Occupational Cancer Research Centre

The Burden of Occupational Cancer in Canada

Paul A. Demers, PhD
Director, OCRC, Cancer Care Ontario
Professor, University of Toronto

CBOM Pre-Conference, Toronto,
September, 2019

Conflict of Interests

- I have no conflicts of interest
- The Burden of Occupational Cancer Study was funded by the Canadian Cancer Society
- OCRC is funded by the Ontario Ministry of Labour, Cancer Care Ontario, and the Canadian Cancer Society
- CAREX Canada is funded by the Canadian Partnership Against Cancer

What I Will Talk About Today

- IARC and Occupational Cancer
- Burden of Occupational Cancer Project
  - Annual cancers dues to well-recognized carcinogens
  - Number of people still exposed
  - Prevention recommendations

Is Cancer a Rare Disease?

Canadian Cancer Society / Société canadienne du cancer

- The Canadian Cancer Society estimates that in 2019 in Canada:
  - 220,400 people will be diagnosed with cancer
  - 82,100 will die due cancer
- About 1 in 2 Canadians will develop cancer in their lifetimes and 1 in 4 will die of cancer

How do we know what causes Cancer?

- Cancer is unusual in that several well-respected organizations have classification schemes. In North America we have:
  - The International Agency for Research on Cancer (IARC)
  - The US National Toxicology Program (NTP)
  - The American Converence of Governmental Industrial Hygienists (ACGIH)

International Agency for Research on Cancer

World Health Organization

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans

English | Français

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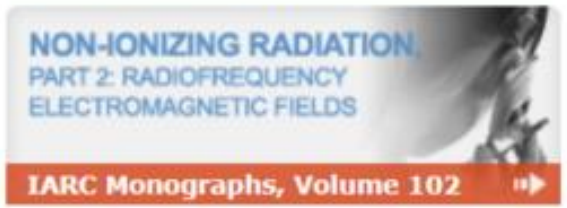
The *IARC Monographs* identify environmental factors that can increase the risk of human cancer. These include chemicals, complex mixtures, occupational exposures, physical agents, biological agents, and lifestyle factors. National health agencies can use this information as scientific support for their actions to prevent exposure to potential carcinogens.

Interdisciplinary working groups of expert scientists review the published studies and evaluate the weight of the evidence that an agent can increase the risk of cancer. The principles, procedures, and scientific criteria that guide the evaluations are described in the Preamble to the *IARC Monographs*.

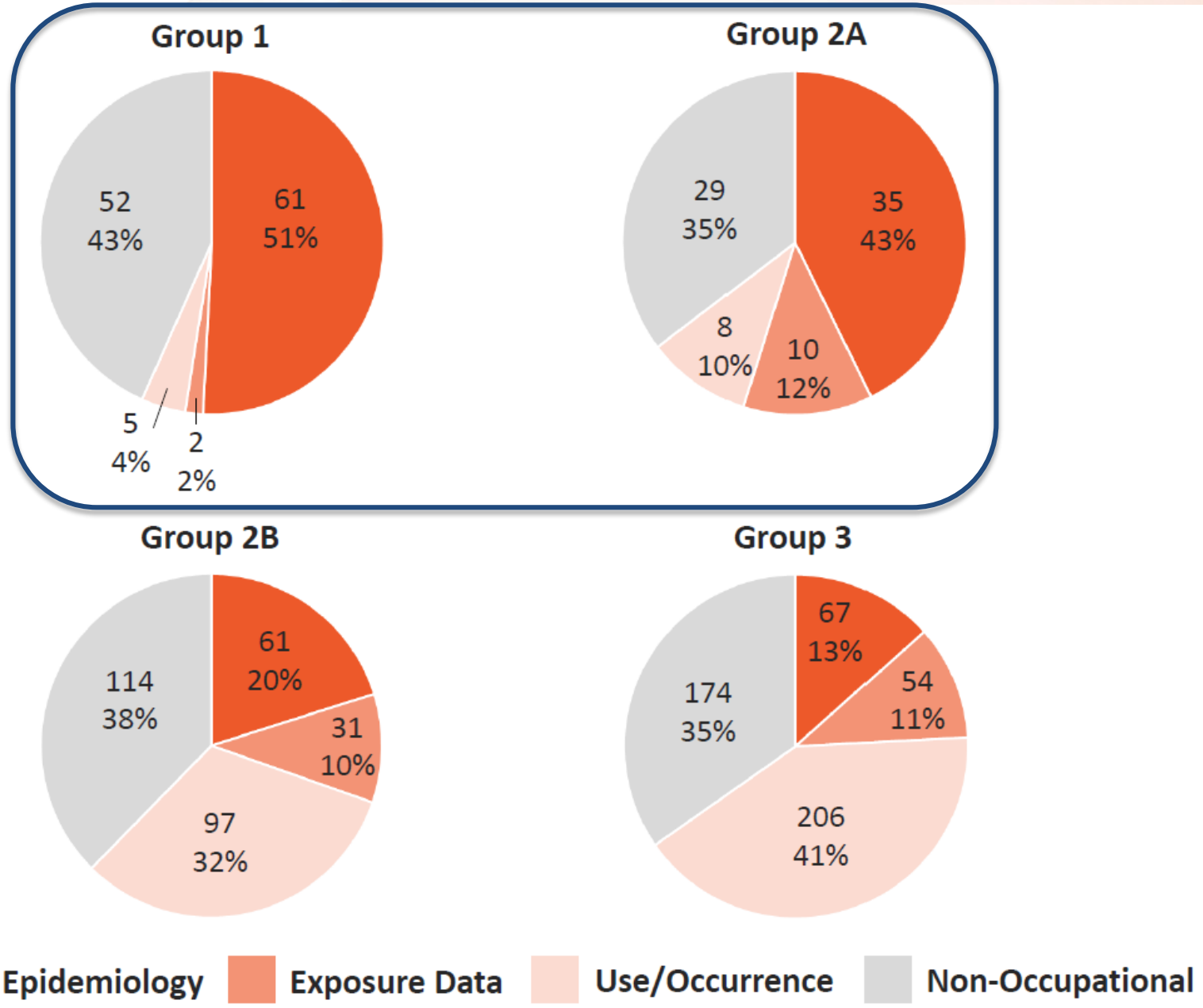
Since 1971, more than 1000 agents have been evaluated, of which more than 400 have been identified as carcinogenic, probably carcinogenic, or possibly carcinogenic to humans.



IARC Evaluation of Carcinogens

- 1013 Agents have been evaluated (as of summer 2019)
- Group 1: Carcinogenic in humans (120 agents)
  - Almost always requires strong human evidence
- Group 2A: Probably carcinogenic in humans (82 agents)
  - Generally limited human and strong animal evidence
- Group 2B: Possibly carcinogenic in humans (311 agents)
  - Generally strong animal and inadequate human evidence
- Group 3: Not classifiable (500 agents)
  - Generally inadequate evidence in humans and limited or inadequate in animals

IARC Occupational Carcinogens



IARC Lung Carcinogens (including most "*circumstances*")

