Models for Exposure Surveillance

NAS

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Noah Seixas, PhD, CIH
Outline

• Why survey exposures?
• What do we know
• Historical Surveys
  – NOHS/NOES
• Administrative and Compiled Databases
  – MSHA/IMIS
  – Noise JEM
  – Modeled data (SYN-JEM)
• Industry/Hazard Based Programs
  – IMA-DMP
• Survey of workers
  – Australian Exposure Survey
  – QWL/GSS
• Concluding remarks
  – Changing world of work
  – Redefine occupational exposures
Why exposures?

- Injury and acute illness surveillance possible, despite challenges, chronic illness cannot be approached in a similar framework.
  - Nature of “occupational” etiology for multifactorial conditions.
- What is a work-related condition/event?
  - Events that occur while at work. Inadequate definition
    - Example: Suicides. Counting only those at work misses a large portion of work-related deaths. E.g., opioid related deaths due to work injuries.
    - Even more evident for chronic disease, e.g., heart disease, CA
    - We are missing the bulk of the health impact of adverse working conditions
- No other way to address occupational contributions to chronic disease
  - Except signature diseases such as asbestosis, mesothelioma.
  - Chronic diseases are the conditions with by far the greatest public health impact, social and economic costs
- Leading indicator
  - Feedback to worksite for prevention
  - Burden estimates rely on exposure estimates with D-R models
    - E.g., Lesley Rushton, occupational contribution to UK CA
What is exposure?

- Prevalence
- Frequency
- Duration
- Intensity
What do we know about exposures?

### Trends in Inhalation Exposure—A Review of the Data in the Published Scientific Literature

**KAREN S. CREELEY**, **HILARY COWIE**, **MARTIE VAN TONGEREN**, **HANS KROMHOUT**, **JOHN TICKNER** and **JOHN W. CHERRIE**

<table>
<thead>
<tr>
<th>Agent Type</th>
<th># Trends</th>
<th># (%) Negative</th>
<th>Annual Change Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosols (e.g., Metals, PAHs, PNOC)</td>
<td>38</td>
<td>36 (95%)</td>
<td>+4% / -19%</td>
</tr>
<tr>
<td>Gases and Vapors (e.g., Solvents, CO, Formaldehyde)</td>
<td>39</td>
<td>36 (92%)</td>
<td>+8% / -24%</td>
</tr>
<tr>
<td>Fibers (e.g., Asbestos, RCF)</td>
<td>10</td>
<td>10 (100%)</td>
<td>-4% / -32%</td>
</tr>
</tbody>
</table>

*Data are interpolated between 1900 and 1910*  
*Sources: ABS; RBA; Withers, Endres and Perry (1985)*
NOHS/NOES

- Only US attempts at systematic exposure estimation
- Allows estimation of #/% persons exposed full and part time to agents, by SIC, etc.
- Limitations
  - Seriously out of date
  - Exclusions (small business, Agriculture, Government, etc.)
  - Only observed exposures
  - Highest attention to chemical exposures

**TABLE 1. Basic Survey Parameters**

<table>
<thead>
<tr>
<th>Basic Parameters</th>
<th>NOHS</th>
<th>NOES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of surveyors</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Establishments surveyed</td>
<td>4636</td>
<td>4490</td>
</tr>
<tr>
<td>Employees surveyed</td>
<td>895,725</td>
<td>1,830,330</td>
</tr>
<tr>
<td>Metropolitan areas</td>
<td>67</td>
<td>98</td>
</tr>
<tr>
<td>Unique industries</td>
<td>639 (four-digit SIC)</td>
<td>523 (four-digit SIC)</td>
</tr>
<tr>
<td>Unique occupations</td>
<td>442</td>
<td>410</td>
</tr>
<tr>
<td>Unique hazards</td>
<td>8,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Unique trademarked products</td>
<td>86,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Records in database</td>
<td>5 million</td>
<td>2.1 million</td>
</tr>
</tbody>
</table>
Use of Administrative Databases

- **MSHA**
  - Intensive sampling requirements for Operators
  - Large database
  - Very limited agents
  - Biases
  - Decreasing numbers

