Proportion of cancers that are work-related

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Chemical and Biological Hazards Prevention
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Is it important?

- To whom is it important?
  - the physician
    - Early detection/ recognition
  - the community (Public health level)
    - Prevention
    - Resource allocation
  - the worker (individual level)
    - Prevention & compensation

- Why is it important?
  - To raise awareness
  - To change working conditions…
Laws

- 1775 – Percival Pott: scrotum skin cancer among chimney sweepers → 1778 laws restricting work of children sweeps ...(total interdiction in 1875)

补偿

- 1879 – Haerting & Hesse, lung carcinomas among Schneeberg underground silver miners → 1925 list of compensatable diseases (link with uranium 1936)
Practical usefulness?

Work practices

- 1920s – Radium dial painting & lip cancer
  → litigation settled in 1928, changes in occupational disease labor laws & work practices

Source: [http://www.mun.ca/biology/s carr/Radium_Watch_dial2.jpg](http://www.mun.ca/biology/s carr/Radium_Watch_dial2.jpg)

Practical usefulness?

Exposure standards

- 1974 – Creech & Johnson: liver angiosarcoma among workers in polymerization of polyvinyl chloride
  → 1974 OSHA proposed a 500-fold reduction in occupational standard & industry developed closed-loop polymerisation process

Source: [http://image.made-in-china.com/2f0j00PeRQfubysKm/PVC-Soft-Hard-Granule-Injection-Molding-Food-Extrusion-Grade-.jpg](http://image.made-in-china.com/2f0j00PeRQfubysKm/PVC-Soft-Hard-Granule-Injection-Molding-Food-Extrusion-Grade-.jpg)
How can it be done?

- No clear "marker" of occupational origin (thus, cannot be counted)
- Has to be estimated: Population Attributable Fraction ($AF_p$)

$AF_p$
Proportion by which the incidence rate of a given outcome in the entire population would be reduced if exposure were eliminated (Ref.: Last, 2001)

- $AF_{wr}$: work-related AF

2 main methods

A. Calculate country/region-specific attributable proportions
   - USA (Doll & Peto, 1981; Steenland & al., 2003)
   - Finland (Nurminen & Karjalainen, 2001)
   - Great Britain (Rushton et al., 2010)

B. Use attributable proportions published for other countries/regions & apply them to local populations
   - Australia (Fritschi & al., 2006)
   - Alberta (Orenstein & al., 2010)
   - Québec (Labrèche & al., 2013)
A - "Gold standard" method

1. Select time of interest
   - Ex. cancers diagnosed in 2013

2. Select cancers & carcinogens of interest
   (Literature review carcinogens, consider possibly overlapping exposures)
   - Ex. bladder cancers

3. Define relevant period of exposure according to latency
   - Solid cancers (15-40-year latency) → 1973-1998
   - Hematopoietic cancers (5-10-year latency) → 2003-2008

4. Evaluate % of target population exposed in the relevant period
   - taking into account turnover in different industries, average age at retirement and local survival rates

5. Find absolute or relative risks of cancer in relation to selected exposures
   - for each cancer
A - "Gold standard" method

6. Calculate a summary AF for each cancer…
   - Considering each exposure level of each carcinogen

   - $AF_R = \Pr(E/D) \times \frac{(RR - 1)}{RR}$
   - $AF = \frac{\sum \sum \Pr(E_{ij}) (RR_{ij} - 1)}{1 + \sum \sum \Pr(E_{ij}) (RR_{ij} - 1)}$
   - Confidence intervals for random error…

7. Apply AFs to local cancer numbers/rates to get numbers for each cancer

B- Simpler method

- Apply $AF_p$ published by other researchers to local cancer rates
  - Method selected in Australia, Alberta, Québec

- The Quebec study:
  - Selection of studies that considered many cancer sites
  - From countries comparable to Québec
    - Nurminen & Karjalainen, 2001 – Finland
    - Rushton et al., 2010, 2011, 2012 – Great Britain
The Quebec study

