The Burden of Occupational Cancer: Major Workplace Carcinogens and Prevention of Exposure in Ontario

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Conflict of Interests

• I have no conflicts of interest

• The report was funded by Cancer Care Ontario through the Population Health and Prevention Unit

• The Burden of Cancer Project was funded by the Canadian Cancer Society Research Institute

• CAREX Canada is funded by the Canadian Partnership Against Cancer

• The OCRC is funded by the Ontario Ministry of Labour, Cancer Care Ontario, and the Canadian Cancer Society
Burden of Occupational Cancer in Ontario

Major Workplace Carcinogens and Prevention of Exposure
Objectives of the report

- The primary objectives were to
  - describe & quantify important occupational risk factors for cancer in Ontario
  - present policy recommendations for reducing occupational carcinogen exposure

- The secondary objectives were to
  - propose workplace-based opportunities for reducing exposure
  - discuss emerging issues in occupational cancer research that are relevant to Ontario
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
The burden project is a national collaborative effort with:

- Cheryl Peters, Calvin Ge
- Anne-Marie Nicol
- Hugh Davies
- Chris McLeod
- Joanne Kim, Manisha Pahwa,
- Desre Kramer, Daniel Song,
- Victoria Arrandale, Kate Jardine
- Emile Tompa
- Christina Kalcevich
- Young Jung, Amir Mofidi
- France Labrèche
- Martin Lebeau
- Jérôme Lavoué
- Lesley Rushton
- Sally Hutchings
Contents of the Report

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

- 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

Special thanks to:

- Policy Advisory Committee: Ray Copes, Fe de Leon, Linn Holness, Andy King, Katherine Lippel, Rowena Pinto, Ellen Simmons, William Swanson, Valerie Wolfe
- Reviewers: Jeremy Beach, Paul Bozek, Hugh Davies, Leon Genesove, Tracy Kirkham, Cheryl Peters
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.
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

Identify everybody exposed in all exposure circumstances (for occupational add by industry, occupation, duration and level of exposure)

Risk Exposure Period (REP)


At Risk of Cancer
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. Occupational Cancer Research Centre, Toronto
CAREX Canada: Job-Exposure Matrix

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

National Occupational Classification System 2006 (NOCS)

<table>
<thead>
<tr>
<th>Prevalence / Level</th>
<th>Occ 1</th>
<th>Occ 2</th>
<th>...</th>
<th>Occ 519</th>
<th>Occ 520</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind 1</td>
<td>0.2/L</td>
<td>1.0/L</td>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind 2</td>
<td></td>
<td></td>
<td>...</td>
<td>0.5/H</td>
<td>0.1/M</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind 327</td>
<td>0.6/M</td>
<td></td>
<td>...</td>
<td>1.0/L</td>
<td>1.0/L</td>
</tr>
<tr>
<td>Ind 328</td>
<td>0.5/H</td>
<td>1.0/L</td>
<td>...</td>
<td>0.8/L</td>
<td></td>
</tr>
</tbody>
</table>
Applying CAREX JEMs to estimate burden

Risk Exposure Period
(1961 – 2000)
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

⇒ 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

Age-Distribution of Workers Exposed to DEE

<table>
<thead>
<tr>
<th>REP Years</th>
<th>Number of exposed workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>65+</td>
</tr>
<tr>
<td>1966</td>
<td>65+</td>
</tr>
<tr>
<td>1971</td>
<td>65+</td>
</tr>
<tr>
<td>1976</td>
<td>65+</td>
</tr>
<tr>
<td>1981</td>
<td>65+</td>
</tr>
<tr>
<td>1986</td>
<td>65+</td>
</tr>
<tr>
<td>1991</td>
<td>65+</td>
</tr>
<tr>
<td>1996</td>
<td>65+</td>
</tr>
</tbody>
</table>

- 65+
- 55 to 64
- 45 to 54
- 35 to 44
- 25 to 34
- 15 to 24
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*
Conceptual Overview

Census Employment Data → Job-exposure Matrix → Population Model → PrE → Exposed → Overall RR

Exposure Assessment:
- Exposed
- Exposure groups
- Quantitative exposure

Epidemiology:
- Overall RR
- RR by groups
- Continuous exposure-response → AF
Transportation and warehousing
400,000 (49%) exposed

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
20
## Diesel Exhaust Exposure Distribution

<table>
<thead>
<tr>
<th>CAREX Level (based on average exposure)</th>
<th>Population in 2011, ever exposed during Relevant Exposure Period</th>
<th>Cumulative Exposure ($\mu g/m^3$- years EC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Low</td>
<td>1,357,000 (84%)</td>
<td>41</td>
</tr>
<tr>
<td>Moderate</td>
<td>199,000 (12%)</td>
<td>131</td>
</tr>
<tr>
<td>High</td>
<td>56,000 (3%)</td>
<td>1,575</td>
</tr>
</tbody>
</table>
6.8% of the 2011 population, or 1,612,000 current or former workers