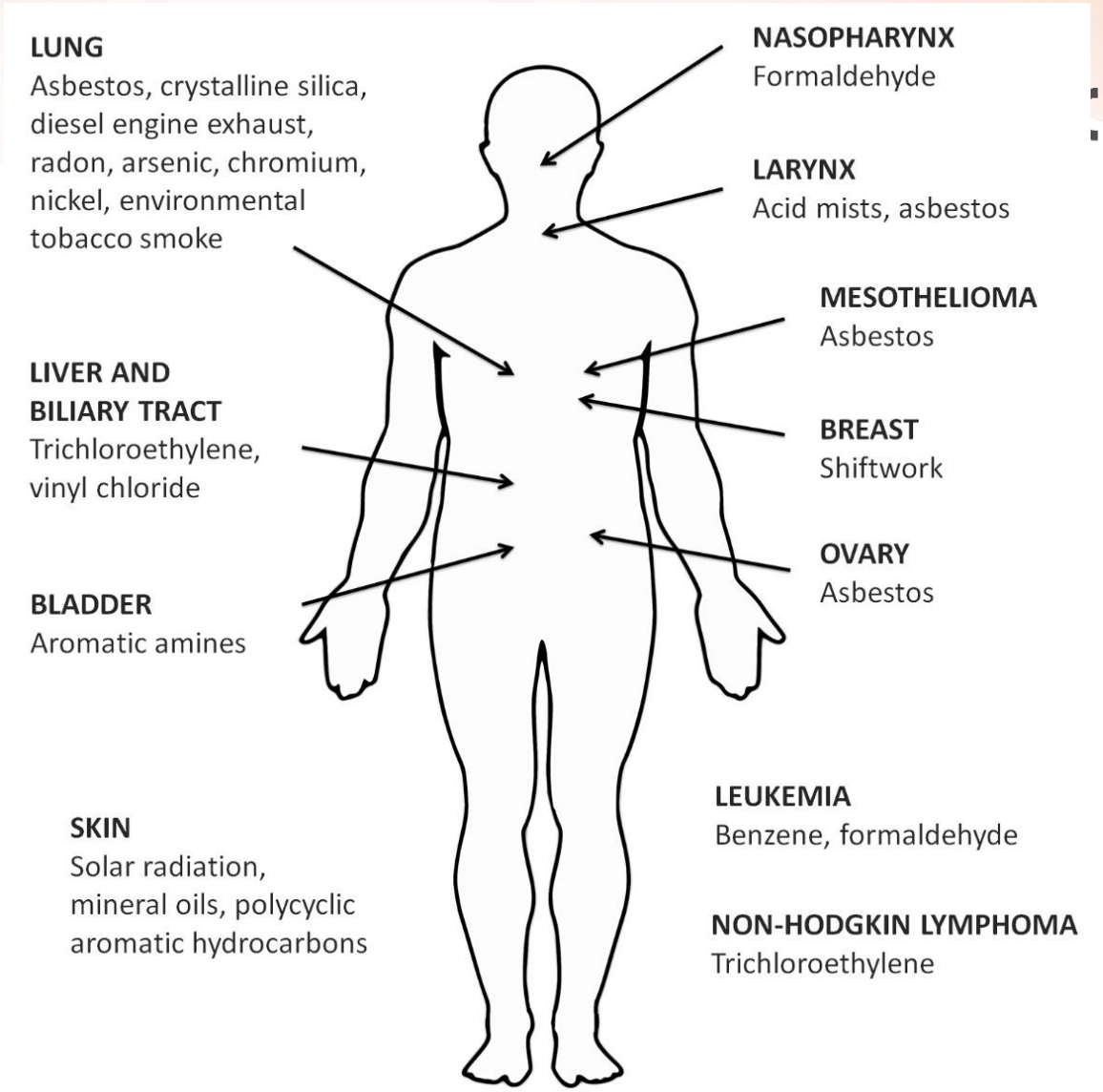
Lung Carcinogens	Suspected Lung Carcinogens
Arsenic, **Asbestos**, Beryllium, BCME, CME, Cadmium, Chromium(VI), **Diesel engine exhaust**, Nickel, ***Painting***, Particulate matter in outdoor air pollution, Plutonium, **Radon**, Coal-tar pitch, **Crystalline silica**, Soot, Tobacco smoke (secondhand), ***Welding fumes***, X-radiation, gamma-radiation	Strong inorganic acid mists, Bitumens, Alpha-Chlorinated toluenes and benzoyl chloride (combined exposures), Cobalt metal with tungsten carbide, Creosotes, Diazinon, Fibrous silicon carbide, Hydrazine insecticides, 2,3,7,8-Tetrachlorodibenzopara-dioxin

Assessing the Burden of Occupational Cancer in Canada

"burden" is the human impact & the economic costs associated with a specific cause of cancer

This project is funded by Canadian Cancer Society Research Institute Multi-Sector Team Grant #701285

Canadian Cancer Society / Société canadienne du cancer



The burden project is a national collaborative effort with:

Joanne Kim, Manisha Pahwa, Daniel Song , Kate Jardine, Victoria Arrandale, Catherine Slavik, Desre Kramer

Cheryl Peters, Calvin Ge, Elizabeth Rydz, Anne-Marie Nicol

Hugh Davies
Chris McLeod

Emile Tompa
Christina Kalcevich
Young Jung, Amir Mofidi

France Labrèche
Martin Lebeau

Jérôme Lavoué

Lesley Rushton
Sally Hutchings

International Agency for Research on Cancer

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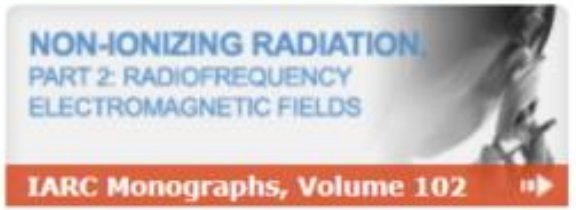


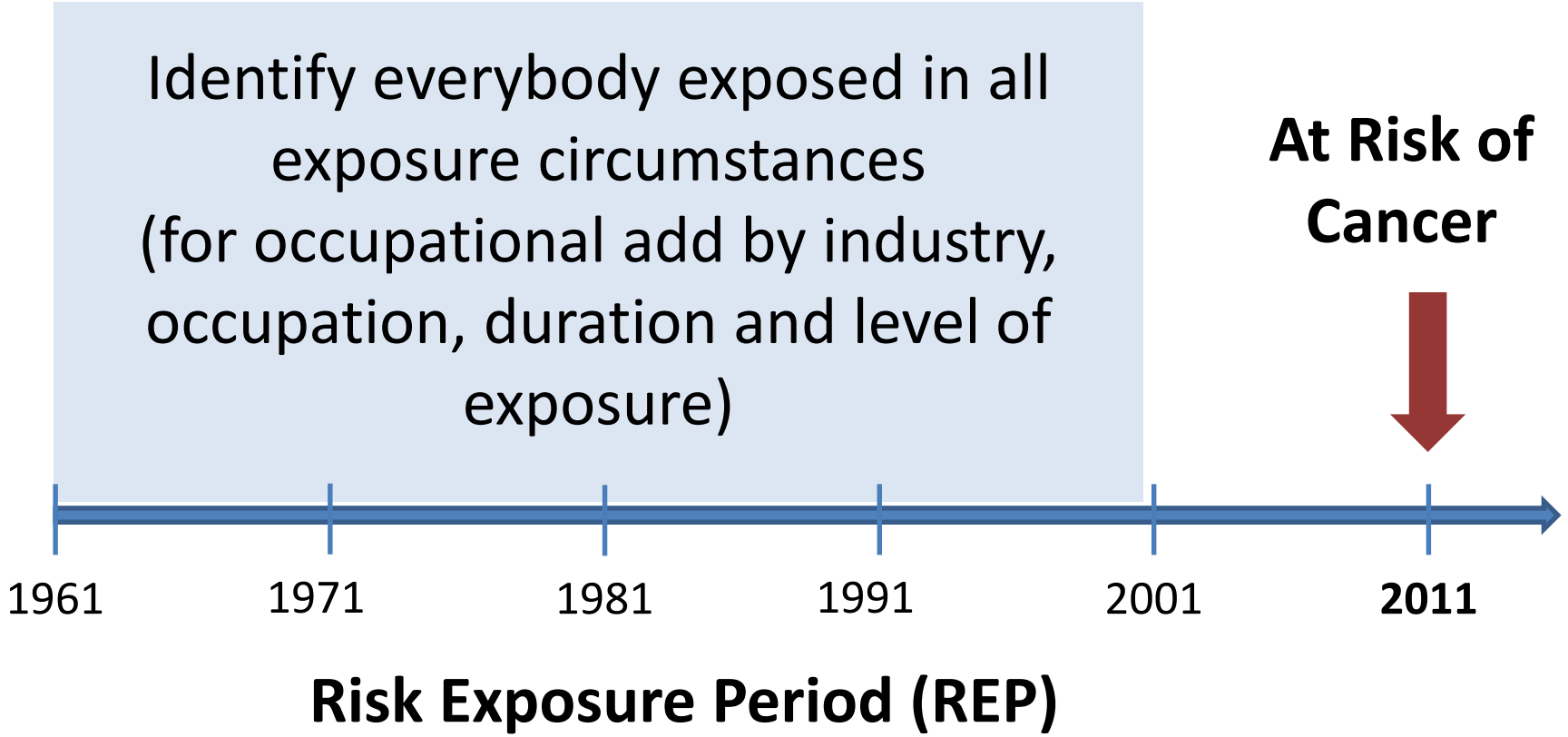
Attributable Risk (AR)

