Da Costa J, Neves P, et al. Respiratory effects among cotton workers in relation to dust and endotoxin exposure. Ann Occup Hyg. 2002;46(suppl_1):277-80. doi: 10.1093/annhyg/mef617
31. Mehta AJ, Henneberger PK, Toren K, et al. Airflow limitation and changes in pulmonary function among bleachery workers. Eur Respir. 2005;26(1):133-9. doi: 10.1183/09031936.05.00083604.
32. Dement J, Welch L, Ringen K, et al. A case-control study of airways obstruction among construction workers. Am J Ind Med. 2015;58(10):1083–1097. doi: 10.1002/ajim.22495.

REFERENCES CONT'D

33. Grahn K, Gustavsson P, Andersson T, et al. Occupational exposure to particles and increased risk of developing chronic obstructive pulmonary disease (COPD): A population-based cohort study in Stockholm, Sweden. Environ Res. 2021; 200:111739. doi: 10.1016/j.envres.2021.111739
34. Moitra S, Farshchi Tabrizi A, Idrissi Machichi K, et al. Non-Malignant Respiratory Illnesses in Association with Occupational Exposure to Asbestos and Other Insulating Materials: Findings from the Alberta Insulator Cohort. Int J Env Res Pub He. 2020;17(19):7085. doi: 10.3390/ijerph17197085.
35. Fell AKM, Aasen TOB, Kongerud J. Work-related COPD. Tidsskr Nor Laegeforen. 2014;134(22):2158-63. doi: 10.4045/tidsskr.14.0255
36. Ferguson J, Costello S, Elser H, et al. Chronic obstructive pulmonary disease mortality: The Diesel Exhaust in Miners Study (DEMS). Environ Res. 2020; 180:108876–. doi: 10.1016/j.envres.2019.108876
37. Möhner M, Nowak D. Estimation of an Exposure Threshold Value for Compensation of Silica-Induced COPD Based on Longitudinal Changes in Pulmonary Function. Int J Env Res Pub He. 2020;17(23):9040. doi: 10.3390/ijerph17239040
38. Skalny AV, Lima TRR, Ke T, et al. Toxic metal exposure as a possible risk factor for COVID-19 and other respiratory infectious diseases. Food Chem Toxicol. 2020;146:111809. doi: 10.1016/j.fct.2020.111809
39. Knobloch J, Casjens S, Lehnert M, et al. Exposure to welding fumes suppresses the activity of T-helper cells. Environ Res. 2020;189:109913. doi: 10.1016/j.envres.2020.109913.
40. Hnizdo E, Sullivan PA, Bang KM, et al. Association between chronic obstructive pulmonary disease and employment by industry and occupation in the US population: a study of data from the Third National Health and Nutrition Examination Survey. Am J Epidemiol. 2002;156(8):738-46. doi: 10.1093/aje/kwf105.
41. Sullivan PA. Vermiculite, respiratory disease, and asbestos exposure in Libby, Montana: update of a cohort mortality study. Environ Health Persp. 2007;115(4):579-85. doi: 10.1289/ehp.9481.
42. National Cancer Institute. Asbestos exposure and cancer risk. 2021. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/asbestos/asbestos-fact-sheet
43. Lacourt A, Gramond C, Rolland P, et al. Occupational and non-occupational attributable risk of asbestos exposure for malignant pleural mesothelioma. Thorax. 2014;69(6):532-9. doi: 10.1136/thoraxjnl-2013-203744
44. Bertazzi PA. Descriptive epidemiology of malignant mesothelioma. Med Lav. 2005;96(4):287-303. PMID: 16457426.
45. Occupational Cancer Research Centre. Mesothelioma surveillance & prognosis in Ontario. Research Brief. 2020. http://www.odsp-ocrc.ca/wp-content/uploads/2021/01/ON-Meso-Research-Brief.pdf
46. Rake C, Gilham C, Hatch J, et al. Occupational, domestic and environmental mesothelioma risks in the British population: a case-control study. Br J Cancer. 2009;100(7):1175-83. doi: 10.1038/sj.bjc.6604879.
47. Energy, Mines and Resources Canada. Canadian Minerals Yearbook. 1950-1978.
48. Government of Canada. Asbestos. 2021. https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/health-risks-asbestos.html
49. Felten MK, Knoll L, Eisenhawer C, et al. Retrospective exposure assessment to airborne asbestos among power industry workers. J Occup Med Toxicol. 2010;5:15. doi: 10.1186/1745-6673-5-15.