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

560 lung cancers
AF = 2.4%

<table>
<thead>
<tr>
<th>Carcinogen</th>
<th>Annual Cancers</th>
<th>Current Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar UV at Work</td>
<td>1400 non-melanoma skin</td>
<td>449,000</td>
</tr>
<tr>
<td>Asbestos</td>
<td>630 lung, 140 mesothelioma, 15 laryngeal, &lt;5 ovarian (?? digestive)</td>
<td>52,000</td>
</tr>
<tr>
<td>Diesel Exhaust</td>
<td>170 lung, (45 bladder)</td>
<td>301,000</td>
</tr>
<tr>
<td>Crystalline Silica</td>
<td>200 lung</td>
<td>142,000</td>
</tr>
<tr>
<td>Welding Fumes</td>
<td>100 lung</td>
<td>169,000</td>
</tr>
<tr>
<td>Nickel*</td>
<td>80 lung</td>
<td>48,000</td>
</tr>
<tr>
<td>Chromium VI*</td>
<td>25 lung</td>
<td>39,000</td>
</tr>
<tr>
<td>ETS at work</td>
<td>50 lung, 10 pharynx, 5 larynx**</td>
<td>125,000</td>
</tr>
<tr>
<td>Radon</td>
<td>60 lung</td>
<td>34,000</td>
</tr>
<tr>
<td>Arsenic</td>
<td>20 lung</td>
<td>8,000</td>
</tr>
<tr>
<td>Benzene</td>
<td>10 leukemia, &lt;5 multiple myeloma</td>
<td>147,000</td>
</tr>
<tr>
<td>PAH’s</td>
<td>(60 lung, 15 skin, 30 bladder)</td>
<td>134,000</td>
</tr>
<tr>
<td>Shiftwork</td>
<td>(180-460 breast)</td>
<td>833,000</td>
</tr>
</tbody>
</table>

* Excluding welding  ** Among never smokers (probable associations)
Solar Ultraviolet (UV) Radiation

• 450,000 workers exposed
• ~ 1,400 non-melanoma skin cancers annually
• Greatest burden in construction & agricultural. Other groups, such as outdoor parks & recreation workers

• 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)
Asbestos

• Approximately 52,000 still regularly exposed
• ~630 lung cancers, 140 mesotheliomas, 15 laryngeal cancers & <5 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
    • Saskatchewan & Federal programs only cover public buildings, we would include workplaces
  • Establish an inter-ministerial working group to address occupational asbestos exposure & issues such as safe disposal, building renovation/abatement, public health...
    • An inter-ministerial working group has been established in British Columbia, and could serve as a model
Diesel Engine Exhaust

• 300,000 workers exposed
• ~ 170 lung and possibly, 45 bladder cancers annually
• Greatest burden in transportation, construction & mining

• Policy recommendations:
  • Adopt occupational exposure limits of 20 $\mu$g/m$^3$ elemental carbon for the mining industry and 5 $\mu$g/m$^3$ 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

• 140,000 workers exposed
• ~ 200 lung cancers annually
• Greatest burden in construction, mining, and mineral products processing

• Policy recommendation:
  • Include construction project employers and workers in the Designated Substances Regulation
  • Ontario should follow 7 provinces, the federal govt., and ACGIH (2009) in implementing a more rigorous OEL of 0.025 mg/m³, respirable for all forms of crystalline silica
    • Current is 0.10 mg/m³ for quartz, 0.05/mg/m³ cristobalite
Welding Fumes

- Classified as Group 1 in 2017
- 170,000 workers exposed
- ~100 lung cancers annually
- Greatest burden in manufacturing & construction

Policy recommendations:

- *Introduce ventilation requirements in Ontario Occupational Health and Safety (OHS) legislation for welding activities*
- *[not from the committee: as a Group 1 carcinogen, a specific OEL for respirable welding fumes is needed]*
Environmental Tobacco Smoke at Work

• Significant progress has been made over the past decades to reduce ETS in workplaces through legislation, supported by increased awareness.

• However, an estimated 125,000 workers still exposed.

• 50 lung, 10 pharynx, 5 larynx annually among never smokers.

• Policy recommendation:
  • Build on successes by strengthening enforcement of smoke-free workplace legislation.
    • According to the Canadian Tobacco Use Monitoring Survey many workers still report exposure to ETS at work and a lack of smoke-free policies.
Radon

• Approximately 34,000 workers exposed in underground work or poorly ventilated workplaces in high background regions

• Approximately 60 lung cancers annually

• Policy recommendations:
  • *Develop explicit and specific regulation of radon in indoor air in Ontario occupational health and safety regulations*
    • Naturally Occuring Radioactive Materials (NORM) Guidelines could be legislated
  • *Implement 100 Bq/m³ (WHO’s guideline) as the exposure standard for remediation in all underground and above-ground work areas*
General policy recommendations to prevent occupational cancer in Ontario

• OELs should be strengthened to align with recent evidence on health effects & be at least as protective as American Conference of Governmental Industrial Hygienists (ACGIH)
  • chromium (VI) compounds: 0.025 mg/m$^3$ (ceiling limit 0.1 mg/m$^3$) for water soluble compounds in alignment with the BC
  • nickel compounds: 0.05 mg/m$^3$ for elemental and insoluble and soluble inorganic nickel compounds; 0.001 ppm for nickel carbonyl; and 0.1 mg/m$^3$ for nickel subsulfide; in alignment BC
  • formaldehyde: 0.3 ppm STEL; in alignment with the ACGIH
  • wood dust: 1 mg/m$^3$ in alignment with ACGIH
General policy recommendations to prevent occupational cancer in Ontario

• Toxics Reduction Act provisions can be amended to more explicitly incorporate worker exposure and Toxics use reduction

  • Ontario in the only province in Canada with this legislation, but it could be strengthened

• Exposure surveillance and exposure registries can help prevent occupational exposure by providing a regular and standardized method of informing workers of potential exposures
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
Thank You!!
This report is available online at