- Burden of disease projects rely on the calculation of AR's (sometimes called etiologic fraction, attributable risk proportion)

- $AR = \frac{Pr(E)(RR-1)}{Pr(E)(RR-1)+1}$

Levin's equation (1953), where Pr(E) is proportion exposed in the target population and RR is the Relative Risk associated with exposure

Challenge: Estimating History of Exposure among the General Population



A National Occupational & Environmental Exposure Surveillance Project

Based at:

1. Faculty of Health Sciences,
   Simon Fraser University, Vancouver
2. School of Population and Public Health,
   University of British Columbia , Vancouver
3. Alberta Health Services
4. Occupational Cancer Research Centre, Toronto

CANADIAN PARTNERSHIP AGAINST CANCER

PARTENARIAT CANADIEN CONTRE LE CANCER

CAREX Canada: Job-Exposure Matrix

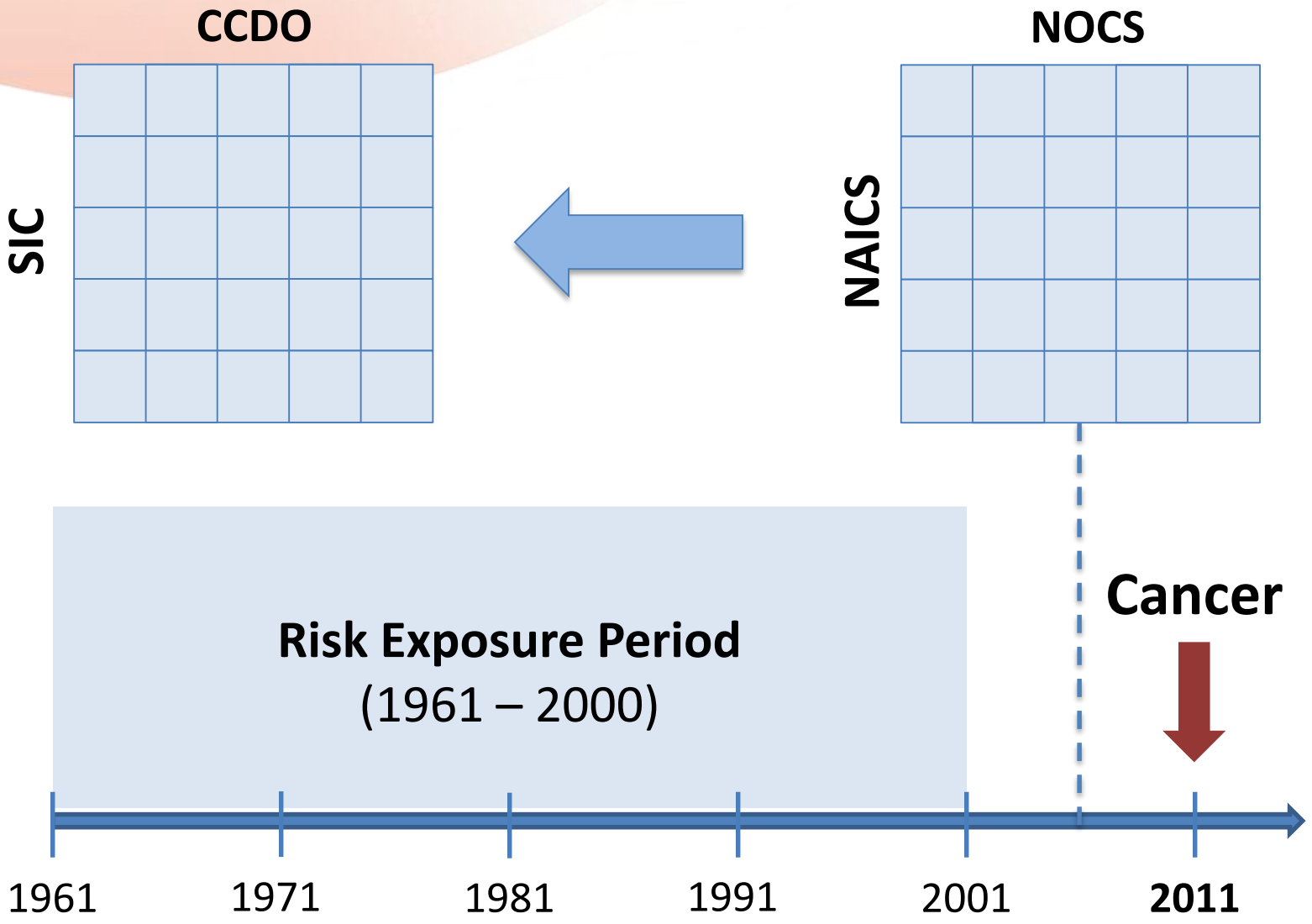
- CAREX Canada: Prevalence and level of exposure
  - 328 industries & 520 occupations

National Occupational Classification System 2006 (NOCS)

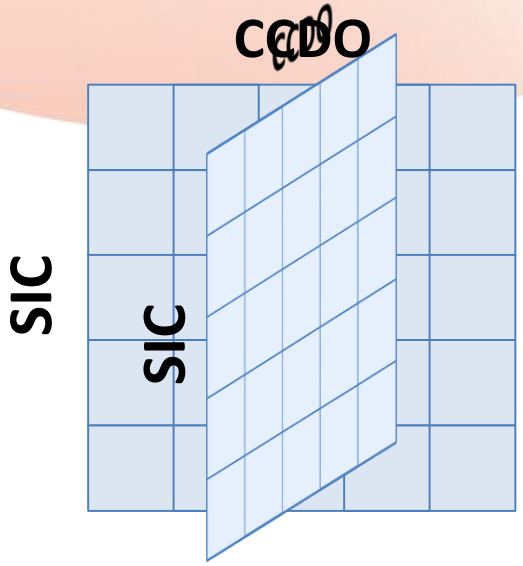
North American Industrial Classification System 2002 (NAICS)

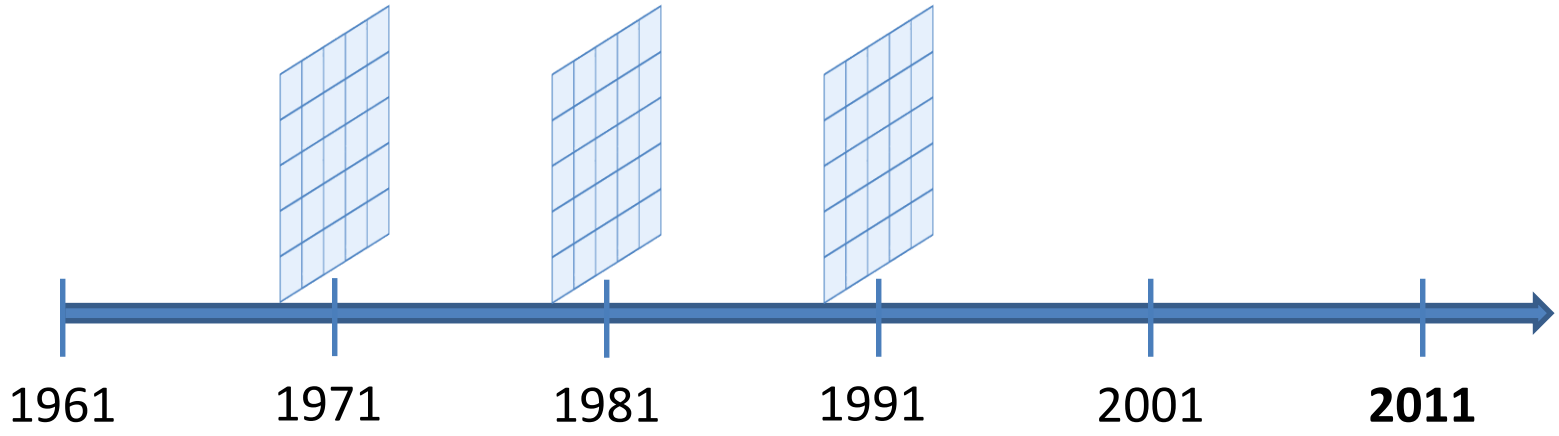
Prevalence / Level	Occ 1	Occ 2	…	Occ 519	Occ 520
Ind 1	0.2/L	1.0/L	…		
Ind 2			…	0.5/H	0.1/M
…	…	…	…	…	…
Ind 327	0.6/M		…	1.0/L	1.0/L
Ind 328	0.5/H	1.0/L	…	0.8/L	

