Occupational Health in the 21st Century: Romance, Separation, Counseling, Remarriage

“Rest after Work” Vincent Van Gogh, 1890

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Words of my PhD advisor

“Most occupational and environmental issues are rarely solved, instead they are just revisited every 20 years or so.”

To which I would add

“That’s a nice invention, you know they came up with that idea over 100 years ago, right?”
1. Romance

“Colebrookedale by night”  
*Philip James de Loutherbourg, 1801*

[Wikipedia.org](https://en.wikipedia.org/wiki/Colebrookedale)
The Romance of Occupational Health:
Using science to solve mysteries,
protect others, and render aid
“All things are poison and nothing is without poison. It is the dose that makes a thing poisonous.”
- Paracelsus, 16th Century Pharmacologist
Paradigm of Exposure (Dose) $\rightarrow$ Response

- Emission
- Exposure
- Intake
- Deposition
- Dose
- Health Effect
- Toxicology & Exposure Biology
- Epidemiology

Engineering Control & Source Apportionment

Occupational Medicine
The Global Burden of Disease: Occupational Risk Factors

Burden of disabling diseases and injuries increasing in the US
Photo by UMDNJ School of Nursing. USA, 2011
2. Separation

“Colliery and wagonway, Northumberland and Durham coalfield”
W. Wheldon, 1845

http://blog.sciencemuseum.org.uk/collections/tag/numsciencemuseum1987-510/
There Are Serious Problems with Our Paradigm for Assessing Worker Exposure to Hazards

-Coverage

-Cost
MEASURING DUST EXPOSURE WITH THE THERMAL PRECIPITATOR IN COLLIERIES AND FOUNDRIES

BY

S. A. ROACH*

BJIM 16(4) 1959

Fig. 4b.—Corresponding normal distribution.
### Examples of Lognormal Exposures Across Industries

<table>
<thead>
<tr>
<th>Hazard, Industry/NORA Sector</th>
<th>Sample Size (n)</th>
<th>GSD (^a) Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical industry, various</td>
<td>96</td>
<td>2.5</td>
<td>(Kromhout et al. 1993)</td>
</tr>
<tr>
<td>EMF radiation, services</td>
<td>491</td>
<td>1.6–4.0</td>
<td>(Bowman et al. 2007)</td>
</tr>
<tr>
<td>Mercury, various</td>
<td>592</td>
<td>1.4–2.1</td>
<td>(Waters et al. 1991)</td>
</tr>
<tr>
<td>Silica, construction</td>
<td>151</td>
<td>1.9–4.7</td>
<td>(Rappaport et al. 2003)</td>
</tr>
<tr>
<td>Diesel exhaust, transportation (^b)</td>
<td>217</td>
<td>1.6–3.3</td>
<td>(Groves and Cain 2000)</td>
</tr>
<tr>
<td>Wood dust, construction</td>
<td>&gt;372</td>
<td>2.1–3.1</td>
<td>(Kauppinen et al. 2006)</td>
</tr>
<tr>
<td>Metalworking fluid, machining (^c)</td>
<td>723</td>
<td>2.0–2.8</td>
<td>(Piacitelli et al. 2001)</td>
</tr>
<tr>
<td>Endotoxin, agriculture</td>
<td>587</td>
<td>8.6</td>
<td>(Spaan et al. 2006)</td>
</tr>
<tr>
<td>Benzene, aviation</td>
<td>69</td>
<td>3.5</td>
<td>(Smith et al. 2010)</td>
</tr>
</tbody>
</table>

\(^a\) GSD: Geometric Standard Deviation of the measured exposure distribution(s)

\(^b\) Estimated as elemental carbon by NIOSH method 5040

\(^c\) Extractable particulate mass from turning, grinding, milling operations in small machine shops
Coverage: Not Enough of It

• How many samples are needed to characterize a log-normal distribution ($\mu$, $\sigma_g$)?
  • 30 samples per environment? (Buringh & Lanting, AIHAJ 1991)

• What about within/between worker variability for compliance-based sampling?
  • 20+ samples, 2-5 per worker (Rappaport et al., AOH 1995)

• How many samples are typically collected per visit?
  • OSHA 21D Consultation Programs: 0 – 3

• How many (full-shift) personal samples could one super-hygienist collect in a day?
Cost
State-of-the-Art for Metals: ICP-AES

- **Instrument cost:**
  - $50,000 - $150,000

- **Sample analysis cost:**
  - $100 for the first metal, $20 for each additional one

- **Personal Sampling Pumps:**
  - $500 - $3,000 each!

