Models for Exposure Surveillance

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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

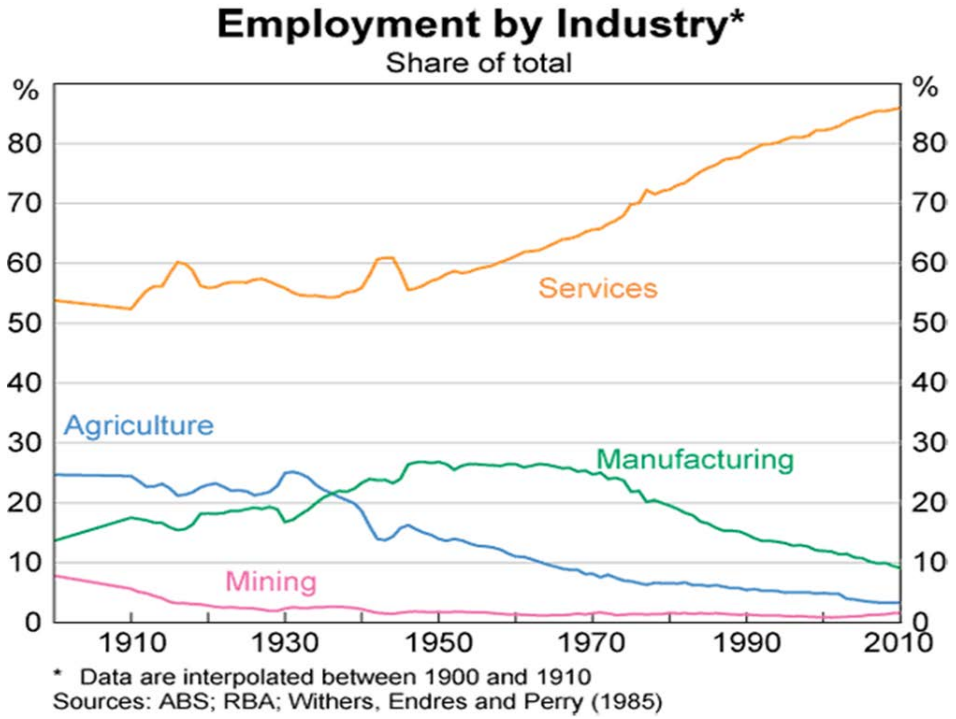
Why exposures?

- 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. CREELY[1]*, HILARY COWIE[1], MARTIE VAN TONGEREN[1,2], HANS KROMHOUT[3], JOHN TICKNER[4] and JOHN W. CHERRIE[1]

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

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

Basic Parameters	NOHS	NOES
Survey dates	February 1972–June 1974	January 1981–May 1983
Number of surveyors	20	15
Establishments surveyed	4636	4490
Employees surveyed	895,725	1,830,330
Metropolitan areas	67	98
Unique industries	639 (four-digit SIC)	523 (four-digit SIC)
Unique occupations	442	410
Unique hazards	8000	12,000
Unique trademarked products	86,000	100,000
Records in database	5 million	2.1 million

