Using Scientific Evidence and Principles to Help Determine the Work-Relatedness of Cancer

Final Report

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Paul A. Demers, Ph.D.
Occupational Cancer Research Centre, Ontario Health

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Table of Contents

List of Tables

List of Figures

Foreword

In 1910, a Royal Commission was undertaken in Ontario to look into workers' compensation schemes. Led by Sir William Meredith, this review took three years to complete and culminated in the publication of the Meredith Report in 1913 and the passage of modern workers' compensation legislation in the province in 1914. In his recommendations, Meredith articulated that the system should be based on the following principles: no fault, non-adversarial, security of benefits, employer pays, and collective liability, and should be administered by an independent public agency with exclusive jurisdiction (1). These principles became the foundation for the "Historic Compromise", in which injured workers gave up the right to sue their employer in exchange for guaranteed benefits, provided by a non-adversarial system for as long as the disability lasted. The compromise aimed to provide fair compensation for workers who became injured or ill because of their work, while protecting employers from legal action and potential bankruptcy. While this compromise was beneficial to all, it has always worked best for injuries and illnesses where the effects are immediate and evidence of exposure to hazards and attribution are clear.

Cancer and other long-latency diseases are challenging for workers' compensation systems. As our knowledge of the chronic health effects of workplace exposures has increased, compensation for workplace cancer has become an important issue for workers employed in hazardous industries, as well as the unions that represent them and their employers. However, it has emerged as a public issue in recent decades through reports in the mass media and greater awareness of the link between exposure to workplace carcinogens and cancer. The handling of cancer claims has been a frequent source of frustration for all parties involved, but most importantly for workers diagnosed with cancer and their families. As a province with a large manufacturing sector and other industries, such as mining, where hazardous exposures were common in the past, challenges regarding the impact of past exposures and their consequences are likely to continue. It is in this context that the Ontario Ministry of Labour, Training and Skills Development commissioned this report.

Acknowledgements

This report was prepared with the assistance of several colleagues as well as the staff of the Occupational Cancer Research Centre (OCRC). Anya Keefe, former Director of the WorkSafeBC Research Secretariat, conducted the environmental scan of relevant practices in other jurisdictions, assisted with the content in the report related to policy and its intersection with science and provided editorial assistance throughout. Dr. Sarah McCormick-Rhodes aided with the literature review to support the explanation of relevant scientific principles in the report. Stephanie Ziembicki, Kate Jardine, and Elizabeth Rydz also provided assistance with literature reviews, graphics, and editing. Thanks to the staff and leadership of the WSIB and the MLTSD staff, who were extremely helpful in explaining the adjudication process, providing any statistics requested, providing historical context, and helpful suggestions. Special thanks to Katherine Lippel, Professor at the University of Ottawa and the Canada Research Chair on Occupational Health and Safety Law, for educating me on the legal *vs.* scientific perspectives on compensation and to Lesley Rushton, Emeritus Reader in Occupational Epidemiology at Imperial College London and chair of the UK Industrial Injuries Advisory Council, for her extremely valuable advice regarding international comparisons. I would also like to thank my colleagues from across Canada and around the world for providing their views on compensation and directing us to useful resources. Lastly, I would like to thank the workers, injured worker advocates, employers, and union representatives who shared their views and experiences with the workers' compensation system in Ontario.

List of abbreviations used in this report

ABRWH	Advisory Board on Radiation and Worker Health
ABTSH	Advisory Board for Toxic Substances and Health
APD	Administrative practice documents
AWCBC	Association of Workers' Compensation Boards of Canada
BaP	Benzo-a-pyrene
BEI	Biological Exposure Index
CNESST	Commission des norms, de l'équité, de la santé et de la sécurité du travail
CWED	Canadian Workplace Exposure Database
DOE	Department of Energy
EEOIC	Energy Employees Occupational Illness Compensation
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
GE	General Electric
IARC	International Agency for Research on Cancer
IIAC	Industrial Injuries Advisory Council
ILO	International Labour Organization
IMIS	Integrated Management Information System
INRS	l'Institut national de recherche et de sécurité pour la prevention des accidents du travail et des maladies professionnelles (French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases)
IRSST	Institut de recherche Robert-Sauvé en santé et en sécurité du travail
ISCRR	Institute for Safety, Compensation and Recovery Research
L&I	Labor and Industries
MESU	Medical Surveillance
MLTSD	Ministry of Labour, Training and Skills Development
MSSS	Ministère de la santé et des services sociaux
NDR	National Dose Registry
NIOSH	National Institute for Occupational Safety and Health
OCRC	Occupational Cancer Research Centre
OHCOW	Occupational Health Clinics for Ontario Workers
OPM	Operational Policy Manual
OSHA	Occupational Safety and Health Administration
OWCP	Office of Workers' Compensation Programs
PEL	Permissible exposure limit
PWHS	Partnership for Work, Health and Safety
SEC	Special Exposure Cohort
SEM	Site Exposure Matrices
SHARP	Safety & Health Assessment & Research for Prevention
SLTC	Salt Lake Technical Center
STAC	Scientific and Technical Advisory Committee
TLV	Threshold Limit Value
UBC	University of British Columbia
UV	Ultraviolet
WSIB	Workplace Safety and Insurance Board
WTC	World Trade Center
WTCHP	World Trade Center Health Program

Executive Summary

Mandate of the review

In January 2019, the Ontario Ministry of Labour, Training and Skills Development (MLTSD) requested an independent review to provide advice to the Ministry on the following questions:

1. How can scientific evidence best be used in determining work-relatedness in an occupational cancer claim, particularly in cases with multiple exposures?
2. Are there any best practices in other jurisdictions that Ontario should consider adopting?
3. What scientific principles should inform the development of occupational disease policy?

Methods

An environmental scan was undertaken to identify relevant legislation and policy instruments. The scan was followed by a more detailed examination of legislative frameworks and key policy instruments to identify the principles governing the compensation of occupational cancer and how entitlement is determined in Ontario. Information was collected from online sources and was supplemented by a series of in-person meetings with representatives from the Workplace Safety and Insurance Board (WSIB) and the MLTSD, as well as in-person meetings or phone calls with stakeholders in Ontario and occupational health researchers from across Canada, the US, New Zealand, Australia, and Europe. In addition, the WSIB provided data on both submitted and accepted cancer claims. Lastly, searches of the published scientific literature were conducted to identify key studies dealing with relevant scientific principles.

Occupational cancer in Ontario

Part 2 of the report sets out the context of occupational cancer and compensation in Ontario. Based on our current knowledge of the causes of cancer, it is estimated that approximately half of all cancer is preventable. While there is still much that we do not know about the causes of cancer, many workplace carcinogens have been identified. The OCRC's Burden of Occupational Cancer Project estimated that there are approximately 3,000 cancers diagnosed per year in Ontario due to occupational exposure to 16 of the most well-established carcinogens.

Adjudication and management of occupational cancer claims in Ontario are handled by the WSIB's Occupational Disease and Survivor Benefits Program. In determining entitlement to compensation for occupational cancers specifically, and occupational diseases more generally, the key adjudicative question to be resolved is that of causation (i.e., what caused the cancer).

Three general principles govern how causation is evaluated and entitlement is determined:

1. Employment does not have to be the predominant or primary cause.
2. Absolute certainty is not required.
3. The worker is afforded the benefit of the doubt.

Entitlement is determined by reference to presumptions provided in Schedules 3 or 4 of O. Reg 175/98, by application of operational policies in Chapters 16 and 23 of the Operational Policy Manual (OPM), and on a case-by-case basis. According to the WSIB, the key step in all occupational disease claims – and the one that is most relevant to this review – is information gathering. In this step, the decision-maker gathers, analyzes and weighs employment history, detailed exposure history, medical history, current scientific evidence on occupational exposures and diseases, and relevant personal information. As appropriate, the decision-makers will consult with medical specialists to resolve questions on causation and work-relatedness.

Compensated claims for deaths from occupational cancer in Ontario have increased dramatically since 1997, surpassing those for traumatic injuries in 2005 and more than doubling them by 2010. Fatal claims, however, only represent part of the cancer picture. Data provided by the WSIB on all cancer claims show that 4,044 cancer claims were filed between 2009 and 2018 and that 1,678 (or 41.5%) were accepted (not including claims related to the firefighter presumptions). On average, the WSIB has accepted 170 cancer claims per year (130 of which are for asbestos-related cancers). This is only a small fraction of the 3,000 estimated occupational cancers predicted for Ontario (including approximately 800 due to asbestos).

Fatal cancer claim rates are the easiest to compare across Canadian jurisdictions and Ontario's is the highest of the major provinces. The rate of all accepted cancer claims in Ontario in 2018 was 2.9 per 100,000 insured workers, which is significantly lower than many countries in the European Union. In a 2016 report, for example, the rate of accepted occupational cancers claims per 100,000 insured workers ranged from 4.7 in Belgium to 15.1 in Germany. The rates in Italy, Denmark and France fell in between (at 6.3, 6.9 and 11.4, respectively).

Scientific principles relevant to this review

Determining causation in the context of workers' compensation is a complex process primarily governed by legal principles, but, hopefully, informed by scientific principles as well. There are a number of national and international agencies and organizations that assess whether chemicals, forms of radiation, or other factors cause cancer, based on scientific principles and the use of peer-reviewed and publicly available scientific evidence. The most widely recognized of these internationally, and in Canada, is the International Agency for Research on Cancer (IARC) which has identified hundreds of known, probable, and possible associations between

workplace exposures and cancer. While our knowledge of what causes cancer has greatly increased and continues to do so, the sophistication with which we approach attribution in workers' compensation has not always kept pace.

Part 3 of the report focuses on the following theories and principles that are relevant to determining the work-relatedness of cancer:

- Multi-stage theories of carcinogenesis emphasize the importance of considering multiple exposures as well as the time intervals between multiple exposures in the carcinogenesis process.
- All cancers are likely to have multiple causes. If these causes are independent of each other, we generally assume that the risk of both is the sum of the two. However, in some cases there may be synergy between causes and the joint effects can be much greater.
- Induction and latency periods are sometimes treated as a property of a disease. However, they are actually a property of the relationship between each exposure and the disease, and each exposure could have different effective time periods.
- Biological processes, such as the development of disease, generally have what is termed a normal distribution (a bell-shaped curve) while, for practical purposes, we generally use a discrete range of years or other units when assessing the length or timing of exposure or its latency. Discrete time ranges for exposure and latency based on nice round numbers are useful, but it should be recognized that these ranges will not apply to all individuals.

Why the compensation of occupational cancers is so challenging

In adjudicating a claim, decision-makers seek to determine whether the disease is due to the nature of the worker's employment (i.e., is the disease work-related?). Part 4 briefly presents some major challenges faced by the workers' compensation system in Ontario and elsewhere. These include:

- A lack of recognition by primary care providers is the major factor underlying the gap between the estimated true number of occupational cancers and the number of cancers compensated in Ontario.
- Epidemiology (which is the science concerned with the occurrence of disease in populations) assesses exposure and risk at the group level, not at the individual level. Epidemiology is useful in developing presumptive criteria, informing policy guidelines or establishing general causation, but caution needs to be used when applying its results to establish causation in individual cases.

- Exposure to multiple established or suspected human carcinogens is common. However, too few epidemiologic studies have looked at the impact of multiple occupational exposures because their focus is almost always on establishing whether a single agent is, or is not, a cause of disease.
- The documentation or estimation of historical exposure to workplace carcinogens is a critical component to making science-based judgements on the work-relatedness of occupational cancer. However, documenting exposure retrospectively is challenging, particularly in the absence of quantitative measurements and other data.
- The term "cluster" has been used in recent years to describe an unusual number of cancers occurring among a relatively small group of people that may be due to new and emerging hazards and a perceived excess risk in a larger population who were exposed to recognized hazards. Unfortunately, there is no agency in Ontario with the responsibility to investigate occupational clusters and neither the WSIB nor the MLTSD have the necessary research capacity.

Relevant practices in other jurisdictions

Part 5 of the report highlights relevant practices in other jurisdictions. Many workers' compensation systems have presumptive lists of occupational diseases, some of which are modelled on the *List of Occupational Diseases* published by the International Labour Organization (ILO). However, there is a wide variation in the number of cancers recognized and the exposures/working conditions associated with them. For example, in the UK, cancers associated with 40 exposures/working conditions are currently included on the Prescribed Diseases List. In jurisdictions around the world scientific advisory panels have been created to provide independent advice for the ongoing updating of national presumptive lists, as well as to inform the development and optimization of policies and processes about causation/work-relatedness.

A number of examples of internal and partnered scientific capacity exist that bring together policymakers, researchers and data resources with the goal of improving compensation and preventing occupational diseases. The report highlights two Canadian and two international examples: the Partnership for Work, Health and Safety (British Columbia) and the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (Québec), the Safety & Health Assessment & Research for Prevention (Washington State, US), and the Institute for Safety, Compensation and Recovery Research (Australia). This part of the report also highlights several large-scale exposure databases (e.g., the Canadian Workplace Exposure Database developed by CAREX Canada), exposure assessment approaches used by the US National Institute for Occupational Health and Safety, as well as a historical exposure matrix created under contract for UNIFOR to assist with the compensation claims of their members.

Observations and recommendations

Part 6 of the report sets out a series of observations and recommendations to support the WSIB's efforts to improve evidence-based decision-making.

Recommendations to update presumptive lists and cancer-relevant policies

1. The WSIB should update and greatly expand the list of presumptions regarding cancer in Schedules 3 and 4 to reflect the current state of scientific knowledge. Presumptions should be based on exposure to carcinogenic agents or processes, and not specific employers, in order to be more broadly applicable. In updating and expanding its presumptive lists, the WSIB may want to consider using criteria such as that used in the independent scientific review undertaken of Australia's deemed diseases list (2). Similar to that review, I would recommend that the following three criteria be used:
    - Evidence of a strong causal link between the disease and occupational exposure, defined on the basis of inclusion in IARC Group 1 (i.e., definite human carcinogen), a systematic review of the evidence, or multiple good quality studies showing a causal relationship between the disease and the occupational exposure.
    - Clear diagnostic criteria for any disease included in a scheduled list to ensure questions don't arise as to whether or not the claimant really has the disease that is the subject of the claim.
    - The occupational disease comprises a considerable proportion of the cases of that disease overall in the exposed population.
2. The WSIB should update and expand all of the policies relevant to adjudication of cancer claims to reflect the current state of scientific knowledge. We have identified several areas for which new policies are needed.
    - A policy that explains how exposure to multiple carcinogens is handled. Given the current state of knowledge regarding the impact of multiple exposures, the effects of exposure to carcinogens impacting the same cancer site should be considered additive, unless there is evidence to the contrary.
    - A policy that states clearly how non-occupational exposures, particularly cigarette smoking, are weighted relative to occupational exposures. As with multiple occupational exposures, the relationship should be considered additive unless there is evidence for a synergistic effect.
3. The WSIB should create an independent, standing Scientific Review Panel to review and recommend changes to the schedules and policies, to review and approve scientific reports, and to assist in the selection of external consultants and researchers. The Panel should be composed of independent scientists with a broad range of expertise, including

epidemiology, toxicology, occupational medicine, and occupational hygiene. The process for choosing members should allow for stakeholder input, including the opportunity for worker representatives and employers to nominate scientists. Scientists with expertise in occupational cancer and occupational disease are a scarce resource in Canada and the scientific challenges are similar across the country. Ontario could consider sharing the support of such a panel with other jurisdictions. This would not only increase efficiencies and leverage other resources, but also increase the independence of the panel.

Recommendations to enhance scientific capacity

1. The WSIB needs to increase its internal scientific capacity to at least its previous levels. This should include scientists with graduate level training in epidemiology, toxicology and exposure science (such as occupational hygiene).
2. Stronger partnerships with external research centres, including those already funded with WSIB funds, are needed for research on emerging issues and gaps of importance to Ontario. Such partnerships should encourage the development of surveillance systems to support evidence-based decision making in adjudication and to assist in identifying emerging issues, including previously unrecognized excesses of cancer.
3. Provincial capacity needs to be developed to investigate cancer clusters and other emerging issues. Ideally that should be in the MLTSD, where it is independent of the WSIB, and could also focus on prevention of future disease as well as compensation. This would require increased research capacity within the Ministry. MLTSD could seek partnerships with other branches of government. For example, Public Health Ontario currently investigates suspected clusters of environmental origin and has appropriate expertise to provide assistance. Historically, MLTSD's physicians undertook these investigations. MLTSD needs to rebuild its scientific capacity.