- **IMIS**
  - Based on inspections only, thus highly biased and non-representative for surveillance
  - Limited number of workplaces, etc.
  - Multiple agents
  - Very few ‘determinants’ of exposure available
  - Data, even for occupation is inconsistently recorded

Philippe Sarazin\textsuperscript{1,2,*}, Igor Burstyn\textsuperscript{3}, Laurel Kincl\textsuperscript{4} and Jérôme Lavoué\textsuperscript{2,5}

- 850,000 records, 1979-2011
- 511,000 (60%) included in analysis
- 19 of 77 agents >10,000
- Results more about regulatory effectiveness than exposure and risk
Noise JEM Results
1979-2014, (n>1M)

From R. Neitzel. NIOSH funded project to amass US noise database and create an online JEM: http://noisejem.sph.umich.edu/
Modeling of exposure databases

- SYN-JEM, assessing occupational carcinogen exposures for lung cancer risk in a EU population-based C-C study (SYNERGY)
  - Asb, RCS, Cr6, Ni, PAHs
  - 1970-2009
  - Many countries contributing data
  - >100,000 exposure measurements

<table>
<thead>
<tr>
<th>Table 2. Model output for the five selected agents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
</tr>
<tr>
<td>Asbestos</td>
</tr>
<tr>
<td>Time trend (% per year, 95% CI)</td>
</tr>
<tr>
<td>Before ban:</td>
</tr>
<tr>
<td>-10.7% (-11.3% to -10.0%)</td>
</tr>
<tr>
<td>After ban:</td>
</tr>
<tr>
<td>+1.7% (-0.4% to +3.7%)</td>
</tr>
<tr>
<td>23.1% (-26.0% to -20.0%)</td>
</tr>
<tr>
<td>Trend in exposure level per hour increase in sampling duration (95% CI)</td>
</tr>
<tr>
<td>Prior exposure rating (GMR, 95% CI)</td>
</tr>
</tbody>
</table>

| Mixed model with region/country, jobs random effects | Peters et al. AOH, 2012 |
Use of Administrative Exposure Databases

• Non representative of population risk
  – Biased to industries and companies likely to be inspected
• Sampling strategy biases toward high exposure conditions
• Limited number of agents
  – Regulated
  – Common
  – Technical measurement (no ergonomic, psychosocial variables)
• Decreasing number of measurements available
• Modeling approaches help to ‘smooth’ over limitations and can be used to assess biases
  – Still hampered by distribution of effort, non-standardized protocols, explanatory variables available, etc.
Took up its responsibility and initiated in 1999-2000 a prospective ‘Dust Monitoring Program’ (DMP)

In 2006, the IMA-DMP database was transferred to The Netherlands, where it is coordinated in a collaborative project of NKAL and IRAS.
Organizational structure

Company

IMA-DMP DATABASE

Company reports

IMA-Europe

Biannual report

Statistical analyses

Biannul debriefing meeting

Sampling

Collection sheets

not ok

 ok

IRAS / NECORD

Quality Control

Submitting data
Sampling strategy

- **Personal** monitoring only

- A minimum of **6 samples** per job function, location and sampling campaign (incl. repeated measurements, min. \( k=2 \))

- **Respirable** dust fraction

- **Standardized** jobs

- Assignment of **unique** worker codes

- **Full-shift**

<table>
<thead>
<tr>
<th>Standardized jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quarry operator</td>
</tr>
<tr>
<td>2. Crusher operator</td>
</tr>
<tr>
<td>3. Wet process operator</td>
</tr>
<tr>
<td>4. Dry process operator</td>
</tr>
<tr>
<td>5. Miller operator</td>
</tr>
<tr>
<td>6. Bagging operator</td>
</tr>
<tr>
<td>7. Transport/bulk loading</td>
</tr>
<tr>
<td>8. Foreman/management Staff</td>
</tr>
<tr>
<td>9. Maintenance</td>
</tr>
<tr>
<td>10. Multi-skilled</td>
</tr>
<tr>
<td>11. Laboratory workers</td>
</tr>
<tr>
<td>12. Research and Development</td>
</tr>
<tr>
<td>13. Plastification</td>
</tr>
<tr>
<td>14. Lime worker</td>
</tr>
</tbody>
</table>
IMA-DMP database