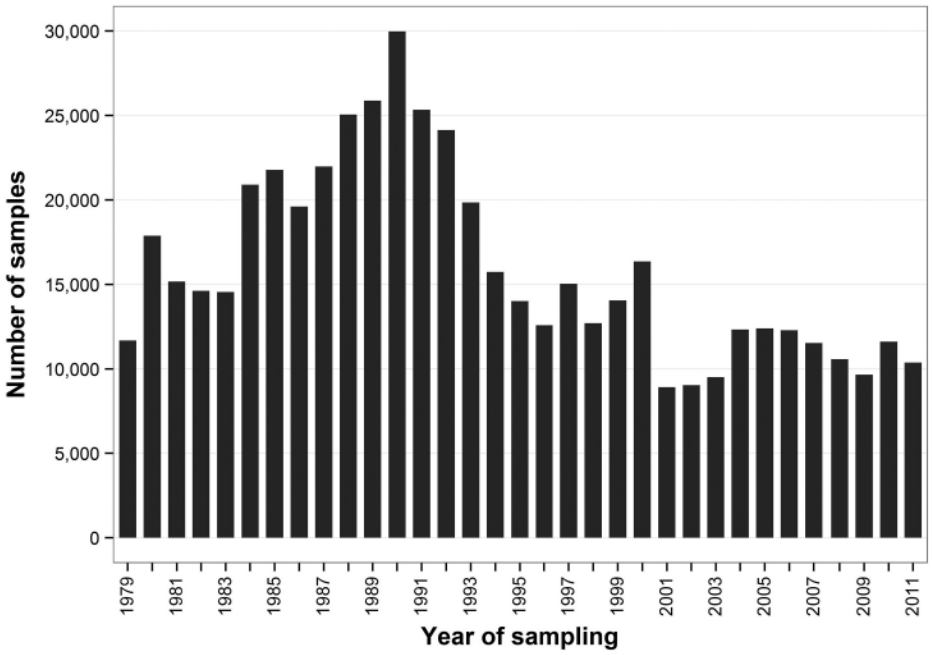
Use of Administrative Databases

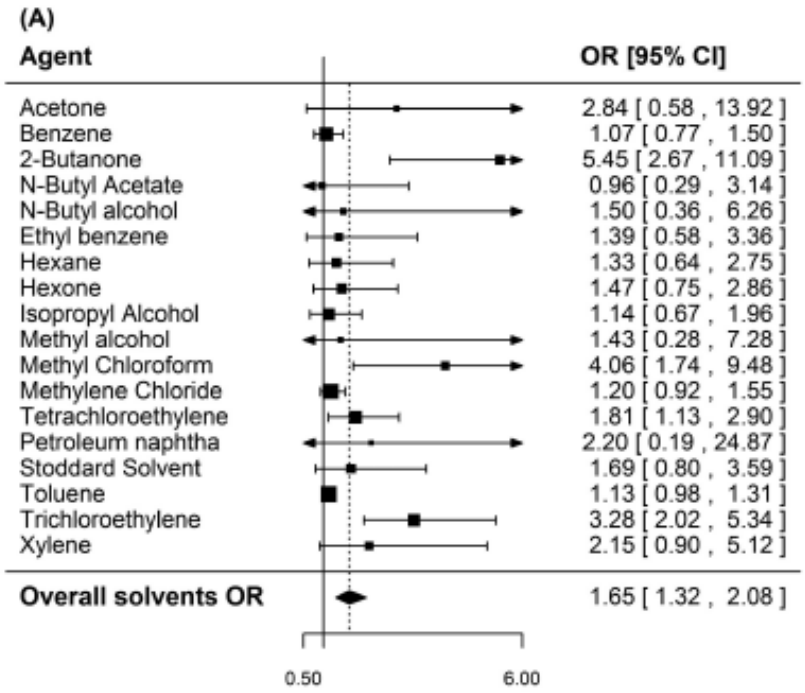
- MSHA
  - Intensive sampling requirements for Operators
  - Large database
  - Very limited agents
  - Biases
  - Decreasing numbers
- IMIS
  - Based on inspections only, thus highly biased and non-representative for surveillance
  - Limited number of workplaces, etc.
  - Multiple agents
  - Very few ‘determinants’ of exposure available
  - Data, even for occupation is inconsistently recorded

Trends in OSHA Compliance Monitoring Data 1979–2011: Statistical Modeling of Ancillary Information across 77 Chemicals

Philippe Sarazin[1,2*], Igor Burstyn[3], Laurel Kincl[4] and Jérôme Lavoué[2,5]