Recommendations to improve access to exposure data for compensation (and prevention)

1. Adjudication should be improved by better access to electronic exposure data. While MESU is useful, it could use a better interface and does not cover all circumstances or time periods needed. The WSIB should attempt to partner with the Canadian Workplace Exposure Database (CWED) which contains the MESU data, but also contains exposure data collected by other provinces to cover a wider range of exposure.
2. MLTSD should lower data access barriers and create better mechanisms to provide exposure-related data to WSIB. In addition, exchange of data in both directions between MLTSD and WSIB could also contribute to prevention. The Ministry should consider this in the context of its statutory obligations and the existing privacy regulatory framework in Ontario. Facilitating this may require the Ministry to computerize records and, potentially, statutory changes.

3. MLTSD should collect copies of exposure monitoring results from employers at the time of inspections and computerize those results to facilitate access to exposure monitoring data. As above, the Ministry should consider this recommendation in the context of Ontario's existing privacy regulatory framework and statutory changes may be needed.
4. WSIB should explore opportunities to work with external research organizations to digitize historical exposure or employment records for high-risk industries, such as was done with the Mining Master File. Such efforts could also be taken using internal resources.

Recommendations to improve recognition through medical education

1. Physician education is a challenging area that deserves more investigation. While a detailed review of this issue is beyond the scope of this report, it is important that medical education be improved in Ontario to increase the recognition of occupational cancer.

Part 1: About this report

This report focuses on ways that the use of scientific evidence in the adjudication of occupational cancer claims could be improved. It is important to state up front that this report will not include a discussion of compensation for cancer among firefighters. In Ontario (and many other jurisdictions), firefighters have received a broad set of presumptions that set them apart from all other workers. They are in a unique situation, with their own legislation and in this report, we have chosen to focus on the policies and processes that impact all other workers in the province covered by the WSIB.

It is also important to acknowledge that workers' compensation decisions are not based on science alone and that there are other legal and medical issues that are beyond the scope of this review. Some terms used in this report to describe scientific issues and principles may have a different meaning in a legal context. One particular example is the term "work-related". Our interpretation of this term aligns with the Oxford English Dictionary's (OED) definition: "having a connection or relation (sometimes causal) to the thing specified" (i.e., work) (3). Similarly, our interpretation of the term "work-relatedness" aligns with the OED's definition: "the state, condition, or fact of being related or connected" to work (3). We recognize that this interpretation may not have the same meaning as the legal interpretation of work-related (i.e., "arising out of and in the course of employment").

Mandate of the review

In January 2019, the Ontario Ministry of Labour, Training and Skills Development (MLTSD) requested an independent review to provide advice to the Ministry on the following questions:

1. How can scientific evidence best be used in determining work-relatedness in an occupational cancer claim, particularly in cases with multiple exposures?
2. Are there any best practices in other jurisdictions that Ontario should consider adopting?
3. What scientific principles should inform the development of occupational disease policy?

The Ministry's desired outcomes were:

- An expert independent assessment of how scientific evidence should be considered in evaluating whether a cancer is work-related.
- Independent expert opinions on the additive implications of exposures, combined effects of exposures and synergies between different causes of disease.

- That Ontario workers and employers gain increased confidence that compensation laws and decisions take into account up-to-date science and best practices related to work-related cancers.
- That the MLTSD gain expert information to support evidence-based decision making when considering this technical area.

Methods

To achieve the review's objectives, an environmental scan was undertaken to identify relevant legislation and related policy instruments (including regulations, policies, and adjudicative practice documents). The scan was followed by a more detailed examination of legislative frameworks and key policy instruments to identify the principles governing the compensation of occupational cancer and how entitlement is determined. Information was collected from online sources and was supplemented by a series of in-person meetings with representatives from the WSIB and the MLTSD, as well as in-person meetings or phone calls with stakeholders in Ontario and occupational health researchers from across Canada, the US, New Zealand, Australia, and Europe. In addition, the WSIB provided analyses of both submitted and accepted cancer claims. Lastly, searches of the published scientific literature were conducted to identify key studies that would be helpful for preparing the part of the report dealing with scientific principles.

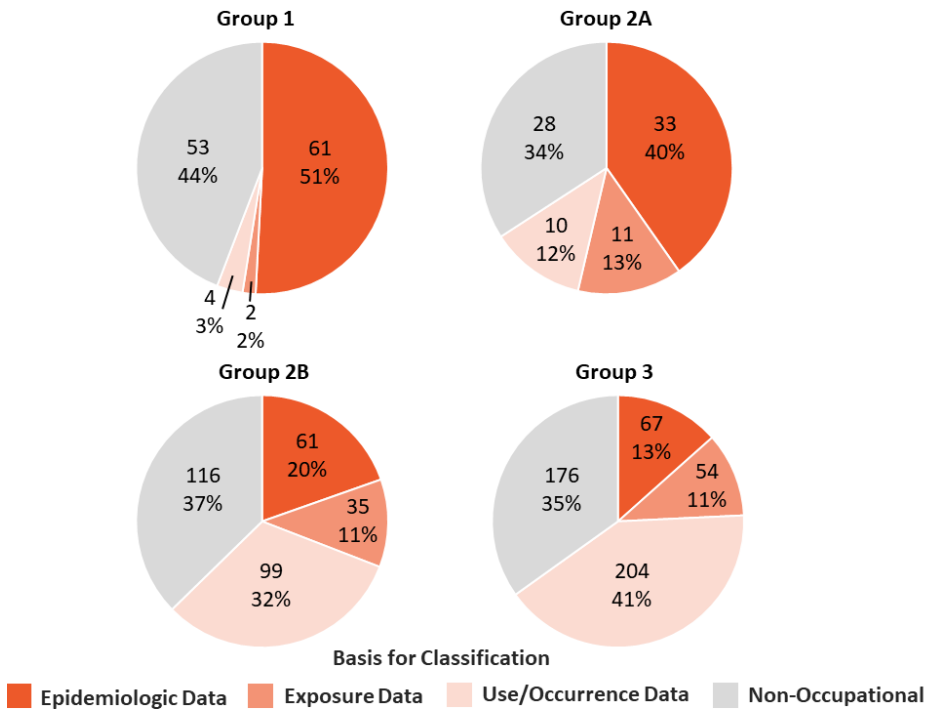
Part 2: Occupational cancer in Ontario

Setting the context

The Canadian Cancer Society has estimated that 82,100 Ontarians will receive a cancer diagnosis in 2019 and that 29,700 will die from cancer (4). Looking to the future, unless we make progress in prevention and treatment, approximately 44% of us will be diagnosed with cancer in our lifetime and 24% of us will die of cancer. Based on what is currently known about the causes of cancer, it has been estimated that approximately half of all cancers, including those caused by work, are preventable (5, 6).

While there is still much that we do not know about the causes of cancer, many workplace carcinogens have been identified. A recent paper by researchers from the International Agency for Research on Cancer (IARC), which has a program to classify the carcinogenicity of suspected agents, identified 47 Group 1 (definite) carcinogens that were classified on the basis of workplace evidence of carcinogenicity (7). Expanding on this analysis, the Occupational Cancer Research Centre (OCRC) has identified 63 IARC Group 1 and 44 IARC Group 2A (probable) workplace carcinogens based on epidemiologic or exposure studies cited in the monographs as of July 2019 (Figure 1) (8).

Figure 1: OCRC analysis of workplace carcinogens, by IARC classification



The impact of occupational carcinogens in Ontario

Hundreds of thousands of Ontarians have been exposed to a wide range of known and suspected carcinogens in the workplace. However, the impact of these exposures on health is not always clear. In order to answer this question, the OCRC started the Burden of Occupational Cancer Project[1], which developed estimates of the number and proportion of cancers caused by exposure to workplace carcinogens in Canada. The project was funded by a national team grant from the Canadian Cancer Society and was done in collaboration with researchers from British Columbia (BC), Quebec and Ontario (5). Economic cost estimates were developed by the Institute for Work & Health (9), while estimates of historical exposure were primarily developed by CAREX Canada. Where adequate data were available, the project estimated the number of cancers due to exposure to well-established occupational carcinogens. While the long-term objective of the burden project is to promote prevention of workplace cancer in Canada, its results are also pertinent to this report.

As shown in Table 1, approximately 3,000 cancers diagnosed each year in Ontario are due to occupational exposure to 16 carcinogens commonly found in the workplace (10).

Table 1: Burden of occupational cancer in Ontario

Carcinogen	Annual cancers in Ontario (Note 1)	Currently exposed (Note 2)
Solar UV at work	1400 non-melanoma skin	449,000
Asbestos	630 lung, 140 mesothelioma, 15 laryngeal, <5 ovarian, *additional colorectal and stomach*	52,000
Diesel exhaust	170 lung, *45 bladder*	301,000
Crystalline silica	200 lung	142,000
Welding fumes	100 lung	169,000
Nickel	80 lung	48,000
Chromium VI	25 lung	39,000
Second-hand smoke at work	50 lung, 10 pharyngeal, 5 laryngeal (Note 3)	125,000
Radon	60 lung	34,000
Arsenic	20 lung	8,000
Benzene	10 leukemia, <5 multiple myeloma	147,000
PAHs	*60 lung, 15 skin, 30 bladder*	134,000
Shiftwork	*180-460 breast*	833,000
Artificial UV Radiation	5 ocular	48,000
Wood dust	<5 sinonasal, <5 nasopharyngeal	92,000
Formaldehyde	<5 leukemia, <5 sinonasal, <5 nasopharyngeal	63,000

Notes:

1. Based on 2011 cancer statistics; IARC probable associations are italicized.
2. Source: CAREX Canada.
3. Among never smokers.

[1] The term 'burden' refers to the human impact and economic cost associated with a cause of disease.

Solar radiation, asbestos, diesel engine exhaust and crystalline silica are the occupational carcinogens with the largest impact on cancer burden in Ontario (10).

- Approximately 449,000 workers in Ontario spend a significant amount of time working outdoors and are exposed to solar radiation, which causes an estimated 1,400 non-melanoma skin cancer cases annually.
- Although fewer than 55,000 workers in Ontario are currently exposed to asbestos at work, past exposure is responsible for 630 lung cancers, 140 mesotheliomas, 15 laryngeal cancers and fewer than 5 ovarian cancers annually in the province. Asbestos exposure may also be responsible for additional colorectal and stomach cancers, but the project was not able to estimate the number.
- Diesel engine exhaust exposure, which currently affects about 301,000 Ontario workers, accounts for 170 lung and a suspected 45 bladder cancer cases each year.
- Crystalline silica causes approximately 200 lung cancer cases each year and there are an estimated 142,000 Ontario workers currently exposed.

The economic analyses for the study, which were led by the Institute for Work & Health, looked at direct costs (i.e., healthcare costs, out-of-pocket costs, insurance administration, and informal caregiver costs), indirect costs (i.e., productivity/output costs and replacement costs for ill workers), and intangible costs (i.e., monetary value of the loss of health-related quality of life). The economic estimates represent the total lifetime costs of newly diagnosed cancers in Canada (based on the reference year of 2011).

- The estimated costs per case of mesothelioma and lung cancer were approximately $1.1M and $1.0M, respectively (9).
- The estimated cost for each case of occupational bladder cancer was $660,000 (11).
- The estimated cost for each case of non-melanoma skin cancer differed between squamous cell and basal cell carcinomas ($10,600 *vs*. $5,700, respectively) (12).
- Economic burden estimates can also be made for specific exposures. For example, the economic burden for lung cancer and mesothelioma due to asbestos exposure in Canada added up to $831 million in direct and indirect costs for newly identified cases and $C1.5 billion in quality of life costs (13).

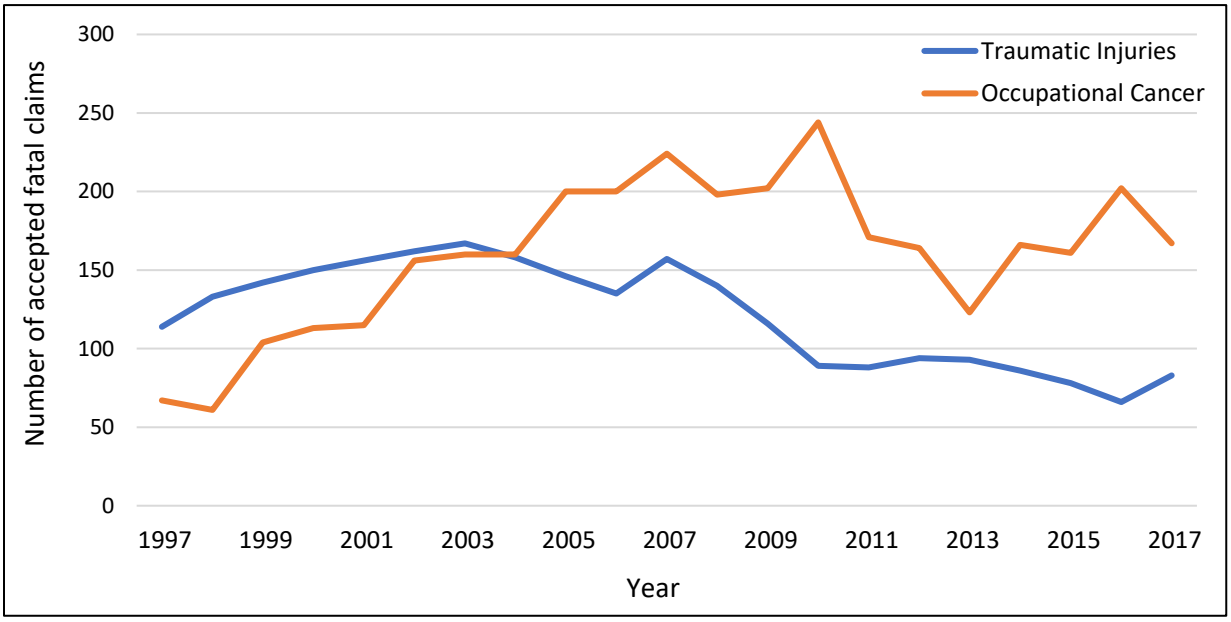
It is important to point out that these are not the costs to the compensation system, but costs measured at the societal level.

The number of cancers that are currently compensated in Ontario

In 2013, the OCRC published a report that used data from the Association of Workers' Compensation Boards of Canada (AWCBC) to describe trends in compensated claims for deaths

from occupational cancer in Ontario and Canada overall for the period 1997–2010 (14). Compensated claims for deaths from occupational cancer have increased dramatically over that period, surpassing those for traumatic injuries in Canada. The change was particularly dramatic in Ontario where the number surpassed injuries in 2005 and, by 2010, there were more than twice as many fatal cancers compensated. The analysis was extended to 2017 for this report (Figure 2). Although the number fluctuates from year to year, the data demonstrate that there are still many more fatal cancer claims accepted annually than traumatic injury claims.

Figure 2: WSIB accepted workplace fatalities (1997–2017)



Fatal claims, however, only represent part of the cancer picture. Data provided by the WSIB on all cancer claims[2] reveal that 4,044 cancer claims were submitted to the WSIB between 2009 and 2018 and that, of these, 1,678 (or 41.5%) were accepted (Table 2). Thus, over the past 10 years, an average of 400 cancer claims were submitted to the WSIB per year and, on average, 170 cancer claims were accepted per year (excluding claims related to the firefighter presumptions). The pattern of accepted claims was as follows: 762 mesothelioma (45% of all accepted cancer claims), 596 lung cancer (36%), 71 skin cancer (4.2%), 40 bladder cancer (2.4%) and 209 'other' (12%). This pattern is largely explained because over half of the submitted claims (n=2,035) were for cancers due to asbestos and of these, 63% (n=1,291) were accepted (Table 3). In contrast, only 19% (n=391) of all other claims were accepted.

[2] Includes submitted, as well as accepted claims.