Per 01/05/2015

- Total of 27,832 observations

- 27,697 respirable dust, 23,480 respirable quartz from 35 industrial mineral companies

- Data from 160 sites located in 23 countries


- Representative for a total work force ≈ 5,000
IMA-DMP database
Per 01/05/2015

Temporal trends in number of measurements and sites

![Graph showing temporal trends in number of measurements and sites.](image)
Results

Temporal trend in respirable dust concentration (mg/m³)
Results

Temporal trends in exposure concentrations by time period

<table>
<thead>
<tr>
<th>Time period</th>
<th>Trend per campaign (respirable dust)</th>
<th>Trend per campaign (respirable quartz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002 - 2015</td>
<td>-5.1%***</td>
<td>-3.1%***</td>
</tr>
<tr>
<td>2002-2009</td>
<td>-6.1%***</td>
<td>-5.3%***</td>
</tr>
<tr>
<td>2009-2013</td>
<td>+0.9%</td>
<td>+4.9%</td>
</tr>
<tr>
<td>2013-2015</td>
<td>-1.4%</td>
<td>-3.4%</td>
</tr>
</tbody>
</table>

* Trend statistically significant for p < 0.05; ** P<0.01; *** p<0.0001

A temporary reversed trend due to **economic crisis**?

- Less money for maintenance contracts
- Laying-off part of the workforce
- Delay of investments in control measures
Alternative Approach
Survey of workers

• Australian Work Exposures Study
  – 5000 adults in Australia
  – 38 carcinogens
  – Telephone surveys using OccIdeas
  – About half were unlikely to be exposed
  – Rest were interviewed with 57 detailed “job specific modules”
  – Exposure based on JSM description of tasks and conditions:
    • No, Possible or Probable
    • High, Medium, Low
Conclusion: 6.3% of workers or 631,000 Australians have ‘probable’ exposure to lead.

Options for exposure surveillance

• Exploit existing databases, using modeling
  – Increasingly difficult because of reduction in effort

• Create industry- or hazard-specific systems with centralized management
  – Requires cooperation of private sector
  – Exposure “monitoring” standard with central repository?

• Population surveys
  – Self-reports are non-quantitative
  – But can capture a wide range of exposures and work organization challenges
  – Relatively inexpensive
  – Link to other surveys
“The Fissured Workplace”, by David Weil
Also includes contracting production through supply chains.

Not all workers can be found or classified by employer.

Need a broadened definition of ‘exposures’
What is a work-related health outcome?
Thus: what are the exposures of interest?

- Only: ONIPTS, Pneumoconioses, Occupational CA, Acute injury, MSDs, etc.?
- Are these the conditions leading to health disparities?
- Can no longer ignore
  - Stress related conditions
  - Mental health issues
  - Violence
- What about public health issues not normally thought of as work-related?
  - Nutrition, Exercise
    - Occupational ‘built environment’
  - Sleep deprivation
    - Multiple jobs, shift work, extended shifts, work load and activity
  - Access to health care
    - Insurance benefits
  - A “Living Wage”
    - Wages / income are key health determinants

- What does work have to do with these exposures?
Conclusions

• World of work is rapidly changing and complex
  – Need to capture the new work forms in surveillance activities

• Focused and systematic surveillance can be very powerful for control and research
  – Modeling data is powerful but dependent on availability of rich data resources
  – “Hygiene without numbers” is unlikely to produce similar results

• Population surveys are needed to capture the wide range of work organizations and hazards
Warning: “Hygiene without Numbers”

- Increasing use and interest in use of exposure estimation algorithms
  - Simple: COSHH Essentials
  - Complex: Advanced Reach Tool (Bayesian estimation routines)

- Validity and accuracy remains questionable
  - May be useful for enterprise risk management
  - Prediction in EU REACH regulations
  - Not for actual exposure levels or surveillance