Applying CAREX JEMs to estimate burden



Apply the CAREX JEM to Census Data

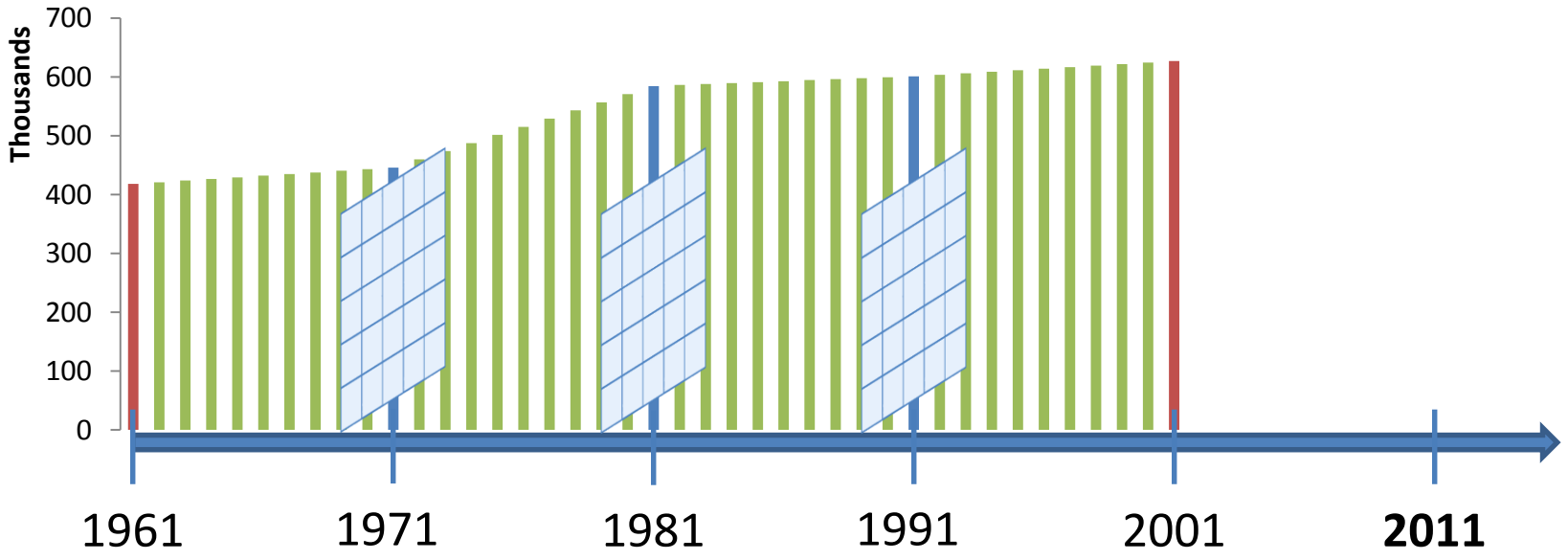




Apply the CAREX JEM to Census Data

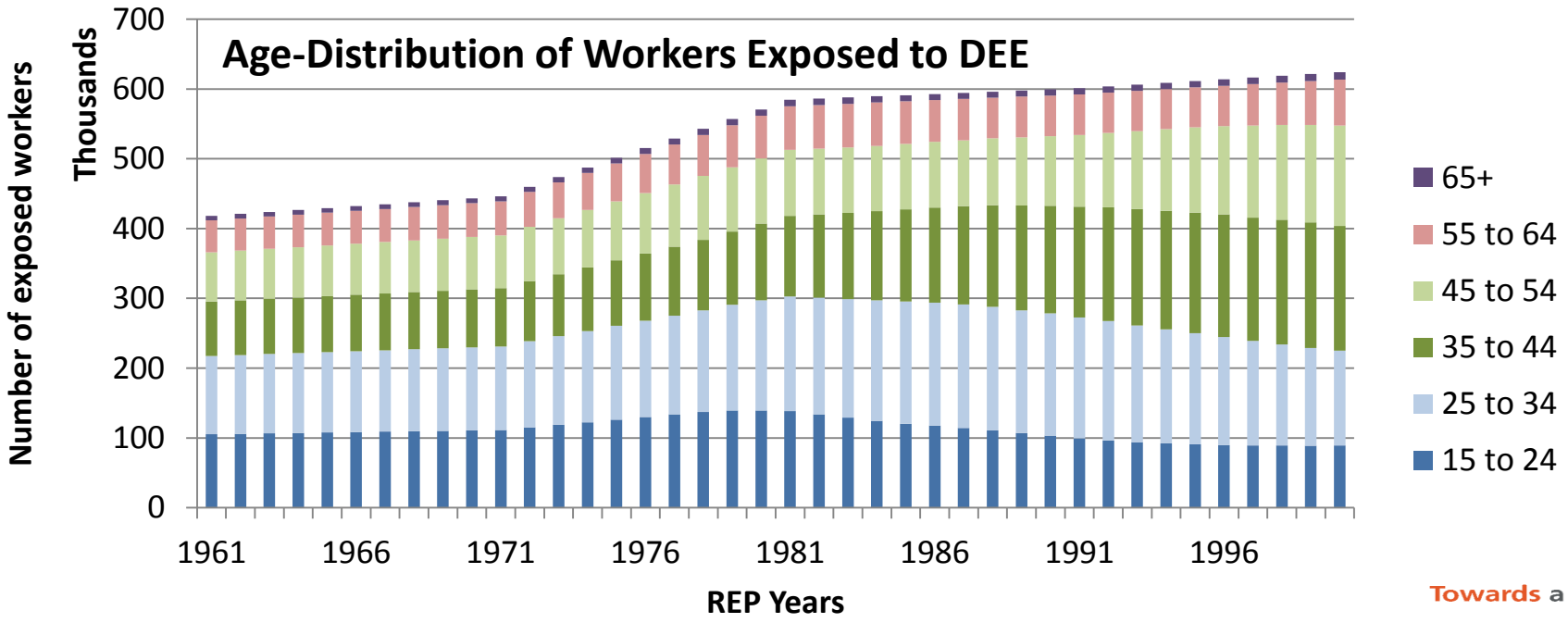
- Census employment data (1971/1981/1991)
- Use 1961 and 2001 census data to anchor time trends
- Add estimates for intermediate years