Table 2: Allowed cancer claims (2009-2018), by primary diagnosis/cause of death

Primary cancer	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Mesothelioma	90	79	88	70	73	80	66	78	76	62	762
Lung cancer	87	75	56	62	45	48	71	45	54	53	596
Other cancers	49	38	41	32	27	17	17	20	32	47	320
Total	**226**	**192**	**185**	**164**	**145**	**145**	**154**	**143**	**162**	**162**	**1,678**

Table 3: Primary causal agent for accepted cancer claims in Ontario (2009-2018)

Agent	Cases
Asbestos	1291
Crystalline silica	23
Benzene	21
Defoliants and herbicides	38
Solar & ultraviolet radiation	24
Coal Tar	14
Foundry emissions	13
Coke oven emissions	11
Nickel & sinter plant emissions	18
Welding fumes	9
Uranium (radon)	8
Exhaust gases - diesel	7
Rubber chemicals	6
Ultraviolet radiation	6
Solvents	6
Aluminum powder	6
Trichloroethylene	5
Ionizing radiation	5
Aromatic hydrocarbons	5
Other and unspecified agents	172

The gap between the estimated burden and what is compensated in Ontario

Comparing the data in Table 1 (page 4) and Table 3 (above) reveals that claim statistics do not reflect the estimated true number of occupational cancers in Ontario. Cancers due to asbestos exposure were the most well compensated category between 2009 and 2018, with an average of approximately 130 cases compensated each year (Table 3). Of these, approximately 80 were for mesothelioma (Table 2). However, based on the reference year of 2011, the Burden of Occupational Cancer Project estimated that occupational asbestos exposure caused 630 lung cancers and 140 mesotheliomas (and smaller numbers of larynx, ovary, colorectal and stomach cancers) in Ontario (Table 1) (13). Similar discrepancies are observed in the number of predicted cases *vs*. the number of accepted claims for exposure to solar UV radiation (1,400 predicted *vs*. 24 accepted), diesel engine exhaust (170 predicted *vs*. 7 accepted), crystalline silica (200 predicted *vs*. 23 accepted) and welding fumes (100 predicted *vs*. 9 accepted). Based

on well-established associations, a total of 2,900 cancer cases are predicted overall for the 16 carcinogens listed in Table 1 compared to the average of 170 accepted claims per year. It is important to point out that only a fraction of this gap is explained by rejection of claims, given that only 400 claims are filed per year and many of these are for associations not on the IARC list.

How Ontario compares to other jurisdictions

Ontario *vs*. other Canadian provinces

To compare compensation in Ontario to other provinces, we calculated the claims rate per 100,000 workers, using data from the AWCBC on accepted fatal claims and a report on the scope of labour force coverage (15). Based on AWCBC data, there were 161 fatal cancer claims in Ontario in 2015, resulting in a claim rate of 3.1 per 100,000 covered workers. The overall claim rate for Canada that year was 2.5, which was similar to BC (at 2.4), Quebec and Manitoba (both at 2.5). Newfoundland and Labrador had the highest rate (at 5.2), while Alberta had the lowest (at 1.2) and the remaining provinces (which had too few cases to report individually) had a combined rate of 2.0 claims per 100,000 insured workers. Based on AWCBC data, mesothelioma due to asbestos exposure was the dominant fatal cancer compensated in Canada, comprising 46% of all claims. Mesothelioma accounted for 36% of the fatal claims in Ontario and Alberta, for 58% in Quebec, and for 65% in BC.

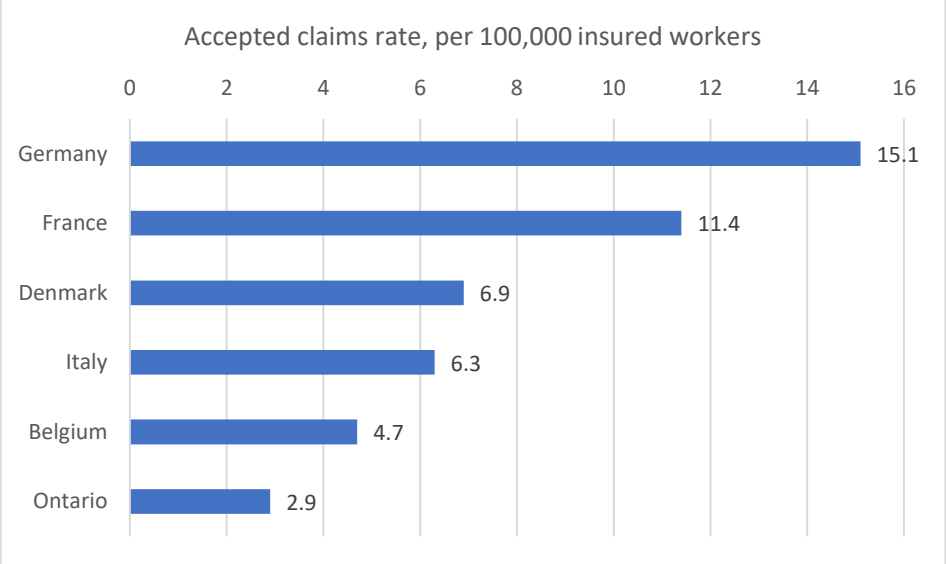
The Burden of Occupational Cancer Project estimates that there almost five asbestos-related lung cancers for every mesothelioma and our findings indicate that these are both severely under-reported and under-compensated. There are a number of factors that potentially impact compensation, such as provincial policies and the recognition of causality by clinicians. In 2016, the OCRC conducted a small analysis to investigate the impact of these factors on compensation for fatal mesotheliomas and lung cancers due to asbestos (16). To calculate the proportion compensated, we divided the mean number of compensated fatal asbestos cases for the period 2011–2014 (determined from AWCBC data) by the number of estimated fatal asbestos cancers in 2011 from the Burden of Occupational Cancer Project. The overall results showed that 61% of mesotheliomas and 5% of lung cancers due to asbestos in Canada were compensated. Ontario's results were 61% and 6%, respectively. Among the other provinces, only BC was substantially better for mesothelioma, with virtually all cases being compensated at that time. For lung cancer, Quebec and BC were similar to Ontario, with the remaining provinces compensating fewer.

Ontario *vs*. select international jurisdictions

To compare compensation in Canada to some of the major European jurisdictions, we used data from a report entitled "*Incidence and detection of occupational cancer in nine European*

countries", which included statistics for Germany, Austria, Belgium, Denmark, Finland, France, Italy, Sweden and Switzerland (17). In 2016, the countries with the highest rates of accepted occupational cancers claims per 100,000 insured workers were: Germany, France, Denmark, Italy, and Belgium (Figure 3). In 2018, Ontario accepted 162 cancer claims of all kinds. With a covered population that year of 5,592,000 people, the rate of accepted cancer claims in Ontario was significantly lower than all of these jurisdictions at 2.9 per 100,000 insured workers.

Figure 3: How the accepted claims rate in Ontario compares to selected European jurisdictions



The countries that accepted the highest percentage of submitted claims were Austria (87.2%) and France (79.1%), while Denmark accepted the lowest at 28.2%. For comparison, Ontario accepted 42% of submitted claims in 2018.

In all jurisdictions except Germany, accepted cancer claims for 2016 were driven by asbestos-related cancers. In Germany, asbestos-related cancers made up 30% of accepted claims, while in the remaining eight countries, 75% or more were asbestos-related. In Ontario, asbestos-related cancers accounted for 77% of all accepted claims in 2018. Overall, Germany, France and Italy compensated the greatest variety of cancer types. In 2015, Germany began including skin cancer caused by UV radiation on its list of occupational diseases and by 2016, the majority of accepted claims were for skin cancer (3,782 claims, or 58%). France had the second-lowest percentage of asbestos-related claims (at 75%) and it was the only country to compensate more asbestos-related lung cancer than mesothelioma.

For both Germany and France, almost all recognized cases were on the presumptive lists (see Selected international jurisdictions in Part 5 of this report). Germany recognized only 28 "off-list" cancers (0.43%) while France recognized 94 (4.44%). While occupational carcinogen

exposure can vary between countries based on the major industries and exposure prevention, it is interesting to note that Sweden, which does not include any cancers on its presumptive list, had a ratio of only 0.5 accepted claims per 100,000 insured in 2016, and recognized only 27 claims (out of 56 submitted, 48%).

How occupational cancer claims are compensated in Ontario

This section briefly summarizes our understanding of how claims for occupational cancer are adjudicated in Ontario and how scientific principles are currently used to inform the policy development process. While a detailed analysis of the policy and legal context for compensating occupational cancers is outside the scope of this review, we have provided a list of the WSIB's occupational cancer policies considered in this review in Appendix 2.

In determining entitlement to compensation for occupational cancers specifically, and for occupational diseases more generally, the key adjudicative question to be resolved is that of causation. Thus, in adjudicating a claim, decision-makers seek to determine whether the disease is due to the nature of the worker's employment (i.e., is the disease work-related?). Three general principles govern how causation is evaluated and entitlement is determined:

1. **Employment does not have to be the predominant or primary cause.** The exposure has to contribute in a significant or material way to the development of the disease, but there is no requirement in law or policy that the employment or the exposure be the only cause. To determine if the exposure was of causative significance, decision-makers are expected to apply the *de minimus* test (i.e., did the worker have a more than trifling amount of exposure?).
2. **Absolute certainty is not required.** Because the standard of proof is the balance of probabilities, absolute certainty is not required to evaluate causation and to determine entitlement. Decision-makers must weigh the evidence and be satisfied that it is more likely than not that the work exposure was a significant contributing factor in the development of the worker's cancer.
3. **The worker is afforded the benefit of the doubt.** Where the evidence for and against causation is evenly weighted, the *Workplace Safety and Insurance Act, 1997* requires that the benefit of the doubt be given to the claimant and the issue be resolved in their favour[3].

These principles apply to the adjudication of all claims, regardless of whether they are for occupational diseases, physical injuries or psychological injuries. The threshold for causation and the evidentiary burden are the same for injuries and diseases, other than those to which a presumption applies where the evidentiary burden of rebutting work-relatedness falls on the

[3] The benefit of the doubt provisions are set out in Section 119(2) of the *Act* and are interpreted in Policy 11-01-13.

employer.

Adjudication and management of occupational cancer claims in Ontario are handled by the WSIB's Occupational Disease and Survivor Benefits Program, a unit comprised of senior adjudicators, physicians, occupational hygienists, and nurse case managers. Entitlement is determined using the following methods[4]: by reference to presumptions provided in Schedules 3 or 4 of O. Reg 175/98, by application of operational policies in Chapters 16 and 23 of the Operational Policy Manual (OPM), and on a case-by-case basis[5]. According to the WSIB, the key step in all occupational disease claims – and the one that is most relevant to this review – is information gathering. In this step, regardless of the method of adjudication, the decision-maker gathers, analyzes and weighs the following information: employment history, detailed exposure history, medical history (e.g., diagnostic reports and medical opinions), current scientific evidence on occupational exposures and diseases, and relevant personal information (18). As appropriate, the decision-makers will consult internal and external resources[6] to resolve any questions they have on causation and work-relatedness.

Compensation of cancers presumed to be work-related

Many workers' compensation systems in Canada and around the world have presumptive lists of occupational diseases, which appear either in schedules to the legislation or in supporting regulations. If a worker is diagnosed with a disease identified in the regulated list and has worked in the corresponding activities, the disease will be presumed to be an occupational disease. While presumptions of work-relatedness are generally rebuttable (i.e., evidence to the contrary may be provided that allows the compensation board to conclude that, in the specific case of an individual worker, the disease was not attributable to work), some jurisdictions, including Ontario, have occupational disease presumptions that are non-rebuttable (i.e., evidence to the contrary is not permitted).

Under Schedules 3 and 4 of O. Reg 175/98, three cancers are afforded a presumption of work-relatedness: epitheliomatous (skin) cancer, primary cancer of the nasal cavities or of the paranasal sinuses, and mesothelioma of the pleura or peritoneum (Table 4)[7]. The presumptions listed in Schedule 3 are rebuttable, while those listed in Schedule 4 are not.

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[4] The other method used is the application of sections 15.1 and 15.2 of the *Act* (and reference to O. Reg 253/07) to claims from firefighters. As noted elsewhere in this report, discussion of firefighter claims is outside the scope of this review.

[5] In claims with a diagnosis of a cancer recognized by presumption, entitlement is first determined by considering whether the worker's exposure meets the criteria set out in the second column of the appropriate schedule. If these criteria are not met, entitlement is then considered under any relevant policy or on a case-by-case basis. Case-by-case adjudication is based on the facts of the claim and an assessment of evidence of causal connection between occupational exposure and the disease.

[6] Internal resources include the following: occupational and other specialist physicians, advanced practice nurses, occupational hygienists, and Operational Policy Branch support (includes policy and scientific support).

[7] Ontario Regulation 253/07 also includes a list of 17 cancers that are prescribed diseases for the purposes of Section 15.1(4) of the *Act*.

Table 4: Occupational cancer presumptions listed in O. Reg 175/98, Schedules 3 and 4

Description of Disease	Description of Process
Cancers listed in Schedule 3, with rebuttable presumption of work-relatedness	
Cancer — epitheliomatous (skin) cancer	Any process involving use or handling of tar pitch, bitumen, mineral oil or paraffin or any compound, product or residue of these substances
Cancer — primary cancer of the nasal cavities or of paranasal sinuses	Concentrating, smelting or refining in the nickel producing industry
Cancers listed in Schedule 4, with non-rebuttable presumption of work-relatedness	
Primary malignant neoplasm of the mesothelium of the pleura of peritoneum [sic]	Any mining, milling, manufacturing, assembling, construction, repair, alteration, maintenance or demolition process involving the generation of airborne asbestos fibres
Primary cancer of the nasal cavities or of paranasal sinuses	Any process at the Copper Cliff sinter plant of Inco Limited
Primary cancer of the nasal cavities or of paranasal sinuses	Any process in the Port Colborne leaching, calcining and sintering department of Inco Limited that was practised before January 1, 1966

Compensation of cancers where work-relatedness is not presumed

In Ontario, as in many jurisdictions, workers diagnosed with cancer may still apply for – and be entitled to – compensation even when their cancer is not listed in a presumptive schedule or where their exposures do not correspond to the exposures stipulated under a presumption. In these cases, it must be shown, on the balance of probabilities, that their disease was contracted out of or in the course of employment by reason of their exposure to hazards in the workplace (19, 20). The requirements for what must be proven vary by jurisdiction, but generally it is necessary to provide evidence that it is more probable than not that the disease was caused by the worker's employment, even if the worker was exposed to other hazards outside the workplace (19, 20).

In Ontario, relevant policies are found in Chapters 11, 16 and 23 of the OPM. Ontario does not have a general policy on determining work-relatedness for occupational cancer claims. Excluding the one policy for cancers in firefighters, occupational cancers account for 12 of the 22 occupational disease policies included in these chapters. Of the 12 occupational cancer policies, 7 provide guidelines on adjudicating lung cancer claims and 2 provide guidelines on adjudicating laryngeal cancer claims. The remaining 3 occupational cancer policies provide guidelines on nasal cancer, gastrointestinal cancer, and mesothelioma. All of the WSIB's occupational cancer policies considered in this review are listed in Appendix 2.

Part 3: Scientific principles relevant to this review

Determining causation in the context of workers' compensation is a complex process primarily governed by legal principles (19), but, hopefully, informed by scientific principles as well. There are a number of national and international agencies and organizations that assess whether chemicals, forms of radiation, or other factors cause cancer. The most widely recognized of these internationally, and in Canada, is IARC, which classifies agents into four categories: Group 1 (definite human carcinogens), Group 2A (probable), Group 2B (possible) and Group 3 (not classifiable) (21, 22). IARC's evaluation process, which is well documented, is based on scientific principles and the use of peer-reviewed – and publicly available – scientific evidence.

To do its evaluations, IARC Working Groups conduct reviews of all available human studies. Epidemiologic studies are reviewed using a "weight-of-evidence" approach where the results of all studies meeting the minimum quality criteria are considered, rather than focusing on the results of positive studies alone. IARC also evaluates animal and other experimental studies (but uses a different set of pre-defined rules) and has attempted to systematize their approach to identifying and classifying the mechanisms of carcinogenesis (23). In the context of compensation, it is important to recognize that IARC assesses whether a chemical or other agent can cause cancer (a *hazard* assessment), as opposed to the level of exposure necessary to cause cancer (a *risk* assessment). There are other organizations (such as the US National Toxicology Program, the US Environmental Protection Agency and the Dutch Expert Committee on Occupational Hazards) that use independent scientific committees to evaluate studies across disciplines[8], assess carcinogenic hazards, and conduct risk assessments to identify the level at which adverse health effects occur.

Over the last decade, IARC re-evaluated all Group 1 carcinogens and changed its evaluation process to systematically identify which cancer types (i.e., lung, skin, etc.) are caused by specific carcinogens. This, in my opinion, is a valuable gift to the adjudication process[9]. While our knowledge of what causes cancer has greatly increased and continues to do so, the sophistication with which we approach attribution in workers' compensation has not always kept pace. In this part of the report, we will focus on the theories and principles that are relevant to determining work-relatedness of cancer.