- Cancer incidence/mortality (2002-2006), 28 cancers
  - Québec tumour registry (annual average number of incident cases over 5-year period)
  - Québec mortality database (annual average number of deaths over 5-year period)

- Between-country comparison in terms of
  - Socio-economic profile
  - Smoking & alcohol consumption

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The Quebec study

- Socioeconomic profiles
  - Comparison Québec – Canada (% of workers/industry)
    - Québec ± ≈ Canada, except + production workers & - agricultural workers
  - Comparison Canada – UK – Finland

<table>
<thead>
<tr>
<th>Industry</th>
<th>1970-1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, hunting &amp; fishing</td>
<td>Fin &gt; Can &gt; UK</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>UK &gt;&gt; Can &gt; Fin</td>
</tr>
<tr>
<td>Building and public works</td>
<td>Can ≈ UK ≈ Fin</td>
</tr>
<tr>
<td>Transportation, warehousing, communications</td>
<td>Can ≈ UK ≈ Fin</td>
</tr>
<tr>
<td>Trade, food services, accommodation</td>
<td>Can &gt; UK &gt; Fin</td>
</tr>
<tr>
<td>Social &amp; personal services</td>
<td>Can &gt; UK &gt;&gt; Fin</td>
</tr>
</tbody>
</table>
The Quebec study

- Smoking & alcohol consumption
  - Listing of cancers with smoking as causal factor (n=15 cancer sites/28) & with alcohol as causal factor (n=8/28)
  - For these cancers, AFs from country with consumption habits comparable to those of Canadians 20-30 years ago (UK)

The Québec study results

- AF<sub>wr</sub>, all cancers together (n=28)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>♂</th>
<th>♀</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incident cases</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plausible %</td>
<td>6.0</td>
<td>9.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Plausible range of %</td>
<td>5.0-8.3</td>
<td>8.3-13.1</td>
<td>1.6-3.3</td>
</tr>
<tr>
<td><strong>Cancer deaths</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plausible %</td>
<td>7.6</td>
<td>11.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Plausible range of %</td>
<td>6.9-10.9</td>
<td>11.0-17.2</td>
<td>2.1-3.6</td>
</tr>
</tbody>
</table>
### Incident cases

<table>
<thead>
<tr>
<th>Cancer</th>
<th>Plausible ( A_{Fr} )</th>
<th>Average number of cases</th>
<th>Plausible ( A_{Fr} )</th>
<th>Average number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesothelioma</td>
<td>93.5</td>
<td>98.0</td>
<td>53.8</td>
<td>15.1</td>
</tr>
<tr>
<td>Sinuses/nasal cavities</td>
<td>43.3</td>
<td>13.9</td>
<td>19.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Trachea/bronchus/lung</td>
<td>21.1</td>
<td>810.5</td>
<td>5.3</td>
<td>143.7</td>
</tr>
<tr>
<td>Pharynx</td>
<td>10.8</td>
<td>4.1</td>
<td>2.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Skin, non melanoma</td>
<td>10.0</td>
<td>116.6</td>
<td>2.5</td>
<td>24.6</td>
</tr>
<tr>
<td>Leukaemias</td>
<td>9.7</td>
<td>52.3</td>
<td>1.5</td>
<td>6.4</td>
</tr>
<tr>
<td>Non-Hodgkin lymphomas</td>
<td>7.8</td>
<td>62.2</td>
<td>2.1</td>
<td>14.6</td>
</tr>
<tr>
<td>Bladder</td>
<td>7.1</td>
<td>102.9</td>
<td>1.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Breast</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td>6.0</td>
<td>238.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brain</td>
<td>5.6</td>
<td>17.3</td>
<td>0.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Colon</td>
<td>5.6</td>
<td>91.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Several occupational cancer studies

![Chart showing occupational cancer studies](image)