  $\Rightarrow$ Number of exposed workers in each REP year



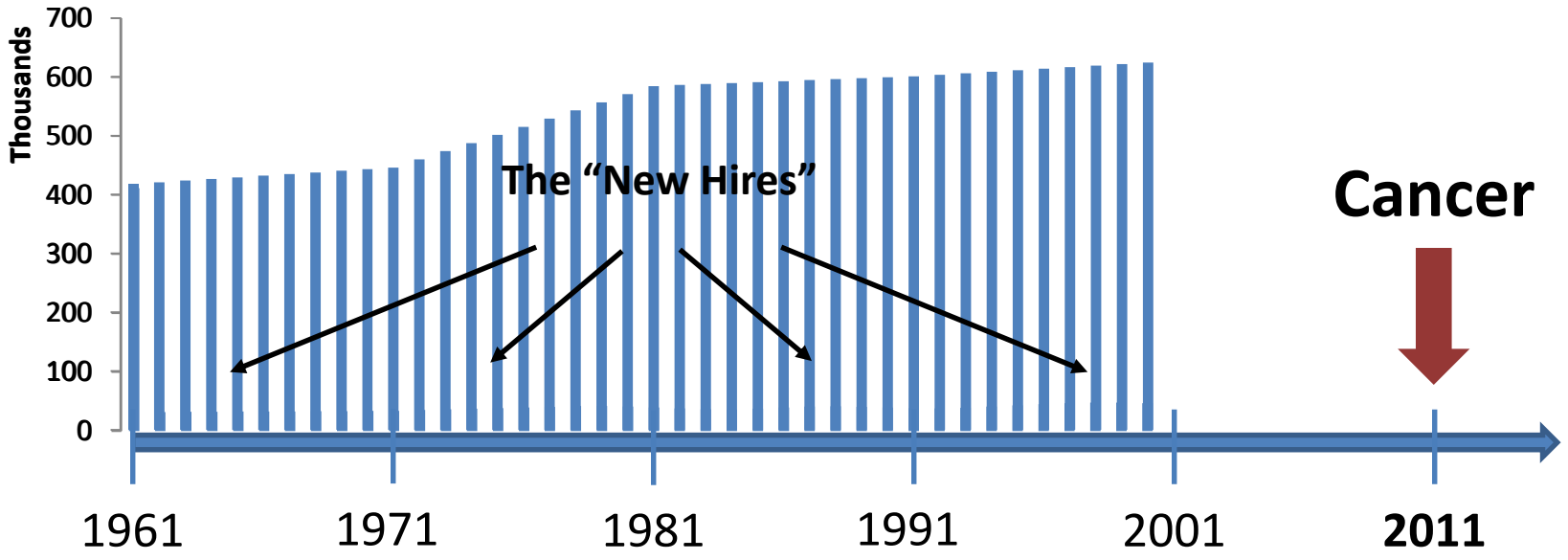
Exposed: Detailed Picture over Time

- CAREX JEM + Census data
  - *Industry, occupation, province, sex, exposure level*
- Labour Force Survey for age distribution
- National Enhanced Cancer Surveillance System for tenure distribution



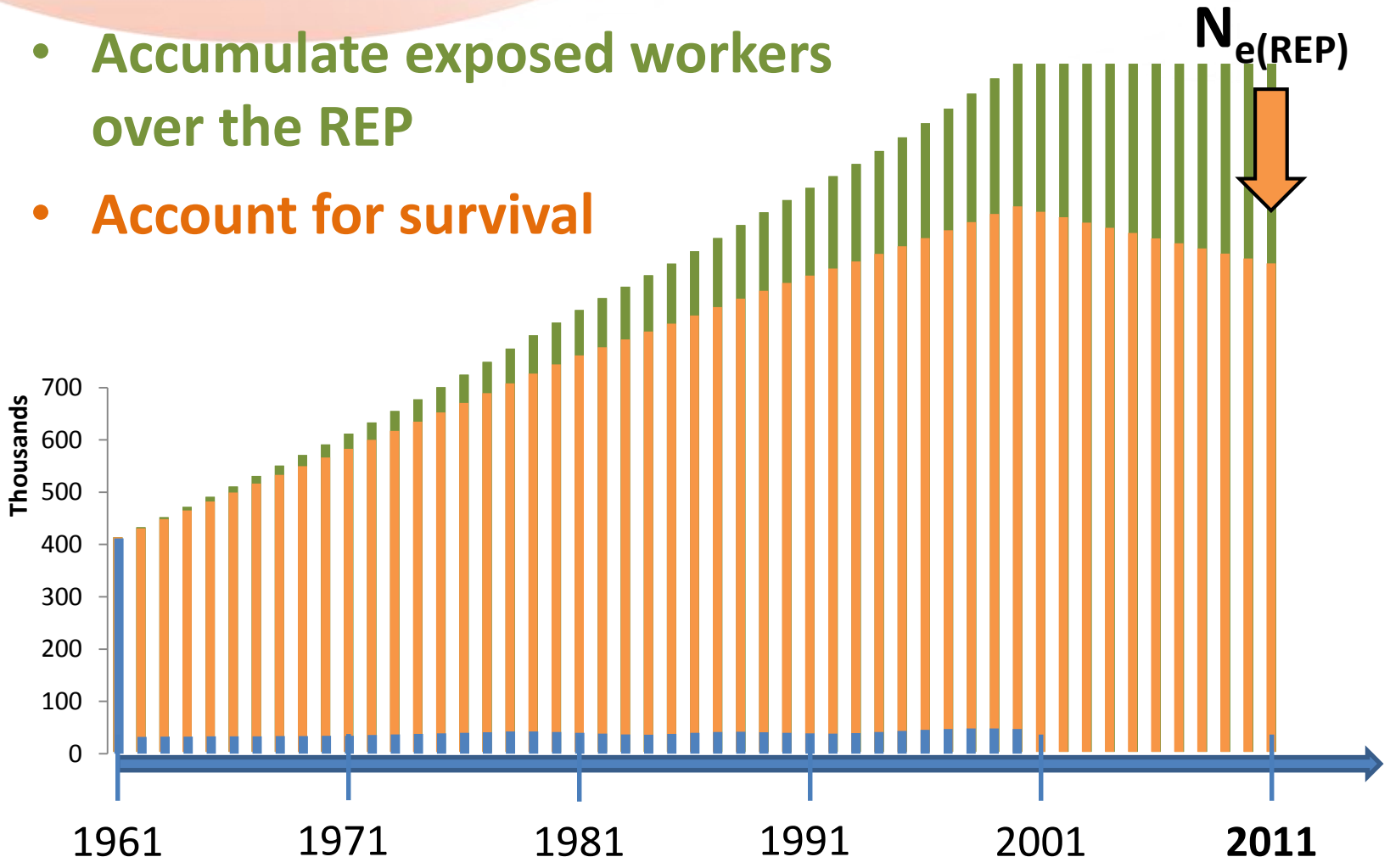
Population Modelling

- How to estimate the number of workers ever exposed ($N_{e(REP)}$)?
  - Count everyone in the initial REP year
  - Add “new hires” from each subsequent year

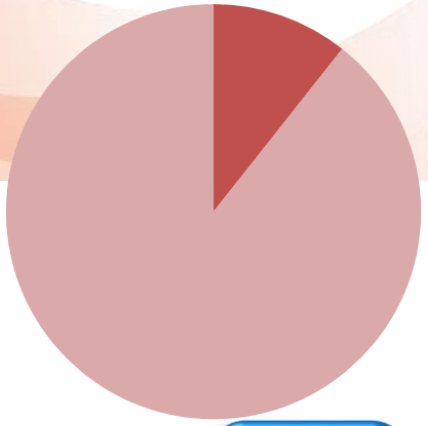


Population Modelling

- Accumulate exposed workers over the REP
- Account for survival



*For illustration purposes only, not real results



Transportation and warehousing

400,000 (49%) exposed

Diesel exhaust exposure

Construction

94,000 (9%) exposed

Mining & oil and gas

61,000 (26%) exposed

Agriculture, forestry, and fishing

54,000 (10%) exposed

Public admin

51,000 (5%) exposed

Diesel Exhaust Exposure Distribution

CAREX Level (based on average exposure)	Population in 2011, ever exposed during Relevant Exposure Period	Cumulative Exposure (µg/m³- years EC)		
		Mean	Min	Max
Low	1,357,000 (84%)	41	5	99
Moderate	199,000 (12%)	131	17	299
High	56,000 (3%)	1,575	225	2,957

Example: Diesel & Lung Cancer (national)

Proportion in 2011 exposed
(1961 – 2001)

6.8% of the 2011 population, or 1,612,000 current or former workers

Relative Risk and Source

A dose-response curve from a meta-analysis of cohort studies *

Attributable Cancers

560
lung cancers
AF = 2.4%

* Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. 2014. Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts. Env Health Persp 122:172-77.