Multi-stage theory of carcinogenesis

The multi-stage theory of how cancer is caused (also known as the Armitage-Doll model) was developed in 1954 (24). Although other models have been proposed since that time, the basic

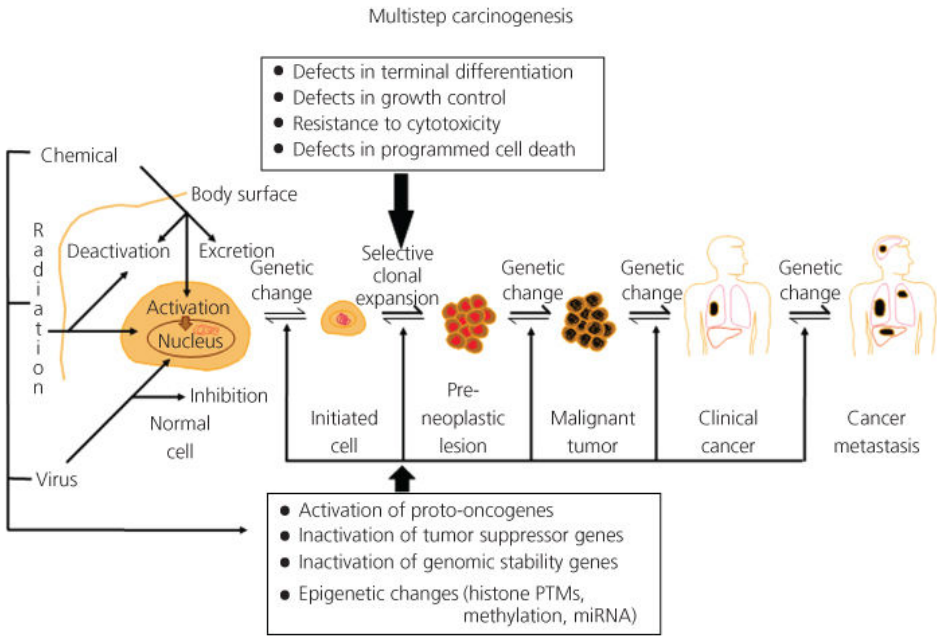
[8] Such as toxicology, occupational hygiene, occupational medicine, and occupational epidemiology.

[9] The List of Classifications by cancer sites with sufficient or limited evidence in humans, Volumes 1 to 123 can be downloaded at https://monographs.iarc.fr/wp-content/uploads/2018/07/Table4.pdf.

theory has been well accepted and supported by experimental data. From a practical point of view, these models have contributed to our understanding that a cancer in an individual does not have a single cause but is the result of a complex series of events that occur at different stages, from the initiation of disease[10] (mutation) at an early stage through promotion[11] and progression[12] at later stages. Multi-stage models therefore emphasize the importance of considering the sequence of multiple exposures as well as the time intervals between multiple exposures in the carcinogenesis process.

Carcinogens (chemicals, radiation or viruses) can have an impact through various mechanisms at any or multiple stages, from the earliest stages continuing even after the clinical disease has developed (25). Figure 4 below is one representation of how our understanding has continued to increase in sophistication. In the model, there are many stages in the development of cancer, but the earliest stage is still the mutation that results in the initiated cell, while the last potential stage is the development of metastases.

Figure 4: Our evolving understanding of the mechanism of carcinogenesis



Source: Hofseth et al (2017)

[10]The first stage of carcinogenesis. The primary step of tumor induction, where the potential for unregulated growth is established.

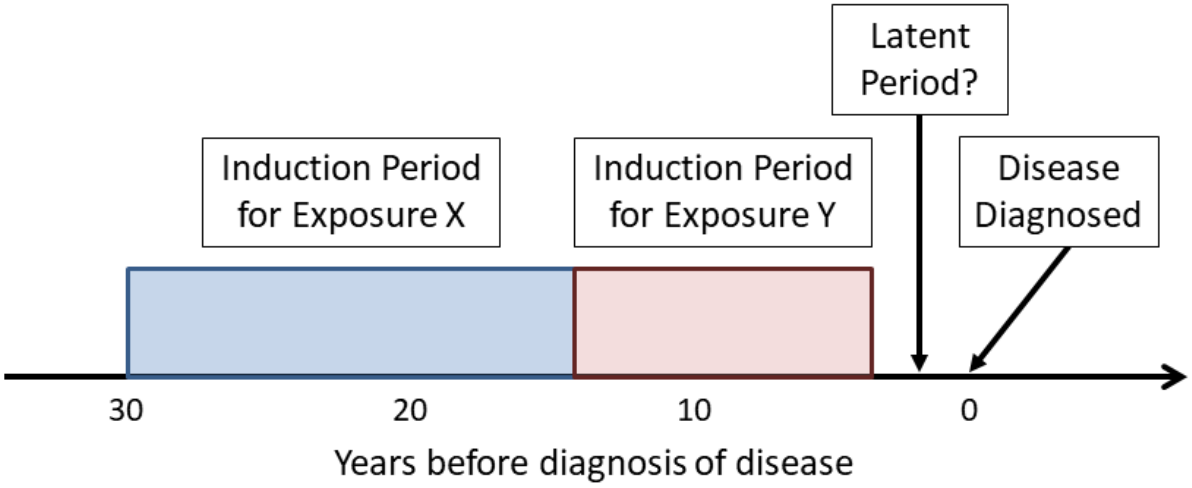
[11]The second stage of carcinogenesis, in which a promoting agent induces an initiated cell to divide abnormally.

[12]The third stage of carcinogenesis. A phase of unregulated growth and invasiveness, frequently with metastases and morphologic changes in the cancer cells.

Latency and induction

Multi-stage theories also relate directly to the concepts of induction and latency. The induction period is when an exposure has its effect on increasing the risk of cancer. Latency refers to the time period between the induction period and the detection of disease. While induction and latency are sometimes treated as a property of a disease, they are actually a property of the relationship between each exposure and the disease (Figure 5). The series of events needed for the development of cancer means that different causes could have different effective time periods of exposure, depending on whether they have early or late stage effects. Thus, there could be differences in the time between when a contributing exposure occurs and the detection of disease.

Figure 5: Latent and induction periods in the chronic disease model

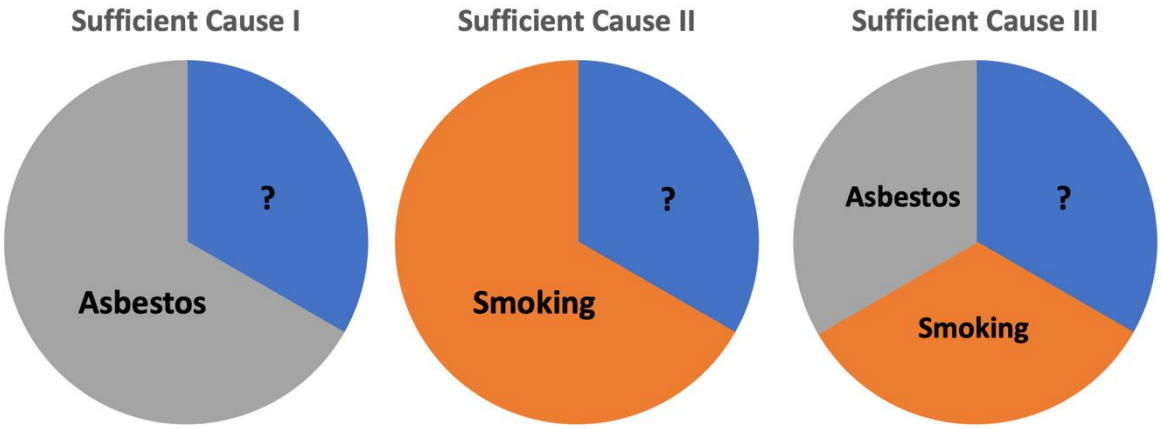


Some epidemiological studies are better suited to assisting with attribution than others. For example, while many studies assume a 10- to 15-year latency lag for asbestos exposure and lung cancer, some researchers have investigated the association between occupational asbestos exposure and lung cancer using a latency modeling approach that allowed the authors to investigate the time since each yearly exposure compared to the time since first exposure. They found that there was a "shorter latency period than previously assumed, especially for high intensity of exposure" (26). This study is a powerful illustration of how assuming a default latent period disregards the effect of time and intensity of exposure on the latent period variability.

The role of multiple exposures

Another useful theory of how multiple exposures can contribute is Rothman's causal pie model (27). In this conceptual model, a "sufficient cause" of disease is illustrated as a pie consisting of a set of component causes (illustrated as pieces of the pie) that together can cause a disease. An important concept is that "sufficient cause" requires all components to operate and if any component is removed, it is no longer sufficient. The causal pie model is illustrated in Figure 6, below, using the example of asbestos exposure, cigarette smoking and lung cancer. In this example, there are three sufficient causes (represented by I, II and III). Sufficient Cause I is asbestos plus some unknown factor or factors, Sufficient Cause II is smoking plus some unknown factor(s), and Sufficient Cause III is asbestos and smoking plus some unknown factor(s). Note that in this example the size of the pie slices does not reflect their relative importance.

Figure 6: Causal pie model – the example of asbestos, smoking and lung cancer*



*Rothman's causal pie model conceptualizes how multiple exposures can contribute to the onset of work-related disease and the sizes of the slices have nothing to do with the relative contributions of each exposure.

The combined impact of multiple causes

The impact of an individual cause can be measured in several ways:

- **Added Risk:** The first, and perhaps simplest, way to measure the impact of a cause is to consider how much it adds to the risk of disease. For example, if the risk of disease for people who are not exposed to the cause is 2 per 100,000 people, and the risk among people who are exposed is 8 per 100,000 then the *added risk* is 6 per 100,000.

- **Relative Risk:** Another way to measure the impact of a cause is to look at the ratio of the risk among those who are exposed *vs*. those who are unexposed. So, in the above **example**, the *relative risk* among exposed people is 4 times the risk of people who are not exposed (i.e., 8 divided by 2).

While there are situations in which individuals are exposed to a single causative agent, it is much more common for people to be exposed to multiple established or suspected human carcinogens at the same time. In these situations, it is also necessary to consider whether the causes act independently or interdependently (i.e., whether they interact with each other).

- **Independent Causes:** Two or more causes are independent if "the occurrence of one is in no way predictable from the occurrence of the other" and the causes do not interact with each other to increase or decrease the risk (28). In this situation, we would generally expect that the combined effect of two or more independent causes would be the sum of their solitary effects. In other words, they have what is called an *additive relationship*. So, if the risk of chemical X is 6 per 100,000 and the risk of chemical Y is 4 per 100,000, we would expect the risk of cancer to be 10 per 100,000 (i.e., 6+4=10).
- **Interdependent Causes:** Two or more causes are interdependent (or interactive) if they operate together to "produce or prevent an effect" (28). In this situation, we would generally expect that the combined effect of two or more interdependent causes would be greater than the sum of their solitary effects. In other words, they have what is called a *synergistic relationship*[13]. So, in the above example, if the two causes interact with each other and create a risk that is greater than 10, we would say there is synergy between the two causes. If the risk in people exposed to both causes were equal to 24 per 100,000, we would say that the relationship is *multiplicative* (i.e., 6x4=24).

The multistage model "predicts that the interaction between two carcinogens acting at different stages can range from purely additive to many times more than multiplicative depending on the sequence and interval between the two exposures" (29, 30).

Epidemiologic studies can be used to illustrate some of the principles above. The classic example of interaction is from the 1979 study of New Jersey insulation workers (31). Table 5 presents the reported risks of lung cancer among workers with different exposure histories.

Table 5: Lung cancer, asbestos, and smoking from a study of New Jersey insulation workers

Exposure history		**Lung cancer**	
Smoking	**Asbestos**	**Mortality rate (per 100,000)**	**Relative risk**
No	No	11	Reference
No	Yes	58	5.3

[13]It is possible for the combined effect of two or more causes to be less than the sum of their solitary effects (i.e., they combine to create a protective or preventive effect). In this case, the causes have an antagonistic relationship.

Yes	No	123	11.2
Yes	Yes	602	54.7

As the table illustrates, the risk associated with exposure to smoking and asbestos is much greater than the sum of the individual risks, indicating an interaction between the two exposures. Because the observed relative risk (54.7) is approximately the same as multiplying the risk among workers only exposed to asbestos (5.3) times the risk among workers who only smoked (11.2), the relationship between smoking and asbestos in this example shows the classic multiplicative relationship (i.e., 5.3 x 11.2 = 59.4). If the exposure to asbestos and smoking had no interaction, then they may have shown an additive relationship (i.e., 5.3 + 11.2 = 16.5), still substantial but much smaller than 54.7. A more important point is that removing asbestos would not only prevent the cancers caused by asbestos alone, but also the cancers caused by the combination of smoking and asbestos, reducing the lung cancer rate in that group to the rate for smokers alone.

While there are too few studies of multiple exposures to quantify the relationship between many of the common workplace exposures, it would seem reasonable to assume in the absence of contrary evidence that they are independent and that therefore their relationship would be assumed to be additive. Such an approach has been taken by the ACGIH® for calculating the Threshold Limit Value for Mixtures for over 30 years (32):

> "When two or more hazardous substances have a similar toxicologic effect on the same organ or system, their combined effects, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, different substances should be considered as additive where the health effect and target organ or system are the same."
>
> Appendix E of *2019 TLVs and BEIs* (32).

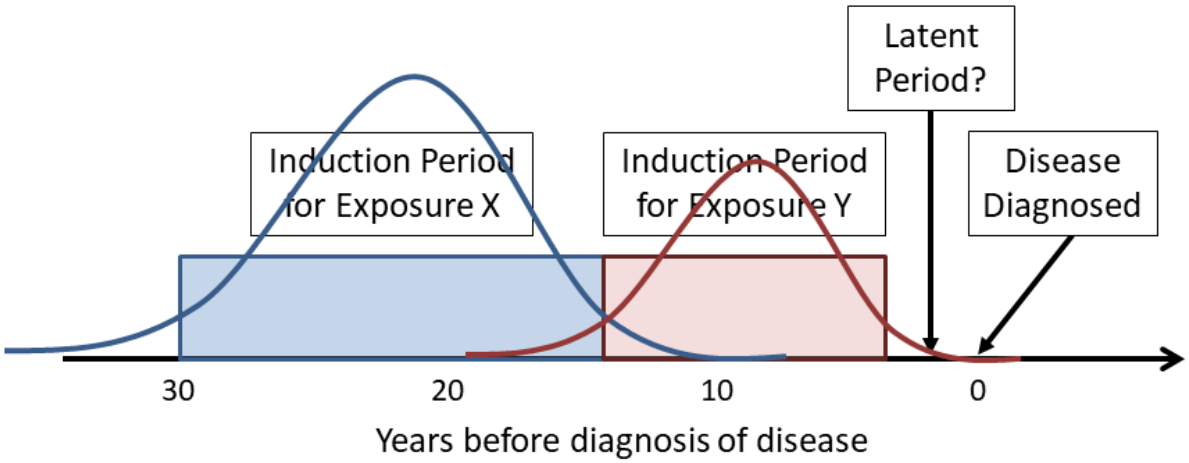
This approach has been adopted in the context of prevention by regulatory agencies within Canada, including WorkSafeBC[14] and the MLTSD under O.Reg. 833 (33). Given that the cancers being compensated are due to exposures that could have been, but were not, prevented, it would be reasonable for the standard that is applied to preventing exposure to mixtures also be applied to compensation.

[14]Section 5.51 of the *Occupational Health and Safety Regulation* states: "If there is exposure to a mixture of 2 or more substances with established exposure limits which exhibit similar toxicological effects, the effects of such exposure must be considered additive unless it is known otherwise, and the additive exposure must not exceed 100%". According to the corresponding guideline, this section applies to all exposure limits, except for excursion limits. The guideline goes on to specify that when considering additive effects, similar exposure limits must be compared and for effects to be considered additive, the substances must act upon the same target organ or target organ system and have similar toxicological effects.

Statistical distribution of effects

The final scientific principle that deserves discussion in this area of the report is the statistical distribution of effects. Biological processes, such as the development of disease, generally have what is termed a normal distribution (a bell-shaped curve). For practical purposes, we generally use a discrete range of years or other units when assessing the length or timing of exposure or its latency. For example, we might say that "20 years of exposure" was needed "at least 10 years prior to diagnosis". These numbers are based on epidemiologic studies and represent the period when there was the highest probability that exposure resulted in disease (i.e., the middle portion of the bell-shaped curve). In addition, researchers find round numbers (like 5, 10, 20…) convenient, but biological relationships do not necessarily favour these cut-points. Discrete time ranges for exposure and latency are useful, but it should be recognized that these ranges will not apply to all individuals. The period of time when exposure can contribute to the development of disease is determined by a complex set of factors and some individuals will be in the tail ends of the distribution, outside of the discrete range estimated by epidemiologic studies (Figure 7).

Figure 7: Induction and latency model with statistical distributions overlaid



Part 4: Why the compensation of occupational cancers is so challenging

As noted in Part 2 (in the section entitled "How occupational cancer claims are compensated in Ontario"), occupational cancer claims are adjudicated in a series of steps. To be considered for entitlement, a worker must first think that their cancer is work-related and file a claim. Once a claim is in the system, the WSIB then examines whether a link between the disease and the exposure has been recognized by legislation or has been reported in the scientific literature (general causation), determines the worker's exposure history, and then judges whether there is a link between the worker's exposures and their disease (specific causation).