Occupational Cancer Burden Studies: numbers

<table>
<thead>
<tr>
<th>Authors</th>
<th>N of cancer sites</th>
<th>Exposures</th>
<th>Year of diagnosis (Mort./Inc.)</th>
<th>Annual number of incident work-related cancer cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doll &amp; Peto, 1981 (USA)</td>
<td>~20</td>
<td>Variable</td>
<td>Mort. 1978</td>
<td>♂: 14,777 ♂: 2,292</td>
</tr>
<tr>
<td>Nurminen &amp; Karjalainen, 2001</td>
<td>27</td>
<td>Variable depending on cancer site; a few occupations</td>
<td>Mort. 1998</td>
<td>♂ &amp; ♂: 10,005</td>
</tr>
<tr>
<td>Steenland &amp; al., 2003 (USA)</td>
<td>10</td>
<td>Mainly IARC Gr. 1 carcinogens</td>
<td>Mort. 1997</td>
<td>♂ &amp; ♂: 12,682-26,244</td>
</tr>
<tr>
<td>Rushton &amp; al., 2010 (GB)</td>
<td>24</td>
<td>N=42. Variable depending on cancer site; a few occupations</td>
<td>Inc. 2004</td>
<td>♂: 9,988 ♂: 3,611</td>
</tr>
<tr>
<td>Orenstein &amp; al., 2010 (Alberta)</td>
<td>27</td>
<td>Variable</td>
<td>Inc. 2004</td>
<td>♂: 609 ♂: 152</td>
</tr>
<tr>
<td>Labrèche &amp; al., 2013 (Québec)</td>
<td>27</td>
<td>Variable</td>
<td>Inc. 2006</td>
<td>♂: 1,680 ♂: 478</td>
</tr>
</tbody>
</table>
Methodological considerations

- Use of AF\textsubscript{wr} developed for other countries
- 3 major sources of uncertainty
  - Selected carcinogens (recognized, probable, possible…)
  - Selected risk estimates (varies with epidemiological studies considered)
  - Estimates of exposure in each industrial sector (varies with level of detail of available information)
- Other sources of uncertainty
  - Several differences between countries
    - Varying industrial profiles (consequently varying exposures)
    - Differences in lifestyle habits (smoking & alcohol)
    - Variation in genetic make-up of population
    - …

In summary

- Studies considering > 20 cancers
  - AF\textsubscript{wr} incident cancers: ♂: 4-8% / ♀: 1-3%
  - AF\textsubscript{wr} cancer deaths: ♂: 3-14% / ♀: 1-3%
- Cancers with more cases
  - Incidence: lung, skin, breast, prostate, bladder
  - Mortality: lung, colon, breast, prostate
- Cancers with larger AF\textsubscript{wr}
  - Mesothelioma (♂: 83 - 98%; ♀: 21 - 90%) – Small ‘n’
  - Sinuses/nasal cavities (♂: 24-46%; ♀: 7-20%) – Small ‘n’
  - Lung (♂: 8-29%; ♀: 2-5%) – Large ‘n’
In conclusion

- Useful data to prioritize prevention & research towards workers exposed to carcinogens associated with most frequent forms of cancer
- Few studies have undertaken to estimate direct & indirect costs associated with occupational cancers
  - Alberta Health Services *(Orenstein et al., 2010)*
  - Canadian study *(Demers et al., 2013-16)*
    - Better estimates of numbers of occupational cancers & AF wr specific to Canada + direct & indirect economic burden
    - Estimates of future burden & scenarios of impact of preventive actions (changing exposures)

Finally...

“Occupational cancer, moreover, tends to be concentrated among relatively small groups of people among whom the risk of developing the disease may be quite large, and such risks can usually be reduced, or even eliminated, once they have been identified. The detection of occupational hazards should therefore have a higher priority in any program of cancer prevention than their proportional importance might suggest.”

*Doll & Peto, JNCI 1981; 66(6): 1245*