Top 10 Occupational Carcinogens in Canada

Carcinogen	Annual Cancers	Exposure*
Solar UV at Work	4600 non-melanoma skin	1.5 million
Asbestos	1900 lung, 430 mesothelioma, 45 larynx, 15 ovarian, ** difficult to estimate digestive	152,000
Diesel Exhaust	560 lung, ** 200 bladder	897,000
Crystalline Silica	570 lung	382,000
Welding Fumes	310 lung	333,000
Nickel	170 lung	117,000
Chromium VI	50 lung	104,000
Radon	190 lung	188,000
PAH's	** 130 lung, 50 skin, 80 bladder	350,000
Shiftwork	** 470-1200 breast	1.9 million

* Based on CAREX Canada

** Suspected cancer (IARC 2A)

Asbestos

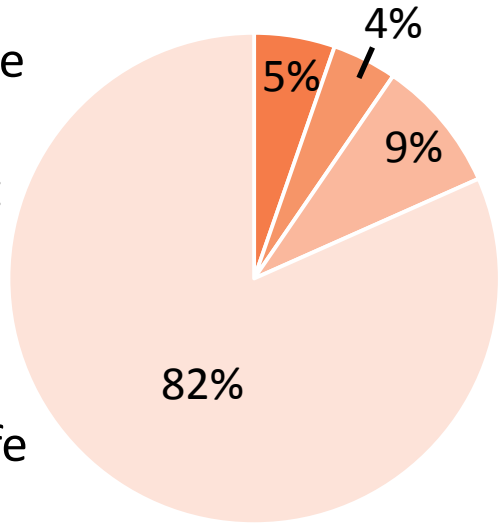
- Approximately 152,000 still regularly exposed
- ~1,900 lung cancers, 430 mesotheliomas, 45 laryngeal cancers & 15 ovarian cancers
- Canadian government committed to ban in 2018. However, much more needed

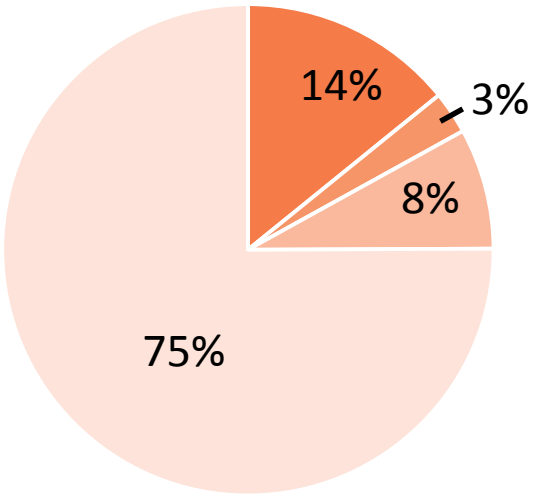
- ***Policy recommendations:***
  - *Create a public registry of all public buildings & workplaces that contain asbestos*
  - *Establish an inter-ministerial working group to address occupational asbestos exposure & issues such as safe disposal, building renovation/abatement, public health…*

Asbestos: Economic Burden

	Lung Cancer	Mesothelioma
Average cost per case	$980K	$1.1 M
Total Cost	$1.9 billion	$480 million

- Healthcare & administrative
- Caregiving & out-of-pocket
- Output & productivity
- Health-related quality of life





Tompa et al. The economic burden of lung cancer and mesothelioma due to occupational and para-occupational asbestos exposure. Occup Environ Med 2017;74:816-22.

Solar Ultraviolet (UV) Radiation

- ~ 4,600 non-melanoma skin cancers annually
- Greatest burden in construction & agricultural. Other groups, such as outdoor utilities, parks & recreation workers
- 1,476,000 Canadian workers exposed

Policy recommendation:

- *Require all workplaces with workers that work outdoors for part or all of the day to develop a comprehensive, multi-component sun safety program*
  - *includes a risk assessment, sun protection control measures, and sun protection policies and training (Sun Safety at Work Canada provides examples)*

Diesel Engine Exhaust

- ~ 560 lung and possibly, 200 bladder cancers annually
- Greatest burden in transportation, construction & mining
- 897,000 workers exposed

***Policy recommendations**:*

- *Adopt occupational exposure limits of 20 µg/m³ elemental carbon for the mining industry and 5 µg/m³ elemental carbon for other workplaces*
- *Upgrade or replace old on-road and off-road trucks and diesel engines*
  - There is a precedent for mandating the transition for on-road vehicles in jurisdictions such as California

Crystalline Silica

- ~ 570 lung cancers annually
- Greatest burden in construction, mining, and mineral products processing
- 382,000 workers exposed

Policy recommendations:

- Occupational exposure limits for silica vary across Canada from 0.025 mg/m^3 to 0.1 mg/m^3 in some jurisdictions. *Implement 0.025 for all workplaces in Canada.*
- Collection of exposure data and ongoing monitoring should be implemented as part of a broader silica control plan to assist in preventing exposure.

Welding Fumes

Classified as Group 1 in 2017

- ~ 310 lung cancers annually
- Greatest burden in manufacturing & construction
- ~375,000 workers exposed

Policy recommendations:

- *Introduce ventilation requirements in Occupational Health and Safety (OHS) legislation for welding activities*
- As a Group 1 carcinogen, a specific OEL for respirable welding fumes is needed

Radon

- Approximately 190 lung cancers annually
- Approximately 188,000 workers exposed in underground work or poorly ventilated workplaces in high background regions

Policy recommendations:

- *Develop explicit and specific regulation of radon in indoor air in occupational health and safety regulations* consistent with the Naturally Occurring Radioactive Materials (NORM) Guidelines
- *Implement 200 Bq/m^3 as the exposure standard for remediation in all underground and above-ground workplaces*

Polycyclic Aromatic Hydrocarbons (PAHs)

- Estimated 350,000 workers exposed
- Largest proportion of workers exposed in accommodation and food services
  - Cooks, chefs, food and beverage servers
- ~130 lung, 80 bladder, 50 skin cancers annually

Policy recommendation:

- *Implement effective engineering controls in workplaces where exposure occurs, especially at high levels.*

Shift Work at Night

- Up to 1200 breast cancer suspected annually
- 1.9 million working Canadians, depending on definition
  - Healthcare, hospitality industry, manufacturing, public safety

Prevention is challenging

  - *Optimizing work schedules to minimize circadian disruption*

Top Occupational Carcinogens in Saskatchewan

Carcinogen	IARC Evaluation	Burden	Number exposed
Solar UV radiation	Definite	2,200 non-melanoma skin	83,000
Asbestos	Definite	90 lung, 20 mesothelioma <5 larynx and ovarian	4,200
Diesel engine exhaust	Definite	25 lung, 10 bladder	38,000
Silica (crystalline)	Definite	20 lung	12,000
Welding fumes Nickel compounds Chromium (VI)	Definite Definite Definite	10 lung <5 lung <5 lung	11,000 3,700 2,800
Radon	Definite	15 lung	30,000
Night shift work	Probable	15-45 breast	58,000
Polycyclic aromatic hydrocarbons	Definite, probable, and possible	<5 lung, <5 bladder, <5 skin	13,000