Challenge 1: Primary care providers under-recognize and under-report occupational cancers

The major factor underlying the gap between the burden of occupational cancer estimates and the number of cancers compensated in Ontario is that primary care providers often do not realize that a patient's cancer may have been caused by exposures in the workplace. There are 3 key reasons for this (34).

1. The clinical and pathological expression of cancers do not generally differ by cause. For example, there is no lab test that can tell us if a lung cancer was caused by smoking or asbestos or another carcinogen.
2. Almost all cancers have multiple causes and individuals differ in susceptibility.
3. Cancers can be diagnosed long after exposure and it can be very difficult to estimate the level and length of exposure, which are strong predictors of the likelihood of people developing cancer.

Occupational physicians are well trained in the recognition of occupational cancer. However, other than some specialty clinics and independent practices, there are very few occupational medicine specialists in Ontario. Thus, the great majority of patients need to rely on their primary care providers for support on workers' compensation claims. Without the recognition by primary care providers, the onus of recognition falls on the patient and fewer workers' compensation claims are filed. In order to reduce the extent of under-recognition, physicians need better training or tools on the causes of cancer and for collecting a full work history from their patients, which would include where the patient had worked, the dates they were employed, and the hazards present.

Challenge 2: Epidemiological findings may have limitations when applied to individual attribution

In adjudicating a claim, decision-makers seek to determine whether the disease is due to the nature of the worker's employment (i.e., is the disease work-related?). To resolve this, the

WSIB must determine both general causation (i.e., is there a link between the disease and exposure) and specific causation (is there a link between *this worker's* exposures and their condition). Epidemiology, which is the science concerned with the occurrence of disease in populations, can answer the former but not always the second question. The aim of epidemiologic studies is to establish whether there is an association between a particular exposure and a particular disease and, further, whether there is a "dose-response" relationship (i.e. whether the risk of disease increases with the intensity of exposure).

Epidemiologists use statistical models to identify the groups where the higher risk of disease occurs based on duration, level, or some other measure of exposure. The ways in which historical exposure may be documented in an epidemiological or occupational hygiene study include: qualitative assessment using a surrogate of exposure (e.g., yes/no exposed, job title, industry), semi-quantitative estimation of exposure (e.g., high, medium, low), quantitative exposure measurements (e.g., time-weighted average concentrations, cumulative exposure, peak exposure), or the measured dose within the body. Regardless of the study design, exposures are assessed at the *group level* (i.e., job title, department, industry), not at the individual level.

Statistical techniques can be used to examine the timing of exposure and to identify the induction and latency periods. The results produced in these studies have ranges that were useful for the statistical model but may not represent individual risk. As noted in Part 3 (in the section entitled "Statistical distributions of effects"), distributions in nature are not so orderly (i.e., they generally don't start on round numbers) and are generally better represented by a bell- (or similarly shaped) curve with "tails" representing real people with disease caused by an exposure but outside of the identified range. Latency is particularly hard to identify, given the many time-related factors at play in disease promotion and progression. Thus, epidemiology is useful in in developing presumptive criteria, informing policy guidelines or establishing general causation (i.e., in determining whether a risk of developing a disease exists in a particular population of workers), but caution is needed when applying its results to establish causation in individual cases.

Further complicating the use of epidemiological findings for determining entitlement in individual cases is that few epidemiologic studies have looked at the impact of multiple occupational exposures. In practice, however, exposure to multiple established or suspected human carcinogens is not uncommon. Construction workers exposed to asbestos, crystalline silica, and diesel exhaust (all lung carcinogens) and nurses exposed to night shift work, antineoplastic drugs, and radiation (known or suspected breast carcinogens) are just two examples. The goal of occupational studies has almost always focused on establishing whether a single agent is, or is not, a cause of disease for the purpose of hazard or risk assessment. This has been useful for supporting regulation and prevention, but not always attribution. The impact of exposure to a single occupational lung carcinogen (e.g., asbestos, crystalline silica,

radon, or diesel engine exhaust) and cigarette smoking has been examined, but primarily to understand whether effects were due to the exposure of interest or only due to smoking. The need for more studies that assess the impact of multiple exposures has been recognized by key agencies, such as IARC and the US National Institute for Occupational Safety and Health (NIOSH) and a new field of research, called "exposomics"[15] has been developed (35, 36), but for now this remains a data gap.

Challenge 3: Information on historical exposures is often lacking

A key component to making science-based judgements on the work-relatedness of occupational cancer is the documentation or estimation of historical exposure to workplace carcinogens. Documenting exposure retrospectively is challenging, particularly in the absence of quantitative measurements and information on the determinants of exposure[16].

MLTSD ceased collecting its own exposure data in the 1990's, when it also closed its laboratory. The last remaining electronic remnant of the data is the Medical Surveillance (MESU) Database, but it does not have all the fields contained in the original database. As the database ages, we will have less and less opportunity to document exposure. Although the Ministry continues to inspect workplaces and requires employers to collect measurements to ensure compliance with occupational exposure limits, copies of the results are not kept and have not been put into electronic form. The lack of information on exposure is a major challenge for all workplaces, but especially so for large, complex workplaces with a long history of exposure to carcinogens, such as the GE Peterborough complex.

Challenge 4: Clusters, complex workplaces, and new/emerging hazards

In the last century, many workplace carcinogens were initially identified by clinicians or other astute observers because an unusual number of cancers had occurred among a relatively small group of people who shared the same potential exposure. The contemporary term that we would use to describe this would be a "cluster investigation". In the complex and mobile world where we are living longer and cancer has become much more common, cluster investigations are becoming increasingly challenging to do. This is particularly true with new or emerging hazards or where a causal relationship has not been established (37). A different challenge is presented when there is a perceived excess risk in a larger population historically exposed to recognized hazards. As a province with a long history of manufacturing, mining and other

[15]The National Institute for Occupational Safety and Health defines the exposome as "the measure of all the exposures of an individual in a lifetime and how those exposures relate to health". Exposomics is the study of the exposome.

[16]Examples include: the physical layout of the worksite and the size of the workroom; type of equipment used; type of task performed and proximity to other workers; how and where work tasks were performed (e.g., indoors/outdoors, continuously/intermittently, mobile/stationary); availability and use of control measures, including personal protective equipment.

hazardous work, there are many potential groups where such excesses could reasonably be suspected.

The investigation of both types of clusters requires a systematic approach. The challenges in both cases include defining the potential group at risk and its exposures (which in the case of cancer could have occurred decades earlier) and calculating whether there is an excess risk. One example of such an investigation was conducted in British Columbia for a potential cluster among hospital workers by the Occupational Health and Safety Agency for Healthcare (38). Although the conclusions drawn by the scientists were not conclusive, the data and analyses have played a key role in the subsequent appeal process, including a judgement from the Supreme Court of Canada[17]. Unfortunately, there is currently no agency in Ontario with the responsibility to investigate occupational clusters and neither the WSIB nor the MLTSD have the necessary research capacity. These investigations had been undertaken in Ontario by occupational physicians within the Ministry who understood occupational disease and workplace exposures and had some training in epidemiology, although this could also be undertaken by an inter-disciplinary research team.

[17]British Columbia (Workers' Compensation Appeal Tribunal) v. Fraser Health Authority, 2016 SCC 25), [2016] 1 SCR 587. Available at: https://decisions.scc-csc.ca/scc-csc/scc-csc/en/item/16042/index.do

Part 5: Relevant practices in other jurisdictions

Presumptive lists

As we note in Part 2, many workers' compensation systems in Canada and around the world have presumptive lists of occupational diseases that appear either in schedules to the legislation or in supporting regulations. The primary purpose of these schedules is to establish causation for diseases where there is sufficient evidence that the disease is specific to a particular exposure, process, or condition of employment. Typically, their goal is to streamline the adjudicative process by avoiding the repeated effort of producing and analyzing medical and other evidence of work-relatedness for each individual case.

Although the specific content of these presumptive lists is a policy choice made by individual jurisdictions, many are modelled on the *List of Occupational Diseases* published by the International Labour Organization (ILO)[18]. The ILO's current *List of Occupational Diseases (revised 2010)*[19], which incorporates the recommendations of two international tripartite expert working groups[20], includes occupational cancers caused by a total of 20 carcinogens (Table 6), as well as "cancers caused by other agents at work not mentioned in the preceding items where a direct link is established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these agents arising from work activities and the cancer(s) contracted by the worker" (39). A footnote to the table states: "In the application of this list the degree and type of exposure and the work or occupation involving a particular risk of exposure should be taken into account when appropriate" (39).

Table 6: Carcinogens included on the ILO's *List of Occupational Diseases (revised 2010)*

Arsenic and its compounds	Asbestos	Benzene
Benzidine and its salts	Beryllium and its compounds	Beta-naphthylamine
Bis-chloromethyl ether (BCME)	Cadmium and its compounds	Chromium VI compounds
Coal tars, coal tar pitches or soots	Coke oven emissions	Erionite
Ethylene oxide	Hepatitis B virus (HBV) and hepatitis C virus (HCV)	Ionizing radiations
Nickel compounds	Tar, pitch, bitumen, mineral oil, anthracene, or the compounds, products or residues of these substances	Toxic nitro- and amino-derivatives of benzene or its homologues
Vinyl chloride	Wood dust	

[18]Jurisdictions in Europe, Asia, and Africa have adopted presumptive lists based on the ILO's *List of Occupational Diseases.*

[19]Approved by the ILO's Governing Body at its 307th Session in March 2010.

[20]The criteria for incorporating diseases on the list were: "they occur in connection with a specific work environment and/or in specific occupations; they occur among the groups of workers concerned with a frequency which exceeds the average incidence within the rest of the population; and there is scientific evidence of a clearly defined pattern of disease following exposure and plausibility of cause".

Other Canadian provinces

Six jurisdictions in Canada have presumptive schedules for occupational diseases (British Columbia, Alberta, Ontario, Quebec, Newfoundland, and Nova Scotia). The presumption of work-relatedness in all of these jurisdictions, except Quebec, is rebuttable. Newfoundland[21] and Ontario are the only jurisdictions in Canada with both rebuttable and non-rebuttable presumptions. Cancers are explicitly identified in five jurisdictions with presumptive schedules (British Columbia, Ontario, Quebec, Newfoundland and Nova Scotia)[22]. However, there is a wide variation in the number of cancers recognized, as well as in the exposures/working conditions associated with them. British Columbia provides rebuttable presumptions for 11 cancers, while Newfoundland provides a rebuttable presumption for 3 cancers. Both Ontario and Nova Scotia provide rebuttable presumptions for 2 cancers. Quebec and Ontario provide non-rebuttable presumptions for 2 cancers[23]. Two jurisdictions have lung cancer presumptions (British Columbia and Quebec). The lung cancer presumption in Quebec is restricted to "any work involving exposure to asbestos fibre", whereas the presumption in British Columbia addresses six different exposures/working conditions. No jurisdiction in Canada represents a best practice in the use of presumptions, when compared to international jurisdictions.

Selected international jurisdictions

In the **United Kingdom**, occupational cancers are compensated under the Industrial Injuries Scheme. Under the law, benefits are payable to workers who are suffering from a prescribed cancer that is listed in the Prescribed Diseases Regulations[24]. Most of the prescribed diseases in the Regulations are afforded a rebuttable presumption that causation is due to a worker's occupation[25]. Eight cancers (leukemia, lung, skin, nasal, bladder, liver, mesothelioma, nasopharyngeal) associated with 40 exposures/working conditions are currently included on the Prescribed Diseases List. The Prescribed Diseases List is updated on the advice of the Industrial Injuries Advisory Council, an independent scientific advisory body created in 1948 to advise the government on matters related to the administration of the Industrial Injuries Scheme.

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[21]Section 90(3.1) of the *Workplace Health, Safety and Compensation Act* provides a non-rebuttable presumption for asbestosis and employment in a process involving asbestos.

[22]In some jurisdictions, including Alberta which does not recognize occupational cancers in the list of presumptions provided in Alberta Regulation 325/2002, "radiation injury or disease due to ionizing radiation" is presumed to be work-related "where there is significant occupational exposure to ionizing radiation". Since cancer is one of the diseases known to be caused by exposure to ionizing radiation, it could be argued that cancer is implicitly recognized by the regulation.

[23]It could be argued that Quebec provides presumptions for 3 cancers as Schedule I (Section 29) of the *Act respecting industrial accidents and occupational disease* includes "disease caused by ionizing radiations" for workers who perform "any work involving exposure to ionizing radiations".

[24]There is no entitlement to benefit in respect of a disease if it is not listed in the Regulations, or if the person's job is not listed against the particular disease.

[25]For prescribed diseases where the presumption does not apply, the onus is on the claimant to establish, on the balance of probability, that their disease was due to the nature of their employment.

Most countries in the **European Union** recognize occupational diseases in two ways: either via a national presumptive list or via a "complementary system" in which proof of the causal link between the disease and the occupational activity is provided on a case-by-case basis (17).

- In **France**, occupational cancers are compensated under the French Social Security Code. Under the law, benefits are payable for diseases that appear on one of the occupational disease tables, as well as for those that don't ("off-table" diseases). For conditions listed in the tables, there is a systematic presumption that if the diseases meet the medical, occupational and administrative requirements set out in the tables, then they are work-related. For "off-table" diseases, entitlement is determined on a case-by-case basis by the regional occupational disease recognition committee. The occupational disease tables are regularly updated by legislative decree to reflect changes in techniques and evolving medical knowledge. Based on a search of the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS) website and a report of the most prevalent occupational cancers compensated in the European Union (17), the following seven cancers are presumed to be work-related in France: mesothelioma, lung cancer, nasal, sino-nasal, leukemia, bladder, skin and liver.
- In **Germany**, occupational cancers are compensated under Book VII of the German Social Insurance Code. In total, 80 diseases have been formally recognized in law by the German government and are listed in an annex to the Ordinance on Occupational Diseases. Based on a report of the most prevalent occupational cancers compensated in the European Union, the following eight cancers are presumed to be work-related in Germany: mesothelioma, lung cancer, laryngeal, nasal, sino-nasal, leukemia, bladder, and skin (17).

Most jurisdictions in **Australia[26] and New Zealand** have a Deemed Diseases List as part of their workers' compensation system (40). Thirteen cancers, associated with 10 exposures/working conditions, are included on the Deemed Diseases lists and are afforded a rebuttable presumption of work-relatedness. They include: mesothelioma, lung cancer, laryngeal cancer, ovarian cancer, bladder cancer, skin cancer, liver cancer/angiosarcoma, nasal cancer, nasopharyngeal cancer, sino-nasal cancer, Hodgkin's lymphoma, kidney cancer and leukemia (40). The presumption of work-relatedness does not apply to diseases not included on the Deemed Diseases lists. In these cases, entitlement is determined on a case-by-case basis.

[26]In 2013, Safe Work Australia commissioned a review of the latest scientific evidence on the causal link between diseases and occupational exposures. The goal was to develop an up-to-date Deemed Diseases List that could be used by Australian jurisdictions considering a revision to the deemed diseases list in their workers' compensation legislation. The review, which was published in 2015, was undertaken by Dr. Tim Driscoll, an independent consultant in epidemiology, occupational health and public health, a specialist in occupational medicine and public health medicine, and a Fellow of the Australasian Faculties of Occupational and Environmental Medicine and Public Health Medicine. The full report is available online at: https://www.safeworkaustralia.gov.au/doc/deemed-diseases-australia.

In the **United States**, several compensation programs have been established to address the burden of disease in targeted populations that have experienced unique, intensive exposures. Two of particular relevance to this report are the Department of Energy's (DOE) Energy Employees Occupational Illness Compensation Program and the World Trade Center Health Program.

- **US Department of Energy (DOE):** The *Energy Employees Occupational Illness Compensation Program Act* (the "*EEOICPA*") was enacted in 2000 to compensate current and former DOE workers and contractors (or their family members) for occupational diseases related to the production of nuclear weapons and other associated job tasks (41). Under this program, cancer is compensable if it is "at least as likely as not" to have been caused by exposure to ionizing radiation during the worker's period of employment at the covered facility (42). Entitlement is determined using the "upper 99% confidence interval of the probability of causation" and dose reconstructions performed by the National Institute for Occupational Safety and Health (NIOSH). Presumptions of causation have also been established for Special Exposure Cohort (SEC) classes (43). To qualify for compensation as a member of an SEC class, a covered employee must have at least one of the 22 specified cancers and worked for a specified period of time[27] at one of the SEC work sites. Eligible claimants are compensated without the need for completion of a NIOSH radiation dose reconstruction (43).
- **US World Trade Center Health Program (WTC Health Program):** This compensation program was formed to address the burden of disease in populations exposed to complex mixtures of chemicals during and following the 9/11 attacks on the World Trade Center (WTC) in New York. Under this program, treatment is provided for a specific list of physical and mental health conditions that have been determined to be caused by exposure to the 9/11 terrorist attacks. The program also covers medically associated health conditions that are caused by the progression or treatment of a covered condition. The WTC Health Program covers over 70 cancers organized into the following categories: blood and lymphoid tissue, digestive system, eye and orbit, female breast, female reproductive organs, head and neck, respiratory system, skin (melanoma and non-melanoma), soft tissue, thyroid, urinary system, mesothelioma, and rare cancers[28]. To be eligible for coverage, the cancers must meet minimum latency periods shown in Table 7 (44).