REFERENCES CONT'D

50. Paustenbach DJ, Finley BL, Lu ET, et al. Environmental and occupational health hazards associated with the presence of asbestos in brake linings and pads (1900 to present): A "state-of-the-art" review. J Toxicol Environ Heal B. 2004;7(1):25–80. doi: 10.1080/10937400490231494
51. Jumat MI, Hayati F, Syed Abdul Rahim SS, et al. Occupational lung disease: A narrative review of lung conditions from the workplace. Ann Med Surg (Lond). 2021 Mar 23;64:102245. doi: 10.1016/j.amsu.2021.102245.
52. Thomas CR, Kelley TR. A brief review of silicosis in the United States. Environ Health Insights. 2010;4:21-6. doi: 10.4137/EHI.S4628
53. Austin EK, James C, Tessier J. Early Detection Methods for Silicosis in Australia and Internationally: A Review of the Literature. Int J Env Res Pub He. 2021 Jul 31;18(15):8123. doi: 10.3390/ijerph18158123.
54. Trethewey SP, Walters GI. The Role of Occupational and Environmental Exposures in the Pathogenesis of Idiopathic Pulmonary Fibrosis: A Narrative Literature Review. Medicina (Kaunas). 2018;54(6):108. doi: 10.3390/medicina54060108
55. Blanc PD, Annesi-Maesano I, Balmes JR, et al. The Occupational Burden of Nonmalignant Respiratory Diseases. An Official American Thoracic Society and European Respiratory Society Statement. Am J Resp Crit Care. 2019;199(11):1312-1334. doi: 10.1164/rccm.201904-0717ST.
56. Lee SH, Dong SK, Young WK, et al. Association between occupational dust exposure and prognosis of idiopathic pulmonary fibrosis: A Korean national survey. Chest. 2015;147(2):465–474. doi: 10.1378/chest.14-0994
57. Park Y, Ahn C, Kim TH. Occupational and environmental risk factors of idiopathic pulmonary fibrosis: a systematic review and meta-analyses. Sci Rep. 2021;11(1):4318. doi: 10.1038/s41598-021-81591-z
58. International Agency for Research on Cancer. IARC Working Group on the Evaluation of Carcinogenic Risk to Humans. Occupational Exposures in the Rubber Manufacturing Industry 2012; 100 F: https://www.ncbi.nlm.nih.gov/books/NBK304412/.
59. Demers PA. Using scientific evidence and principles to help determine the work-relatedness of cancer. Toronto, CA: 2020. http://www.occupationalcancer.ca/wp-content/uploads/2020/07/Final-Report-Using-scientific-evidence-and-principles-to-help-determine-the-work-relatedness-of-cancer-Final-April2020.pdf
60. Occupational Cancer Research Centre. The occupational disease surveillance program, tracking occupational diseases and workplace exposures. Toronto, CA: 2022. www.odsp-ocrc.ca
61. Cooke WE. Pulmonary Asbestosis. Br Med J. 1927;2(3491):1024-5. doi: 10.1136/bmj.2.3491.1024.
62. Doll R. Mortality from lung cancer in asbestos workers. Br J Ind Med. 1955 Apr;12(2):81. doi: 10.1136/oem.12.2.81
63. National Institute for Occupational Safety and Health (NIOSH). Hierarchy of Controls. Centers for Disease Control and Prevention, 2015. https://www.cdc.gov/niosh/topics/hierarchy/default.html
64. Occupational Health Clinics for Ontario Workers Inc. (2021). Silica control tool. https://www.ohcow.on.ca/occupational-illness/silica-control-tool-pilot-program-ontario/
65. Payne JI, Pichora E. Filing for workers' compensation among Ontario cases of mesothelioma. Can Respir J. 2009;16(5):148-152. doi: 10.1155/2009/364258
66. Occupational Cancer Research Centre. (2018). Occupational cancer and asbestosis among asbestos-exposed workers in Ontario. https://www.occupationalcancer.ca/2018/occupational-cancer-and-asbestosis-among-asbestos-exposed-workers-in-ontario/