BURDEN OF OCCUPATIONAL CANCER IN CANADA

Major Workplace Carcinogens and Prevention of Exposure

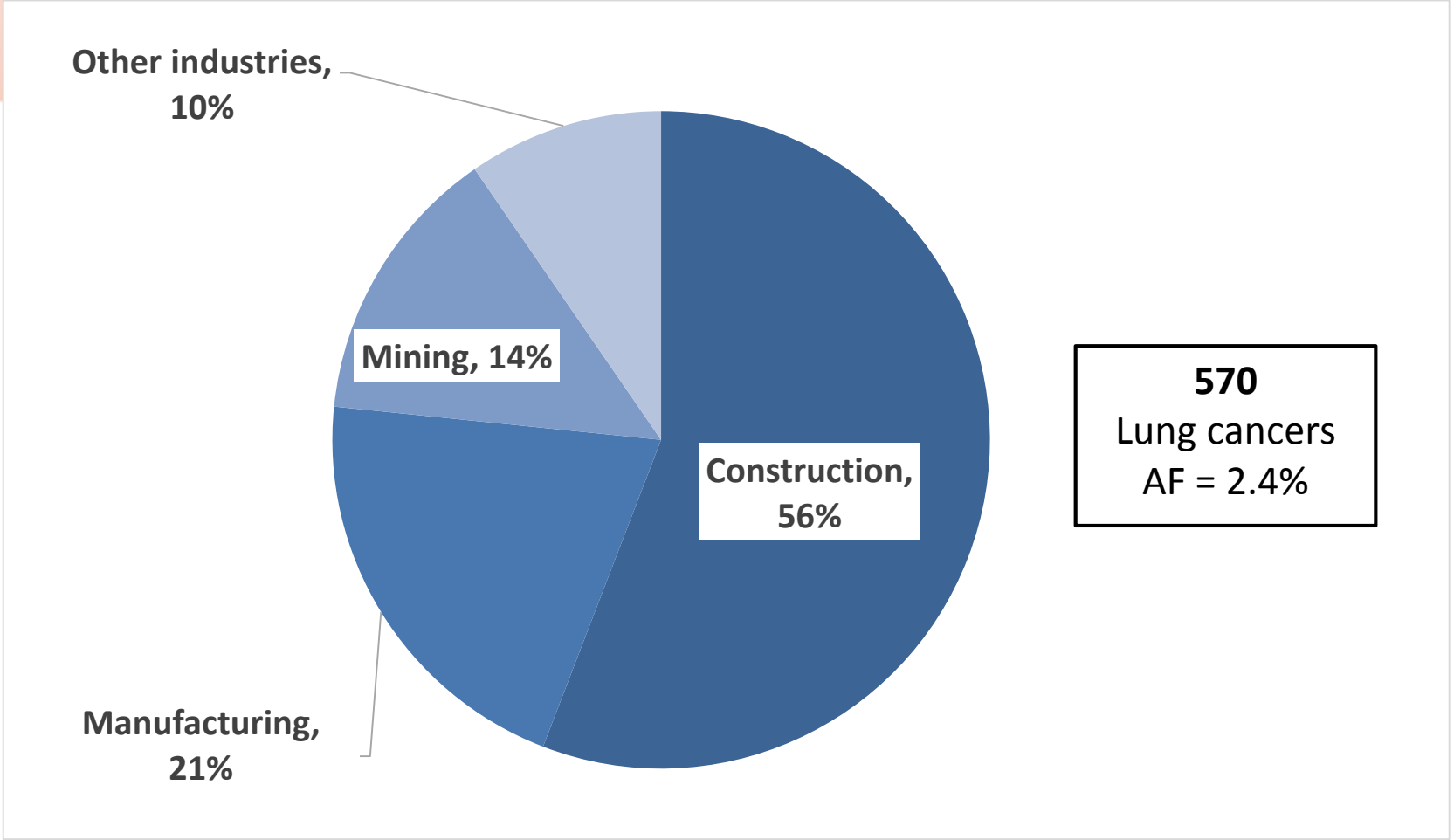
SEPTEMBER 2019

Contents of the National Report

For the most common, well-established (IARC 1 & 2A) carcinogens in Canada:

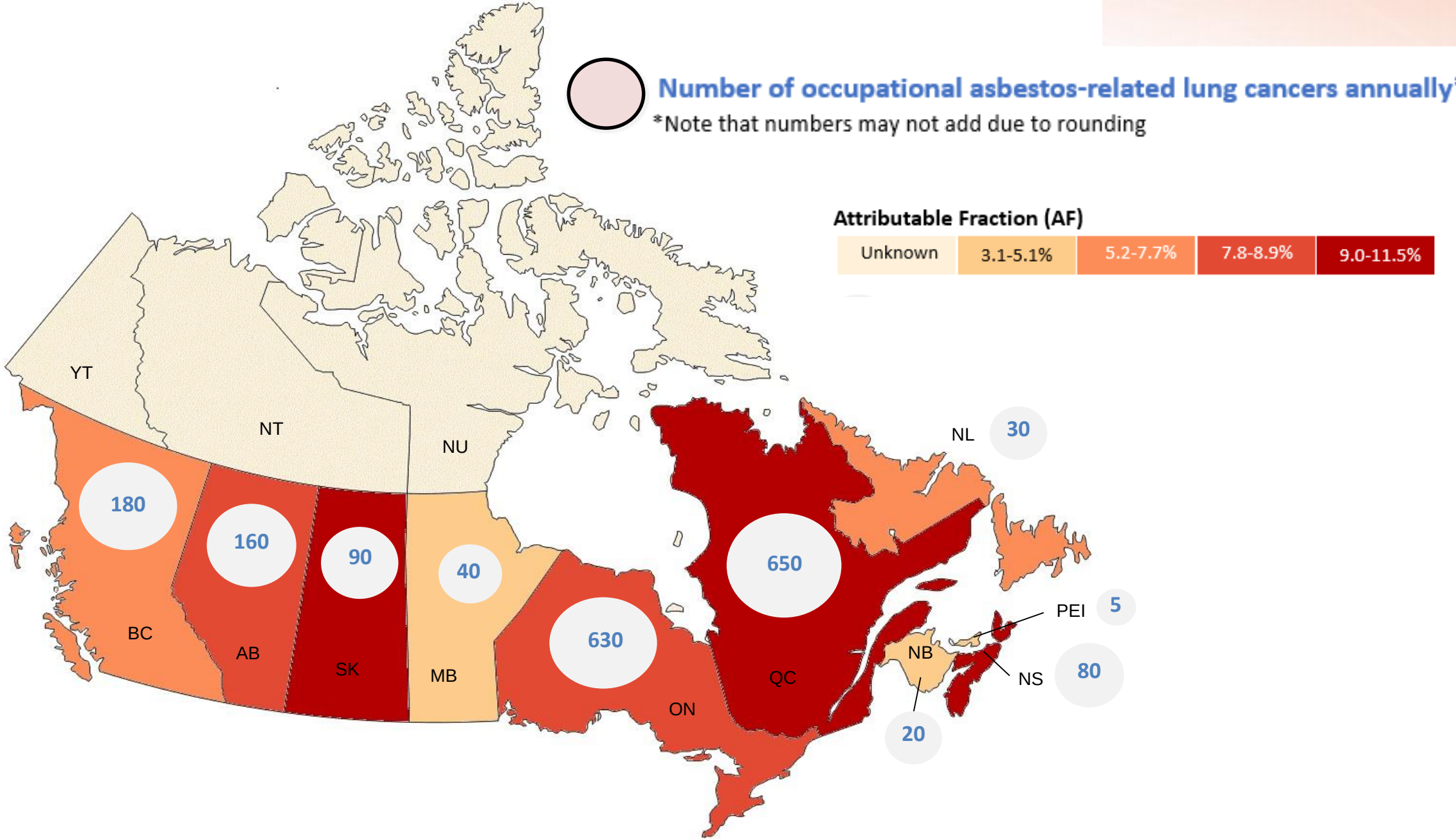
- Number of new cancers diagnosed annually based on the Burden of Occupational Cancer Project
- Number of workers currently exposed and where
- Policy and workplace prevention recommendations
  - We convened a national policy advisory committee

Industry breakdown of total lung cancers attributed to occupational crystalline silica exposure