[27]For leukemia, onset must have occurred at least two years after initial exposure at any covered facility during a covered time period. No time periods specified for primary or secondary lung, bone or renal cancers. For all others, onset must have been at least five years after initial exposure at any covered facility during a covered time period.

[28]Includes any type of cancer that occurs in less than 15 cases per 100,000 persons per year based on data from 2005-2009. Other types of cancer which meet the definition of a rare cancer may also be considered for certification. Every cancer submitted for certification which is not individually identified on the WTC list is reviewed to assess if it meets the definition of a rare cancer.

Table 7: Minimum latency requirements for cancers covered by the WTC Health Program

Cancer	Minimum latency requirement	Based on:
Mesothelioma	11 years	direct observation after exposure to mixed forms of asbestos
All solid cancers (other than mesothelioma, lymphoproliferative, and thyroid cancers)	4 years	low estimates used for lifetime risk modeling of low-level ionizing radiation studies
Lymphoproliferative and hematopoietic cancers (including all types of leukemia and lymphoma)	0.4 years (equivalent to 146 days)	low estimates used for lifetime risk modeling of low-level ionizing radiation studies
Thyroid cancer	2.5 years	low estimates used for lifetime risk modeling of low-level ionizing radiation studies

Note: this table does not include the WTC's minimum latency requirements for childhood cancers

To derive these minimum latency estimates, the Program's Administrator used the four methods listed below, in order of the best available scientific evidence (as judged by the Administrator).

1. **Studies with direct observation of latencies:** This approach considered studies that had been conducted on carcinogenic agents found to be present in the aftermath of 9/11. The population studied must have been large enough to develop a reasonable estimate of the lower bound of the distribution of latencies. This lower bound is the minimum latency estimate.
2. **Authoritative Recommendations:** When estimates of minimum latency were not available from studies with direct observation of latencies, the Administrator reviewed recommendations on minimum latency from authoritative bodies (e.g., the National Academy of Sciences), where available, and selected the shortest latency period.
3. **Studies reporting observed latencies for a cancer from another carcinogen:** This approach considered studies conducted on other carcinogens but gave preference to the findings of studies examining latency in those that were chemically analogous to a 9/11 carcinogen. As with Method 1, the population studied must have been large enough to develop a reasonable estimate of the lower bound of the distribution of latencies. This lower bound is the minimum latency estimate.
4. **Statistical Modeling:** When estimates of minimum latency were not available from studies with direct observations of minimum latencies [Methods 1 and 3] or from authoritative recommendations [Method 2], the Administrator looked to estimates of the minimum latency periods used in statistical modelling and published in the scientific literature. Sources of latency estimates obtained from statistical models

included epidemiologic studies in which exposure is "lagged"[29] and estimates of the lifetime risk of low-level ionizing radiation-related cancers from other studies (45, 46). If Method 4 yields multiple estimates of minimum latency, the Administrator's policy is to resolve any uncertainties inherent in this method in favor of the worker by selecting the shortest latency period.

The strength of the available scientific evidence for estimates of minimum latency for each type of cancer or category of cancer was evaluated and minimum latencies were selected based on that evaluation (44). More detailed information on the basis for selecting the minimum latency periods for each of the agents is available in the *White Paper on Minimum Latency & Types or Categories of Cancer*, which is available on the policies and procedures page of the WTC Health Program's website.

Science-informed policy development

As noted elsewhere in this report, a detailed analysis of the policy and legal context for compensating occupational cancers was outside the scope of this review. Therefore, we did not attempt to review the science underpinning the presumptions or the policies in Ontario or in other jurisdictions, nor did we examine the degree to which science informs policy development. However, there is a specific policy in British Columbia for a large, high-risk workplace that we believe warrants acknowledgement as an example of how research findings and exposure measurement data can be used to develop guidelines for adjudicating occupational cancer claims.

In developing Policy Item 30.10, which sets out guidelines for adjudicating claims for bladder cancer in aluminum smelter workers[30], WorkSafeBC made use of research conducted on the workplace in question and exposure measurement data collected there. The policy incorporates the research evidence that benzo-a-pyrene (a constituent of coal tar pitch volatiles) is the best predictor of risk, it reflects the input received from affected stakeholders on the question of the minimum threshold of cumulative exposure required for entitlement (which was selected using the 95% upper confidence limit to take into account scientific uncertainty) and it also explicitly addresses the synergistic relationship between smoking and exposure to benzo-a-pyrene. Some additional background on the policy development process is provided in Appendix 3.

[29]Statistical models where relatively recent exposures, generally specified in terms of years prior to diagnosis (e.g. 10 or 20 years), are not counted in order to test for a latency period.

[30]This policy is found in Chapter 4 of the Rehabilitation Services and Claims Manual, Volume II.

Scientific advisory panels

In jurisdictions around the world, scientific advisory panels have been created to provide independent advice for the ongoing – and timely – updating of national presumptive lists, as well as to inform the development and optimization of policies and processes about causation/work-relatedness.

United Kingdom

The Industrial Injuries Advisory Council (IIAC) is an independent scientific body, which was established in 1948. Its legislated mandate[31] is to advise the Minister[32] on which diseases and employment circumstances should be recognized in the Prescribed Diseases Regulations. The majority of its members are medical and scientific experts, with relevant knowledge on how and why occupational diseases occur[33]. By law, the IIAC must also include an equal number of members representing workers (typically trade union officials) and employers (typically occupational health and safety professionals). The IIAC's recommendations are principally based on the evidence derived from high-quality, peer-reviewed studies and consideration of the reports of expert bodies (such as the International Agency for Research on Cancer). In addition, it may also put out open calls for evidence, invite experts to contribute evidence, or request further analysis of existing data by outside parties. When making its recommendations, the IIAC considers: the quantity and quality of data (i.e., the number of research studies that point to a particular conclusion and what the best reports show, as well as possible biases); the consistency of the findings; the findings in the most highly exposed populations of workers; the biological plausibility of reported findings; and whether the findings can be applied to groups of workers in the UK.

United States

US Department of Labor (DOL): The Office of Workers' Compensation Programs (OWCP) in the DOL, which administers the *EEOICPA*, is supported by two scientific advisory boards (47):

- Advisory Board on Toxic Substances and Health (ABTSH): The ABTSH (which is a board composed of representatives from the scientific, medical, and claimant communities) provides advice to the Secretary of Labor on: site exposure matrices (SEM), weighing medical evidence, evidentiary requirements for certain lung diseases, and reports from expert industrial hygienists and consulting physicians (47) (Figure 8). Research/working

[31]The IIAC was established in 1948 under the National Insurance (Industrial Injuries) Act 1946. The *Act* not only set out terms of reference for the Council, but also contained provisions for the recognition, as well as the attribution of work-relatedness, of prescribed diseases.

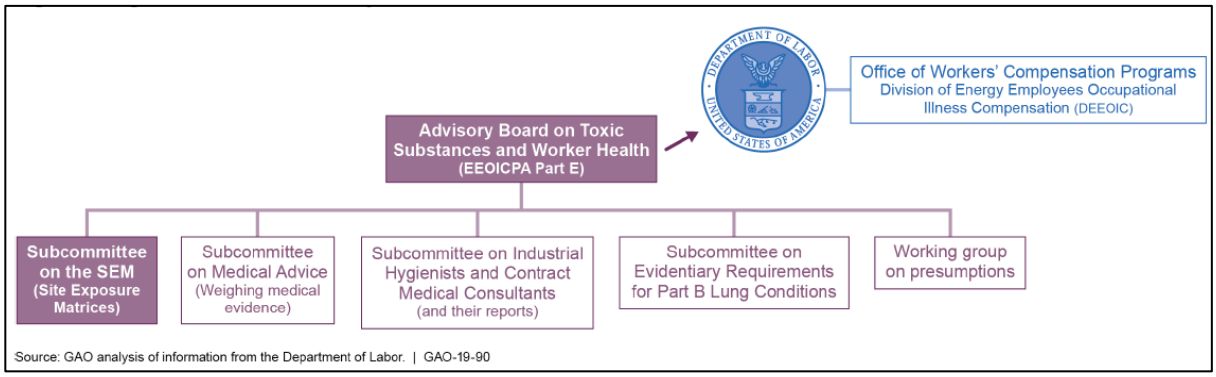
[32]The Council's role is to advise and make recommendations on prescription, but the final decision on whether to accept and implement a recommendation is made by the Secretary of State for Work and Pensions.

[33]Includes specialists in occupational medicine, epidemiology, toxicology and the law.

committees have also been established to develop and update complex databases and models for use in establishing causal links between workplace exposures and associated health outcomes, including the SEM[34] for exposure to toxic substances (48) and radiation risk models that address the cancer-exposure pairs that are most relevant to claims from workers covered by the *EEOICPA*.

- Advisory Board on Radiation and Worker Health: This Advisory Board (which includes a balance of perspectives from scientists, physicians and workers) provides advice to the Secretary of the Department of Health and Human Services on the development of final rules on methods used for completing radiation dose reconstructions, guidelines used to assess the likelihood that an employee's cancer was caused by their work at a DOE or Atomic Weapons Employer facility, and procedures for adding additional classes of employees to the Special Exposure Cohort (SEC)[35]; the scientific validity and quality of dose reconstruction efforts performed by NIOSH; and whether there is a class of employees who should be added to the SEC.

Figure 8: The DOE's Advisory Board on Toxic Substances and Worker Health



Source: Government Accountability Office Report on Energy Employees Compensation (2018).

US World Trade Center Health Program (WTC Health Program): The work of this compensation program is supported and informed by a Scientific and Technical Advisory Committee (STAC), which is composed of WTC responders and WTC survivors as well as a variety of scientific and medical professionals from various backgrounds[36], including occupational medicine,

[34]The SEM was designed by the Department of Labor to be a repository of information on toxic substances present at Department of Energy (DOE) and Radiation Exposure Compensation Act (RECA) sites covered under Part E of the *EEOICPA*. Data contained in the SEM is used by claims examiners to assist in the evaluation of causation.

[35]As described on the OWCP website, "the SEC allows eligible claimants to be compensated without the completion of a NIOSH radiation dose reconstruction or determination of the probability of causation. To qualify for compensation as a member of an SEC class, a covered employee must have at least one of the 22 specified cancers and worked for a specified period of time at one of the SEC work sites."

[36]The STAC must include at least: 4 occupational physicians (at least two of whom must have experience treating WTC rescue and recovery workers), 1 physician with expertise in pulmonary medicine, 2 environmental medicine or environmental health specialists, 2 representatives of WTC responders, 2 representatives of certified-eligible WTC survivors, 1 industrial hygienist, 1 toxicologist, 1 epidemiologist, and, at least 1 mental health professional. Other members may be appointed at the discretion of the Administrator of the WTC Health Program.

environmental health, occupational hygiene, epidemiology, and toxicology (49). The role of the STAC is threefold: to review scientific and medical evidence and make recommendations to the WTC Program Administrator on additional WTC Health Program eligibility criteria and additional WTC-related health conditions; to review and evaluate policies and procedures, as well as any subsequent substantive amendments to such policies and procedures, used to determine whether sufficient evidence exists to support adding a health condition to the List of WTC-Related Health Conditions; and to make recommendations to the WTC Program Administrator regarding the identification of individuals to conduct independent peer reviews of the scientific and technical evidence that would be the basis for issuing a final rule adding a condition to the List of WTC-Related Health Conditions. The STAC played a key role in establishing the minimum latency requirements shown in Table 7.

Internal and partnered scientific capacity

Canadian examples

Partnership for Work, Health and Safety (PWHS, British Columbia): The primary objective of this research partnership, which brings together policymakers, researchers and data resources from national and international organizations, is to address current and emerging issues of work-related health in British Columbia and Canada. The PWHS evolved out of research originally performed in 1998 by researchers at the UBC Centre for Health Services and Policy Research in support of the Royal Commission on Workers' Compensation in BC. A formal partnership between WorkSafeBC and the School of Population and Public Health at UBC was subsequently established in 2005, not long after WorkSafeBC began contributing data to BC's provincially based repository of linked administrative data (Population Data BC).

The PWHS conducts research that falls into four broad categories: policy and program evaluation, determinants of work injury and illness, injury and disease surveillance, and data development. One area of research conducted in the injury and disease surveillance program is of particular relevance to this review.

> **Mesothelioma awareness and compensation:** Based on research showing that less than half of individuals with mesothelioma listed in the BC Cancer Registry had filed a workers' compensation claim, researchers at the PWHS worked with the BC Cancer Agency and WorkSafeBC on an awareness campaign, in which letters were sent to all physicians of newly diagnosed mesothelioma patients. The campaign, which began in November 2004, increased compensation rates by 10% for those patients whose physicians received a letter in the years 2004 to 2006. However, ongoing surveillance of mesothelioma cases has shown that since 2006, the intervention effect of the letter has declined. As a result, the PWHS continues to work with the BC Cancer Agency and WorkSafeBC to refine and improve this notification system. The researchers also found that mesothelioma patients and their families rely

heavily on physicians as trusted sources of information for both medical and compensation-related issues and that they perceive the process for filing a compensation claim to be a complicated and uncertain bureaucratic procedure. A random sample of physicians surveyed reported that they were unfamiliar with the workers' compensation system, that helping mesothelioma patients seek compensation is time consuming, and that the compensation process is a barrier for their patients (50-52).

Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST, Québec): The IRSST, established in 1980, is a bridge between the public sector health and safety networks in Québec and the research community. Its mission is threefold: to contribute to the prevention of industrial accidents and occupational diseases and to the rehabilitation of affected workers through high quality research, to disseminate knowledge and serve as a scientific reference centre and expert, and to provide services and expertise required to support the public occupational health and safety network. The IRSST's research priorities are informed through formal and periodic knowledge exchange with its key stakeholders, which include the senior management of the Commission de la santé et de la sécurité du travail (CNESST), the joint sector-based associations, the Ministère de la santé et des services sociaux (MSSS) and its network, and both employer and union associations. The IRSST conducts and finances research that meets the needs of CNESST and other partners, including analyses that help to detect high-risk populations or industrial activity sectors.

International examples

Safety & Health Assessment & Research for Prevention (SHARP, Washington State, US): The SHARP Program, created in 1990, is an occupational safety and health research program located within the Washington State Department of Labor and Industries (L&I)[37]. Its primary objective is to develop practical solutions to identify and eliminate workplace hazards and reduce the burden of work-related illnesses and injuries. Through partnerships with business and labour, SHARP's multi-disciplinary team of researchers[38] support local, state, and national efforts to improve workplace safety and health. Its research activities integrate workers' compensation data with information from the scientific literature, industry practices, and workplace observations.

Institute for Safety, Compensation and Recovery Research (ISCRR, Australia): The primary role of the Institute for Safety Compensation and Recovery Research (ISCRR) is to facilitate research and best practice in the areas of injury prevention, rehabilitation and compensation. It was established in 2009 as a partnership between three institutions: Monash University, WorkSafe

[37]Although located within L&I, SHARP's activities are independent of L&I's Division of Occupational Safety and Health and the workers' compensation insurance division.

[38]SHARP has research expertise in economics, epidemiology, ergonomics, industrial hygiene, occupational medicine and nursing, safety, toxicology, and computer systems.

Victoria and the Transport Accident Commission. ISCRR's "fit for purpose" research agenda is informed by the issues faced by and the needs of its partners. It has internal capacity to conduct a range of research, including systematic evidence reviews to answer specific research questions, environmental scans to identify current and emerging trends and innovations, rapid scans of research evidence and leading industry practice to inform strategic decision-making on new and emerging topics, program evaluations, data analysis and linkage of large datasets to generate tailored insights for decision making, and early identification and assessment of the effectiveness of innovative technologies that are 1 to 3 years from market.

Methods used to improve the assessment of exposure

Canadian examples

Canadian Workplace Exposure Database (CWED): The CWED is a national Canadian resource for occupational health research and policy development that was originally developed in 2008 by CAREX Canada to assist in estimating worker exposures to carcinogens across the country (53). The CWED was also used in the OCRC's Burden of Occupational Cancer Project (10). CWED contains data from 6 jurisdictions in 5 provinces, as well as data from Labour Canada, spanning 62 years. At present, it holds 478,640 observations, of which approximately 303,000 are from Ontario workplaces. Although the CWED is novel in Canada, it is similar to other large-scale exposure databases developed by governments and organizations in Europe (54-56) and the United States (57, 58).