Grainger.com
Cost Perspective

• The 2010 U.S. Census estimates a population of 466,400 welders, cutters, solderers, brazers nationally.

• Cost to measure each individual’s exposure to one metal just once per year:
  ~ $50M USD in analytical costs
  ~ $10M in capital costs
  ~ $10M in personnel costs
  ~$70M per year
Separation Science: Want vs. Need

What we want: (what’s being funded)
- Highly Sensitive & Specific
- High Accuracy & Precision
- Portable
- Real-time
- GPS, Wi-Fi, Brushed-aluminum housing

What we need: More Samples!
- Ultra-low cost
- Simple
- High Throughput
- Medium accuracy
- High specificity
- Medium sensitivity
- VERY time-integrated (weeks, months, years)
Pop Quiz: What Drives the Development of New Exposure Limit Standards?

a) Mechanistic toxicology
b) Valid exposure data
c) Causal inference epidemiology

d) None of the above, OSHA hasn’t published a new exposure limit standard since 2006
Reflecting on Exposure Science

• We’re not taking enough samples to support defensible epidemiology
• Our methods are inefficient and R&D seems headed in the wrong direction
• It’s all too expensive anyway
3. Counseling

P.J. de Loutherbourg, 'Colebrook Dale' (engraved by William Pickett), 1805
There are known knowns...there are known unknowns...but there are also unknown unknowns. - D. Rumsfeld

The known known: We are not good at guessing

“desktop qualitative judgments [on worker exposure] were little better than random chance”

The known unknown:

We don’t have the exposure data we desire; we must economize the data we do have

• Similarly exposed groups
  *Oldham (1952); Roach (1977)*

• Job-Exposure Matrices
  *Hoar (1980)*

• Variance components, within/between worker variation
  *Kromhout (1987); Rappaport (1991)*

• Control Banding
  *HSE (1998)*

• Bayesian frameworks for exposure estimation
  *Ramachandran (1999); Schinkel (2013)*
The unknown known (S. Žižek): Linear Thinking in a Lognormal World

Measurement Uncertainty

10%

20%

30%

Misclassification Rate

10% 5%

20% 9%

30% 13%
The unknown unknown:

*The Future of OH Research*: Risk Factors as of September 2015
4. Remarriage

C. Monet, ‘Waterloo Bridge’, 1902
Occupational Health in the 21st Century
What Should the Future Hold for You?

1. Learn to speak another language
Health Impact Analysis

Cost of Injury and Illness
Value of OH Profession

How do you define impact?

- Changing laws
- Changing awareness
- Changing behaviors
- Improved wellness

Health Behavior
Human Factors
Safety Culture
Avoidance Behavior

Exposure

Response

- Changing laws
- Changing awareness
- Changing behaviors
- Improved wellness

Health Impact Analysis

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2. Embrace total (environmental) health
   - Indoor & outdoor environment, behavior, wellness

$30B
$8B
$600M
The Fort Collins Commuter Study

(an ‘exposome’ study funded by NIH)

Good et al. JESSE (2016) doi:10.1038/jes.2015.68
Personal Black Carbon

Avg. Cumulative Exposure by Microenvironment

Particulate Matter
Carbon Monoxide
Ultrafine Particles
Where does your job end? What are your responsibilities?
Occupational Health in the 21st Century
What Should the Future Hold for You?

1. Learn to speak another language
2. Embrace total (environmental) health
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3. Less precision, more data!
Goal: Personal Exposure Assessment That’s Actually Affordable

Sampling

$50

Analysis

$2

Interpretation

Me $$$

Technology to Empower Awareness, Knowledge, Action

• 100 years ago you went to the doctor to have your temperature taken

• 25 years ago you did the same to find out if you were pregnant

• 10 years ago you needed official credentials to be called a journalist
Are we experts or are we technicians?

Can we engineer the 'pump hanger' out of the industrial hygienist?

What if we provided workers with the means to assess their own exposures? …would that be good or bad?

‘Big-Data’ can Pay Big Dividends
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3. Less precision, more data!
4. Mixtures, Susceptibility, Allostasis
   - McEwen & Stellar (1993)

“The Environment and Genes Initiative”
“Shimmering Substance” Jackson Pollock, 1946