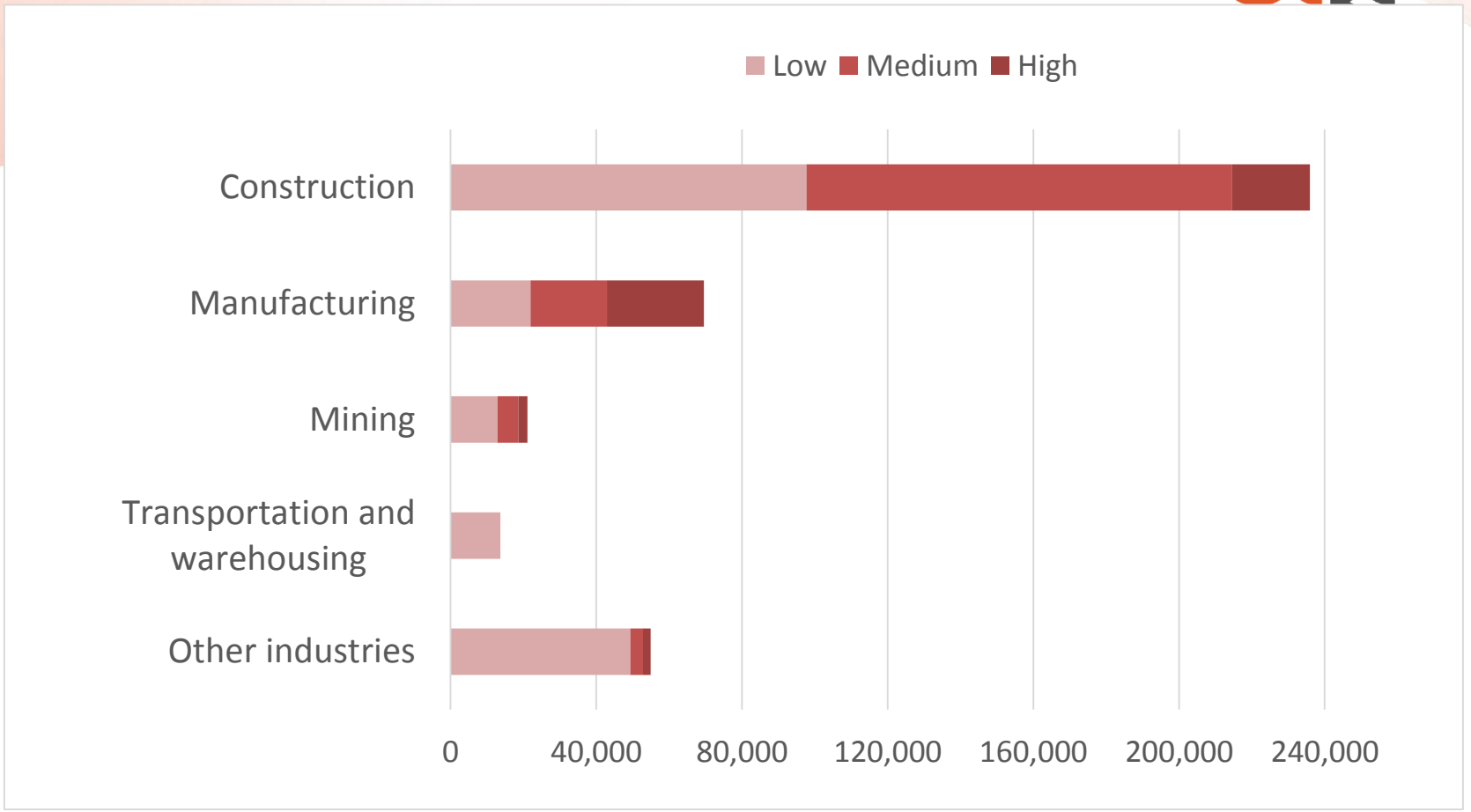
Number of occupational asbestos-related lung cancers annually*

*Note that numbers may not add due to rounding



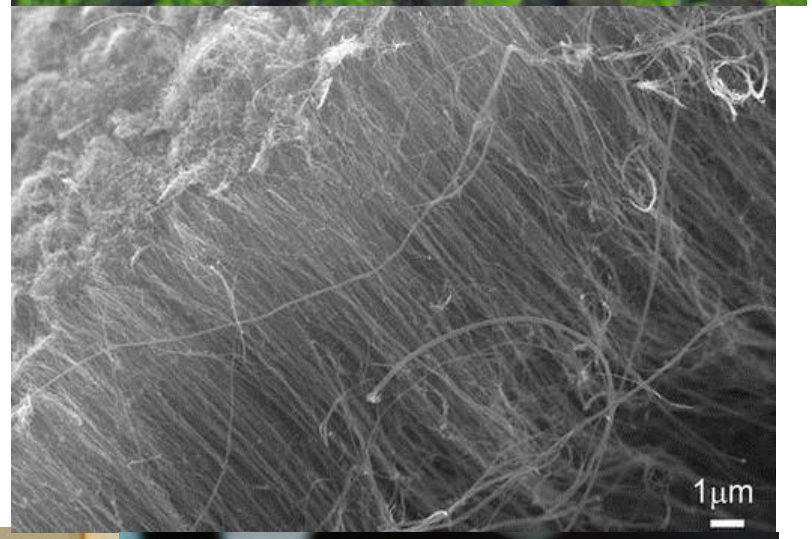
CAREX CANADA

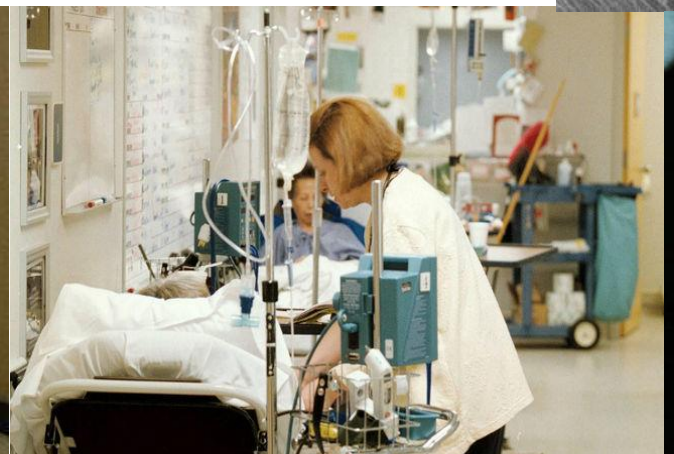
Number of workers occupationally exposed to crystalline silica by level of exposure and industry in Canada



Other Carcinogens & Emerging Issues

- They were also other carcinogens with smaller numbers of cancers or less-established cancer associations
- The report focused on well-established carcinogens, but included emerging issues, including pesticides, anti-neoplastic agents, nanomaterials, sedentary work

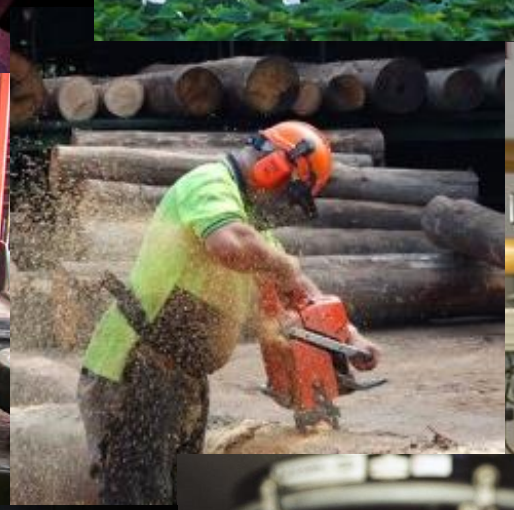
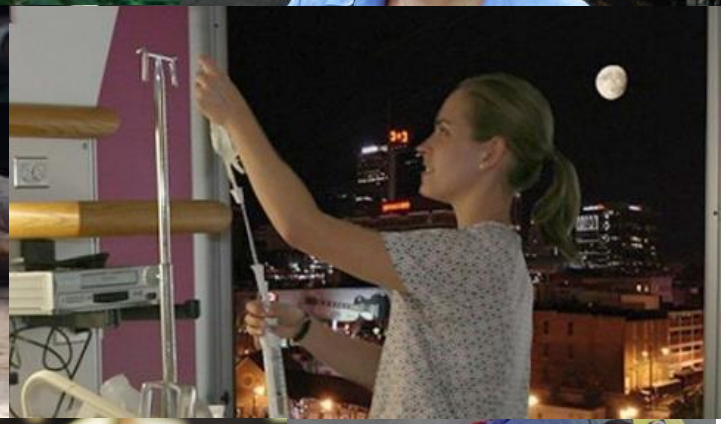












XXII World Congress on Safety and Health at Work
4-7 October 2020, Toronto, Canada

Prevention in the Connected Age

Global solutions to achieve safe and healthy work for all

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The work presented here has been made possible through funding from the OCRC's core funders, listed below.

Thanks to the many OCRC staff and students, our scientific collaborators and policy advisors from across the country who contributed to the research presented here!

http://occupationalcancer.ca