National Dose Registry (NDR): The NDR is the repository of dose records for Canadian workers who are monitored for occupational exposures to ionizing radiation (59). The function of the NDR is to assist regulatory authorities by notifying them of overexposures within their jurisdiction, evaluate dose trends and statistics, contribute to health research and advance scientific knowledge on the risks of exposure to ionizing radiation, and provide dose histories to individual workers and organizations for work planning, workers' compensation and legal cases (60). Operated by Health Canada, the NDR contains records on approximately 1 million workers exposed to ionizing radiation in workplaces since the 1940's. It is currently collecting data on the exposure of close to 170,000 workers with present-day exposure. Key variables contained in the NDR include worker name and identifying information, employer name and address, and personal dosimetry measurements.

GE Exposure Matrix (UNIFOR): Large complex workplaces such as GE Peterborough create special challenges for reconstructing historical exposures. UNIFOR contracted the services of the consultants Robert and Dale DeMatteo to construct an exposure matrix to assist with the compensation claims of their members. Their report used a combination of historical documents and interviews to identify exposures by department and time period in a manner that would be useful for claims adjudication (61).

International examples

National Institute for Occupational Health and Safety (NIOSH, US): Researchers from NIOSH have conducted a national survey of how workers' compensation insurers collect, store and use exposure data (62, 63). They have developed recommendations for standardizing hygiene data collection forms used by workers' compensation insurers to improve usability of existing data and identified ways researchers can help improve data collection strategies. A division within NIOSH (the Division of Compensation Analysis and Support or DCAS) supports the Department of Health and Human Services in its role in the management and implementation of the *Energy Employees Occupational Illness Compensation Program Act of 2000* (*EEOICPA*, described above in the section entitled "Presumptive lists"). DCAS is primarily responsible for reconstructing the radiation dose for certain workers with cancer who file claims under Part B[39] of the *EEOICPA* and developing scientific guidelines to determine the likelihood that an employee's cancer is related to their occupational exposure to ionizing radiation. DCAS's responsibilities also include: establishing a process for adding classes of employees to the Special Exposure Cohort (SEC) and providing staff support for the independent Advisory Board on Radiation and Worker Health.

Occupational Safety and Health Administration (OSHA, US): The Integrated Management Information System (IMIS) was designed as an in-house information resource for OSHA staff and managers and by state agencies which carry out federally-approved OSHA programs. Updated daily, it contains information on over 3 million inspections conducted since 1972 to verify compliance with OSHA's Permissible Exposure Limits (PELs). OSHA's website has a searchable interface that allows users to search IMIS, to track OSHA interventions at particular work sites or to perform statistical analyses of OSHA enforcement activity (64). Many of the occupational hygiene samples taken by OSHA compliance officers when monitoring worker exposures to chemical hazards are submitted to the Salt Lake Technical Center (SLTC) for analysis. In 2010, OSHA made all OSHA measurements analysed by the SLTC since 1984 available online. The sampling results, which can be found on the STLC's website under the title of 'Chemical Exposure Health Data', include data on personal[40], area[41], and bulk[42] samples for various airborne contaminants (65). These data can be accessed individually through search by company names, state, ZIP code, year, industry code, agent, or range of results, and downloaded as compressed XML files (58, 65).

[39]Part B provides compensation of $150,000 and medical benefits to workers (or their survivors) for illness caused by exposure to radiation, beryllium, and silica during their employment at DOE, its contractor, or subcontractor facilities.

[40]Measures the exposure of the individual who was actually wearing a sampling device.

[41]Taken in a fixed location and measures the potential for exposure to airborne contaminants/physical hazards to workers in that area.

[42]Taken to verify if certain constituents are present and if so, in what concentration. Bulk samples are used individually or in conjunction with personal or area samples to help interpret the level of worker risk.

Part 6: Observations and recommendations

Presumptive lists and cancer-relevant policies

The presumptive lists (Schedule 3 and 4) and many of the policies that are specifically related to cancer need updating. In particular, the list of presumptions is very limited compared to other jurisdictions and to the lists of well-established associations identified by agencies such as IARC and ILO. Increasing the use of presumptive lists can reduce the reliance on purely case-by-case review, increase the speed of adjudication and improve transparency by making it clear what the WSIB regards as causal associations. While some of the policies of the WSIB are very clearly written, there are gaps and some policies and presumptions are specific to employers, rather than to carcinogenic exposures, which could be applied more widely. In addition, there is the perception that some key adjudication procedures are not included in the policy manual or in the publicly available documentation. One example of this is how adjudicators handle exposure to multiple carcinogens: adjudication staff told us that they factor it into their determination, but some stakeholders we consulted with believe that is not the case.

Many workers' compensation systems, including the WSIB, use estimated latent periods as a scientific criterion for establishing work-relatedness of disease. In Ontario, there is no general policy on how to factor latency into the adjudication process. For certain cancers, minimum latency requirements that establish the minimum interval between first exposure and diagnosis of disease are set out in the applicable policies[43]. Workers are generally not entitled to compensation if the interval between the date they were first exposed to the carcinogen(s) and the date of diagnosis is less than the minimum interval established in policy. While establishing such intervals is a useful tool for facilitating adjudication for the majority of cases, it should not be used as an absolute barrier because some cases can fall outside this range. It is important to consider this when there are no other risk factors for the cancer in question, or the circumstances for the claimant are unusual, such as when exposures were particularly high or the patient unusually young.

In determining work-relatedness, decision-makers are required to weigh the evidence and be satisfied that work exposure was a significant contributing factor in the development of the worker's cancer. However, the assessment of work-relatedness is often complicated by the fact that workers are rarely exposed to just one workplace hazard. Most workers' compensation systems, including the WSIB, rely on the findings of epidemiological studies to inform their decision-making. However, this approach has limitations because the majority of existing occupational epidemiologic studies from which evidence can be drawn have traditionally focused on the effects of single workplace hazards in isolation. In Ontario, the policies are generally silent on how to factor multiple exposures into the determination of work-relatedness

[43]The minimum latency requirements for cancers in firefighters are found in O. Reg 253/07 and in Policy 23-02-01.

and adjudicators are faced with having to make assessments of work-relatedness on a case-by-case basis. This may lead to invalid assumptions about causal interactions between multiple exposures and inconsistency in decisions.

When determining entitlement, decision-makers are required to consider not only the worker's work-related exposures, but also non-occupational factors. Although there is research available that suggests that a range of non-occupational factors can influence disease risk, the most common and contentious is smoking. There is a widely held perception that, more often than not, a worker's history of smoking is used to dismiss occupational disease claims. If true, this practice would run counter to what the science says about the interaction between smoking and exposure to carcinogens. The conclusions of IARC's 2004 evaluation of the carcinogenicity of tobacco smoke are particularly relevant and should be factored into the adjudication process. This evaluation, which was published over 15 years ago, concluded that smoking was a potential confounder of the association between exposure to various workplace carcinogens and lung cancer, but that there was evidence of synergy between smoking and some important causes of lung cancer (e.g., asbestos, radon, arsenic, nickel) (66).

In most jurisdictions, including Ontario, workers' compensation legislation and policy are generally silent on the synergistic relationship between smoking and certain exposures. Two of the six lung cancer policies[44] specifically mention smoking, but only in the context of minimum cessation requirements[45]. In both of these policies, the cessation interval must be 15 years or less for a smoker or 20 years or less for a confirmed non-smoker or ex-smoker. Implicit in the use of cessation intervals is the assumption that there is no synergy between smoking and exposure and indeed that a cancer in a recent smoker was due only to smoking. There are two other policies that mention smoking. The first, Policy 23-02-02: Laryngeal Cancer and Asbestos Exposure states "in considering the individual merits of each case, a claimant's cigarette smoking and alcohol consumption habits before the diagnosis of laryngeal cancer should be considered". The second, Policy 23-02-03: Lung Cancer Among Workers in the Uranium Mining Industry, states "a worker's non-smoking status can provide evidence of work-relatedness in the weighing of evidence on the individual merits and justice of the case". No further guidance is given.

Our knowledge of what causes workplace cancer is constantly evolving and presumptive lists and policies need to keep pace to retain credibility. This updating requires both internal scientific capacity (see below) and independent scientific review. In the past, the WSIB had the Industrial Disease Standards Panel to conduct reviews. Currently, it handles major scientific questions on an *ad hoc* basis, sometimes using internal reviews (e.g., rubber workers),

[44] Policy 16-02-06: Lung Cancer-Foundry Aerosol Exposure (DOFASCO) and Policy 16-02-09: Lung Cancer-Coke Oven Emissions Exposure.

[45] The cessation interval is defined as "the time between cessation of occupational risk and appearance of lung cancer".

sometimes external consultants (e.g., McIntyre Powder), and on occasion independent panels (e.g., herbicides). Creating a standing scientific panel would allow for the continuous review of scientific information as well as new and emerging issues.

Recommendation: The WSIB should update and greatly expand the list of presumptions regarding cancer in Schedules 3 and 4 to reflect the current state of scientific knowledge. Presumptions should be based on exposure to carcinogenic agents or processes, and not specific employers, in order to be more broadly applicable. In updating and expanding its presumptive lists, the WSIB may want to consider using criteria such as that used in independent scientific review undertaken of Australia's deemed diseases list (2). Similar to that review, we would recommend that the following three criteria be used:

- Evidence of a strong causal link between the disease and occupational exposure, defined on the basis of inclusion in IARC Group 1 (i.e., definite human carcinogen), a systematic review of the evidence, or multiple good quality studies showing a causal relationship between the disease and the occupational exposure.
- Clear diagnostic criteria for any disease included in a scheduled list to ensure questions don't arise as to whether the claimant really has the disease that is the subject of the claim.
- The occupational disease comprises a considerable proportion of the cases of that disease overall in the exposed population.

Recommendation: The WSIB should update and expand all of the policies relevant to adjudication of cancer claims to reflect the current state of scientific knowledge. We have identified two areas for which new policies are needed:

- A policy that explains how exposure to multiple carcinogens is handled. Given the current state of knowledge regarding the impact of multiple exposures, the effects of exposure carcinogens impacting the same cancer site should be considered additive, unless there is evidence to the contrary.
- A policy that states clearly how non-occupational exposures, particularly cigarette smoking, are weighted relative to occupational exposures. As with multiple occupational exposures, the relationship should be considered additive unless there is evidence for a synergistic effect.

Recommendation: The WSIB should create an independent, standing Scientific Review Panel to review and recommend changes to the schedules and policies, to review and approve scientific reports, and to assist in the selection of external consultants and researchers. The Panel should be composed of independent scientists with a broad range of expertise, including epidemiology, toxicology, occupational medicine, and occupational hygiene. The process for choosing members should allow for stakeholder input, including

the opportunity for worker representatives and employers to nominate scientists. Scientists with expertise in occupational cancer and occupational disease are a scarce resource in Canada and the scientific challenges are similar across the country. Ontario could consider sharing the support of such a panel with other jurisdictions. This would not only increase efficiencies and leverage other resources, but also increase the independence of the panel.

Enhancing scientific capacity

Our knowledge of what causes workplace cancer is constantly evolving and presumptive lists and policies need to keep pace to retain credibility. Although both the WSIB and the MLTSD have highly trained professionals, the current level of internal scientific capacity in both organizations is grossly inadequate. For example, in contrast to the over 10 research staff it had a decade ago, the WSIB currently has only 2 dedicated research staff, and the MLTSD, which had the ability in the 1980's to investigate clusters and conduct independent studies, is now almost entirely reliant on external resources. While the WSIB, through the MLTSD, funds scientific research centres, including the Occupational Cancer Research Centre, it does not always take full advantage of their research expertise or their findings.

Capacity needs may be partially addressed by enhancing existing and developing new research partnerships, but internal staff are also needed at both the WSIB and the MLTSD. There is currently no capacity to investigate clusters or to identify potential high-risk industries. There is also too little capacity to translate the results of scientific studies into a form that can be used to drive policy and to support the activities of the Scientific Review Panel.

Recommendation: The WSIB needs to increase its internal scientific capacity to at least its previous levels. This should include scientists with graduate level training in epidemiology, toxicology and exposure science (such as occupational hygiene).

Recommendation: Stronger partnerships with external research centres, including those already funded with WSIB funds, are needed for research on emerging issues and gaps of importance to Ontario. Such partnerships should encourage the development of surveillance systems to support evidence-based decision making in adjudication and to assist in identifying emerging issues, including previously unrecognized excesses of cancer.

Recommendation: Provincial capacity needs to be developed to investigate cancer clusters and other emerging issues. Ideally that should be in the MLTSD, where it is independent of the WSIB, and could also focus on prevention of future disease as well as compensation. This would require increased research capacity within the Ministry. MLTSD could seek partnerships with other branches of government or, possibly, system partners. For example, Public Health Ontario currently investigates suspected clusters of environmental origin and

has appropriate expertise to provide assistance. Historically, MLTSD's physicians undertook these investigations.

Access to exposure data to improve compensation (and prevention)

A necessary component to making science-based judgements on the work-relatedness of occupational cancer is documenting or estimating exposure to workplace carcinogens. This is a major challenge for all workplaces though special efforts may be required for complex, high-risk industries. Ontario has many industries with a long history of contributing to the provincial economy of Ontario, but these industries also come with a long history of carcinogenic exposures. Large complex workplaces such as GE Peterborough create special challenges for reconstructing historical exposures. Special efforts may be needed to document exposure for these workplaces and may require a large investment of human and financial resources, but proper adjudication of large numbers of claims is expensive regardless of the methods. In addition, claims adjudicators need better and more timely access to exposure data. At present, claims adjudicators must submit Freedom of Information requests for documents relevant to workplace exposures held by the Ministry, which introduces delays in an already slow process.

Recommendation: Adjudication should be improved by better access to electronic exposure data. While MESU is useful, it could use a better interface and does not cover all circumstances or time periods needed. The WSIB should attempt to partner with the Canadian Workplace Exposure Database (CWED) which contains the MESU data, but also contains exposure data collected by other provinces to cover a wider range of exposure.

Recommendation: MLTSD should lower data access barriers and create better mechanisms to provide exposure-related data to WSIB. In addition, exchange of data in both directions between MLTSD and WSIB could also contribute to prevention. The Ministry should consider this in the context of the existing privacy regulatory framework in Ontario. Facilitating this may require the Ministry to computerize records and, potentially, statutory changes. The Ministry may want to consult other jurisdictions where mechanisms exist for the sharing of administrative data[46].

Recommendation: MLTSD should collect copies of exposure-monitoring results from employers at the time of inspections and computerize those results to facilitate access to exposure monitoring data. As above, the Ministry should consider this recommendation in the context of Ontario's existing privacy regulatory framework and statutory changes may be needed.

[46]One example is British Columbia where WorkSafeBC has contributed claims and firm-level data to Population Data BC for over a decade. See https://www.popdata.bc.ca/data/occupational/wsbc for information on the specific records contributed and https://www.popdata.bc.ca/privacy for the mechanisms that are in place to meet and exceed all relevant legal, ethical and legislative guidelines for data protection and privacy.

Recommendation: WSIB should explore opportunities to work with external research organizations to digitize historical exposure or employment records for high-risk industries, such as was done with the Mining Master File. Such efforts could also be taken using internal resources.

Improving recognition through medical education

Even for well-established carcinogens there is an extremely large gap between the estimated burden of occupational cancer and submitted claims. Currently, Canadian medical students receive very little basic training in occupational health, including the need to collect an occupational history. Other than a few specialty clinics and some independent practices, there are very few occupational medicine specialists in the province, so the great majority of patients need to rely on their primary care providers for support on workers' compensation claims.

General practitioners have acknowledged the value that additional training in occupational medicine could bring to their practice (67) and primary care provider targeted occupational health training could improve the rate of detection and reporting of occupational disease (68). For example, a recent study demonstrated that physicians who had been trained in occupational medicine or received training in occupational diseases were "more likely to refer a patient on suspicion of occupational disease" (69).

Recommendation: Physician education is a challenging area that deserves more investigation. While a detailed review of this issue is beyond the scope of this report, it is important that medical education be improved in Ontario to increase the recognition of occupational cancer.

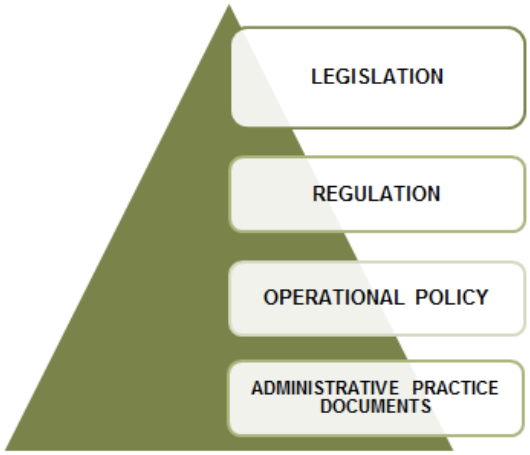
Appendices

Appendix 1: How are occupational cancers compensated in Ontario?

Legislative and policy framework

Four types of policy instruments form the decision-making hierarchy for the compensation of occupational cancer claims in Ontario (Figure 9).

Figure 9: Hierarchy of policy instruments



Source: WSIB (70).

Governing legislation: The WSIB derives its authority to compensate workers for occupational diseases from Section 15 of the *Workplace Safety and Insurance Act, 1997* (the "*Act*"). Under Section 15, a worker is eligible to receive compensation for an occupational disease, including cancer, provided the following medical and legal criteria are met:

1. the worker must have a clinical diagnosis of an illness or a disease,
2. the clinical diagnosis must be made by a recognized health professional[47],
3. the worker must "suffer from" and be impaired by the illness or disease, and
4. the disease must have been "due to the nature of one or more employments in which the worker was engaged".

If all of these criteria are met, the worker is entitled to compensation under the insurance plan "as if the disease were a personal injury by accident and as if the impairment were the happening of the accident"[48].

[47]Defined in Section 2(1) of the *Act* as "a member of the College of a health profession as defined in the *Regulated Health Professions Act, 1991"*.

[48]Defined in Section 2(1) to include: "(a) a wilful and intentional act, not being the act of the worker, (b) a chance event occasioned by a physical or natural cause, and (c) disablement arising out of and in the course of employment".

Section 2(1) of the *Act* defines "occupational disease" to include the following:

(a) a disease resulting from exposure to a substance relating to a particular process, trade or occupation in an industry,

(b) a disease peculiar to or characteristic of a particular industrial process, trade or occupation,

(c) a medical condition that in the opinion of the Board requires a worker to be removed either temporarily or permanently from exposure to a substance because the condition may be a precursor to an occupational disease,

(d) a disease mentioned in Schedule 3 or 4[49], or

(e) a disease prescribed under clause 15.1(8)(d)[50]

The *Act* also provides legislative presumptions[51] regarding the work-relatedness of the occupational diseases listed in Schedules 3 and 4 of Ontario Regulation 175/98 (O. Reg 175/98). Section 15(3) provides a rebuttable presumption for the work-relatedness of the diseases listed in Schedule 3. Under this presumption, if a worker develops a disease listed in Schedule 3 and was employed in the process described opposite the disease before the date of disablement, it is presumed the disease was caused by the nature of the worker's employment, unless the contrary is proved. Section 15(4) provides a non-rebuttable presumption for the work-relatedness of the diseases listed in Schedule 4. Under this presumption, if a worker develops a disease listed in Schedule 4 and was employed in the process described opposite the disease before the date of disablement, the disease is deemed to have occurred due to the nature of the worker's employment.

Regulations: Regulations have the force of law but are subordinate to the governing legislation (70). As a result, they must be authorized by specific provisions in the *Act*. Section 2(1) of the *Act* authorizes the WSIB to recognize the occupational diseases listed in Schedules 3 and 4 of O. Reg 175/98. Under these schedules, three cancers are afforded a presumption of work-relatedness: epitheliomatous (skin) cancer, primary cancer of the nasal cavities or of the paranasal sinuses, and mesothelioma of the pleura or peritoneum (Table 8)[52]. The presumptions for skin cancer and for nasal cancer in the nickel producing industry are rebuttable. The presumptions for mesothelioma and for nasal cancer in two sintering plants at Inco Limited are non-rebuttable.

[49]Schedules 3 and 4 are found in Ontario Regulation 175/98.

[50]These are diseases prescribed by regulation, made under the authority of the Lieutenant Governor in Council.

[51]Section 15.1(4) of the *Act* also provides presumptive coverage for occupational diseases of firefighters, fire investigators, or classes of firefighters or fire investigators. However, as noted elsewhere in this report, discussion of issues related to the compensation of occupational cancers in firefighters is outside the scope of this report.

[52]Ontario Regulation 253/07 also includes a list of 17 cancers that are prescribed diseases for the purposes of Section 15.1(4) of the *Act*.

Table 8: Occupational cancer presumptions listed in O. Reg 175/98, Schedules 3 and 4

Description of Disease	Description of Process
Cancers listed in Schedule 3, with rebuttable presumption of work-relatedness	
Cancer — epitheliomatous (skin) cancer	Any process involving use or handling of tar pitch, bitumen, mineral oil or paraffin or any compound, product or residue of these substances
Cancer — primary cancer of the nasal cavities or of paranasal sinuses	Concentrating, smelting or refining in the nickel producing industry
Cancers listed in Schedule 4, with non-rebuttable presumption of work-relatedness	
Primary malignant neoplasm of the mesothelium of the pleura of peritoneum [sic]	Any mining, milling, manufacturing, assembling, construction, repair, alteration, maintenance or demolition process involving the generation of airborne asbestos fibres
Primary cancer of the nasal cavities or of paranasal sinuses	Any process at the Copper Cliff sinter plant of Inco Limited
Primary cancer of the nasal cavities or of paranasal sinuses	Any process in the Port Colborne leaching, calcining and sintering department of Inco Limited that was practised before January 1, 1966

Operational policies: The meaning and the application of the *Act* (and its supporting regulations) are clarified in the Operational Policy Manual (OPM). Policies do not have the force of law (like the *Act* or the regulations); however, they are binding on the Workplace Safety and Insurance Appeals Tribunal (WSIAT)[53] (70). Three chapters of the OPM that provide guidance to decision-makers for determining entitlement are relevant to this review.

- Chapter 11: Decision Making includes 11 general decision-making policies that are applicable to all claims (e.g., determining the date of injury, the merits and justice of the claim, and the benefit of the doubt).
- Chapter 16: Long Term Exposures includes 28 policies and is divided into two sections. The first section includes 9 policies on disablements, none of which focus on occupational cancers. The second section includes 19 policies under the heading of "occupational diseases". Of these, 17 focus on occupational cancers.
- Chapter 23: Occupational Diseases includes 5 policies and is divided into two sections (acute *vs*. chronic exposures). The section on acute exposures includes 2 infectious disease policies, while the section on chronic exposures includes 3 occupational cancer policies.

Occupational cancers account for 20 of the 33 occupational disease policies included in Chapters 16 and 23. The WSIB's occupational cancer policies considered in this review are listed in Appendix 2.

[53]Section 126(1) of the Act states that "if there is an applicable Board policy with respect to the subject-matter of an appeal, the Appeals Tribunal shall apply it when making its decision".

Administrative practice documents: Administrative practice documents (APDs) provide guidance to assist decision-makers in understanding the interpretation and practical application of operational policies. APDs – which fall under the categories of worker claims, employer accounts, and adjudicative advice documents – do not have the force of law or policy and, as a result, are not binding on the WSIAT. Of the 21 APDs currently available online, the only one relevant to this review is Weighing of Medical Evidence (May 2017).

General principles governing compensation of occupational cancers in Ontario

Like all workers' compensation systems in Canada, the system in Ontario is founded on the Meredith Principles. Because it is a no-fault inquiry system, neither the worker nor the employer is required to prove their case. Responsibility for gathering the relevant information, weighing the evidence, and making decisions on entitlement rests with the WSIB, the independent public agency with the legislative mandate to administer and interpret the *Act*. In determining entitlement to compensation for occupational cancers specifically, and for occupational diseases more generally, the key adjudicative question to be resolved is that of causation. Thus, in adjudicating a claim, decision-makers seek to determine whether the disease is due to the nature of the worker's employment (i.e., is the disease work-related?).

The *Act* and the policies are silent on the legal test for causation in determining entitlement for occupational diseases. However, as noted in a number of WSIAT decisions, the proper legal test for causation for these claims is "whether, on a *balance of probabilities*, a worker's duties at work *significantly contributed* to the onset of an injury or medical condition" [*emphasis added*] (71). This approach is influenced by the Supreme Court of Canada's position on causation in the context of tort cases (19).

> "The Tribunal (like the courts) accepts that a contributing cause does not need to be the major cause of an injury or disease in order to be a "significant contributing" cause or to have made a "material contribution" to the development of an injury/disease. But employment will not be shown to have been a "significant contributing" cause of an injury/disease if the injury/disease would have occurred when it did even in the absence of the employment."
>
> 2003 ONWSIAT 2153, Decision 600/97

The following three general principles govern how causation is evaluated and entitlement is determined:

1. **Employment does not have to be the predominant or primary cause.** The exposure has to contribute in a significant or material way to the development of the disease, but there is no requirement in law or policy that the employment or the exposure be the only cause. Decision-makers are expected to apply the *de minimus* test (i.e., did the

worker have a more than trifling amount of exposure?) to determine if the exposure was of causative significance.

2. **Absolute certainty is not required.** Because the standard of proof is the balance of probabilities, absolute certainty is not required to evaluate causation and to determine entitlement. Decision-makers must weigh the evidence and be satisfied that it is more likely than not that the work exposure was a significant contributing factor in the development of the worker's cancer.
3. **The worker is afforded the benefit of the doubt.** Where the evidence for and against causation is evenly weighted, the *Act* requires that the benefit of the doubt be given to the claimant and the issue be resolved in their favour[54].

Methods of adjudicating occupational cancer claims in Ontario

Occupational cancer claims are handled by the Occupational Disease and Survivor Benefits Program, which includes teams of specially trained and experienced staff (e.g., senior adjudicators, physicians, an occupational hygienist, and nurse case managers). These teams adjudicate the claims using the following four methods:

1. by reference to presumptions provided in Schedules 3 or 4 of O. Reg 175/98
2. through the application of sections 15.1 and 15.2 of the *Act*[55]
3. by application of operational policies in Chapters 16 and 23 of the OPM
4. on a case-by-case basis

When determining entitlement to a disease claim, a decision-maker considers the worker's clinical condition and exposure at work, the up-to-date clinical and scientific information, any pertinent non-occupational factors, and all of the relevant policy instruments.

Adjudication under the presumptions: In claims with a diagnosis of a cancer recognized by presumption, entitlement is determined by considering whether the worker's exposure meets the entitlement criteria set out in the second column of the appropriate schedule. If the presumptive criteria are not met, entitlement is then considered under any relevant policy or on a case-by-case basis. A histopathological confirmation of diagnosis is the first step in determining entitlement for these claims. Once the diagnosis is confirmed, entitlement is first considered under Schedule 4. The next step is to determine whether the worker meets the employment criteria in column 2 of Schedule 4. If those criteria are met, the claim is allowed. If those criteria are not met, entitlement is considered under the rebuttable presumption of

[54]The benefit of the doubt provisions are set out in Section 119(2) of the *Act* and are interpreted in Policy 11-01-13.
[55]These sections apply to the adjudication of cancer claims from firefighters. As noted previously, consideration of the science underpinning these sections is outside the scope of this report.

Schedule 3. If the employment criteria and the latency requirements[56] are met, the claim is allowed. For example, if it is determined that the cancer is not due to the nature of employment in concentrating, smelting or refining in the nickel producing industry, the adjudicator then considers the claim on a case-by-case basis to examine the worker's full job history and determine if causation is due to another well-established occupational cause of nasal cancer (e.g., woodworking in the furniture and cabinet making industry).

Application of the policies: In claims where the presumptions do not apply, entitlement is determined by applying the guidelines set out in the policies on general decision making in Chapter 11, as well as the policies on long-term exposure and chronic exposures in Chapters 16 and 23, respectively, of the OPM.

Case-by-case adjudication: Adjudication of diseases that are not listed in the published policies or schedules may proceed under either the occupational disease or injury by accident provisions of the Act. This also applies when a worker has a disease listed in Schedule 3 or 4 but was not employed in the related process specified in the schedule. Case-by-case adjudication in these claims is based on the facts of the claim and an assessment of evidence of causal connection between occupational exposure and the disease.

Steps in the adjudicative process

Occupational disease claims are adjudicated in a 7-step process: initial claim assessment, information gathering, analysis of evidence, determination of initial entitlement, determination of benefits, communication of the decision, and continuing management of the claim (18). The key step in all occupational disease claims – and the one that is most relevant to this review – is information gathering. In this step, regardless of the method of adjudication, the decision-maker gathers, analyzes and weighs the following information: employment history, detailed exposure history, medical history (e.g., diagnostic reports and medical opinions), current scientific evidence on occupational exposures and diseases, and relevant personal information (18). As appropriate, the decision-makers will consult internal and external resources[57] to resolve any questions they have on causation and work-relatedness.

[56] Workers who meet the disease and employment criteria set out in Schedule 3 *and* have a latency of 15 years or greater are, in most cases, deemed to be entitled to compensation under the presumption. Before determining that the presumption is rebutted for those workers who meet the criteria set out in Schedule 3 but have a latency of 15 years or less, Policy 16-02-01 requires that the adjudicator consider other factors, including the nature and duration of the worker's employment.

[57] Internal resources include the following: occupational and other specialist physicians, advanced practice nurses, occupational hygienists, and Operational Policy Branch support (includes policy and scientific support).

Appendix 2: WSIB occupational cancer policies considered in this review

Adjudication Principles

- Adjudicative Process (11-01-01)
- Decision-Making (11-01-02)
- Merits and Justice (11-01-03)
- Benefit of Doubt (11-01-13)

Long Term Exposures – Occupational Diseases

- Nasal Cancer in the Nickel Producing Industry (16-02-01)
- Lung Cancer in the Nickel Producing Industry (16-02-02)
- Lung Cancer-Foundry Aerosol Exposure (DOFASCO) (16-02-06)
- Lung Cancer - Gold Miners (16-02-07)
- Lung Cancer-Arsenic Exposure (Deloro Smelting and Refining) (16-02-08)
- Lung Cancer-Coke Oven Emissions Exposure (16-02-09)
- Laryngeal Cancer-Asbestos/Nickel Exposure (16-02-10)
- Gastro-Intestinal Cancer-Asbestos Exposure (16-02-11)
- Mesothelioma of the Pleura and Peritoneum (16-02-12)
- Lung Cancer - Asbestos Exposure (16-02-13)

Chronic Exposures

- Laryngeal Cancer and Asbestos Exposure (23-02-02)
- Lung Cancer Among Workers in the Uranium Mining Industry (23-02-03)

Appendix 3: Background on British Columbia's Bladder Cancer Policy

Policy 30.10 of the Rehabilitation Services and Claims Manual sets out guidelines for adjudicating claims for bladder cancer from aluminum smelter workers which do not meet the descriptions contained in BC's presumptive schedule. This policy, which was first adopted in 2000 and subsequently updated in 2009, requires that these claims be adjudicated on the basis of cumulative (or total) exposure to benzo-a-pyrene (BaP), a constituent of coal tar pitch volatiles. The two primary issues faced during the development of the policy were: how should exposure be assessed and what level of exposure should be required for entitlement? In its consultation paper, WorkSafeBC acknowledged that while science could inform the first question, it could only partially inform the second. To answer the first question, it utilized research studies conducted in Quebec and subsequently commissioned a research study in British Columbia. The findings of the BC study were used to update the policy guidelines in 2009.

To determine the level of exposure required for entitlement, WorkSafeBC was faced with considering two questions: at what level of risk is an exposure causally significant and should scientific uncertainties be taken into account? On the issue of causal significance, BC's legislation and policies on occupational disease require that the workplace exposures be a significant contributing factor. Unfortunately, like many jurisdictions, they are silent on what that means in terms of the minimum level of risk. In developing its policy options, WorkSafeBC was aware that, unlike lab-based research, epidemiology is not an exact science and often there is uncertainty associated with the exposure estimates. This uncertainty can have an impact on the dose-response relationship.

In its consultation paper, WorkSafeBC acknowledged that these two questions were social policy questions as opposed to scientific questions and as a result, science could only help inform the policy choices. Therefore, affected stakeholders were asked to provide input on (1) whether the minimum level of risk should be set at a relative risk of 2 or between 1 and 2; and, (2) whether the minimum level of risk should be determined using the point estimates or the 95% upper confidence limit.

The final policy incorporates the research evidence on BaP being a better predictor of risk, it reflects the input received from affected stakeholders on the question of the minimum threshold required for entitlement and it also explicitly addresses the synergistic relationship between smoking and exposure to benzo-a-pyrene. If the worker's relative risk calculated in accordance with the principles set out in the policy is 2 or greater, the worker's smoking history does not change the conclusion that the bladder cancer was due to the employment.

Appendix 4: References

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