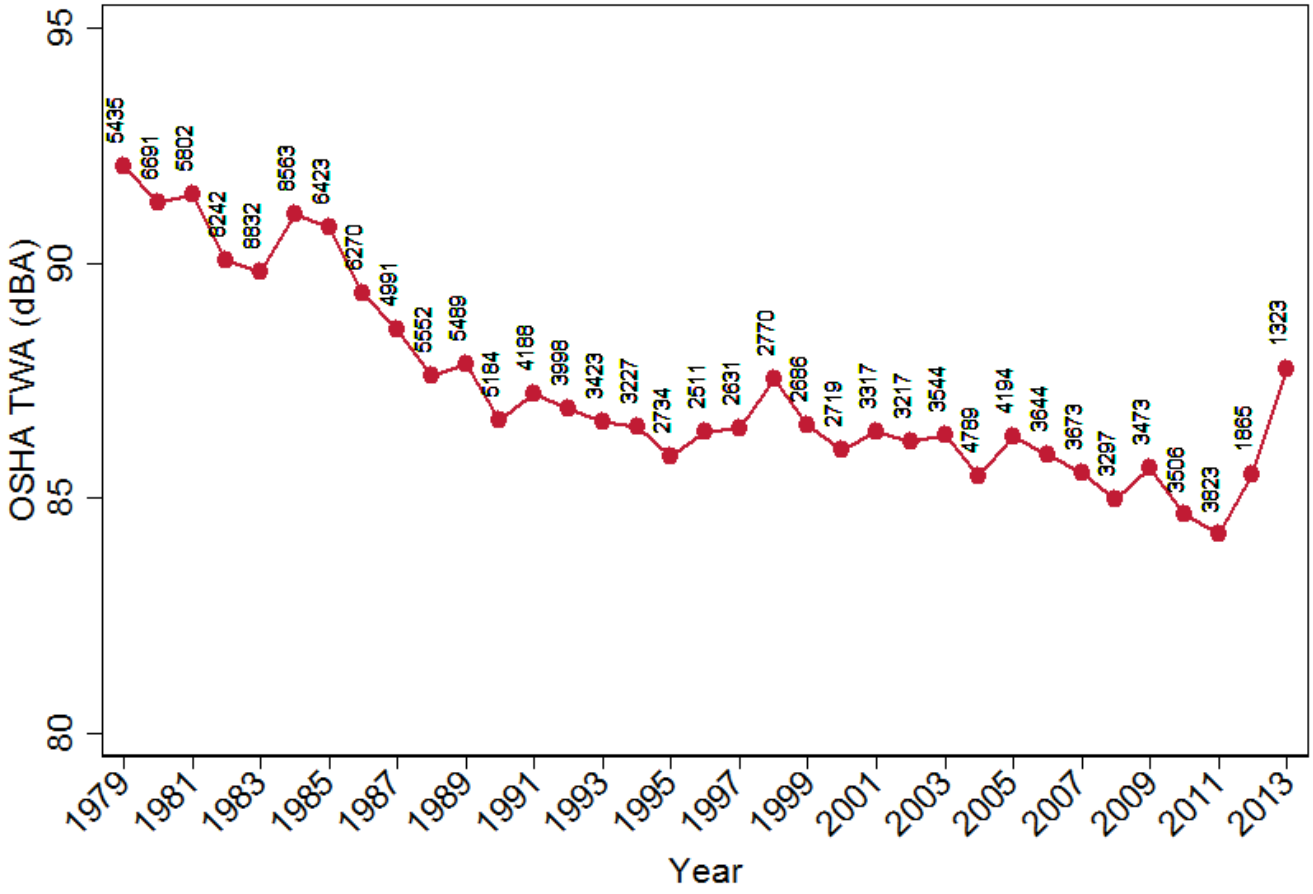
- 850,000 records, 1979-2011
- 511,000 (60%) included in analysis
- 19 of 77 agents >10,000
- Results more about regulatory effectiveness than exposure and risk





Noise JEM Results 1979-2014, (n>1M)

noiseJEM



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 2. Model output for the five selected agents

		Asbestos	Chromium-VI	Nickel	BaP [a]	RCS [b]
Fixed effects						
Time trend (% per year, 95% CI [c])		Before ban: -10.7% (-11.3% to -10.0%) After ban: +1.7% (-0.4% to +3.7%)	-2.7% (-3.2% to -2.3%)	-1.2% (-1.7% to -0.7%)	-1.2% (-3.1% to -0.7%)	-5.5% (-6.0% to -5.0%)
Trend in exposure level per hour increase in sampling duration (95% CI)		-23.1% (-26.0% to -20.0%)	-15.2% (-16.7% to -13.7%)	-16.9% (-18.6% to -15.3%)	-9.2% (-14.5% to -3.5%)	-9.2% (-10.8% to -7.5%)
Prior exposure rating (GMR [d], 95% CI)	Low vs High	0.83 (0.49 to 1.39)	0.83 (0.57 to 1.22)	1.44 (0.93 to 2.23)	0.60 (0.24 to 1.50)	0.61 (0.44 to 0.85)
	None vs High	0.97 (0.59 to 1.59)	0.58 (0.41 to 0.83)	0.63 (0.42 to 0.93)	0.82 (0.37 to 1.84)	0.63 (0.46 to 0.86)

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.

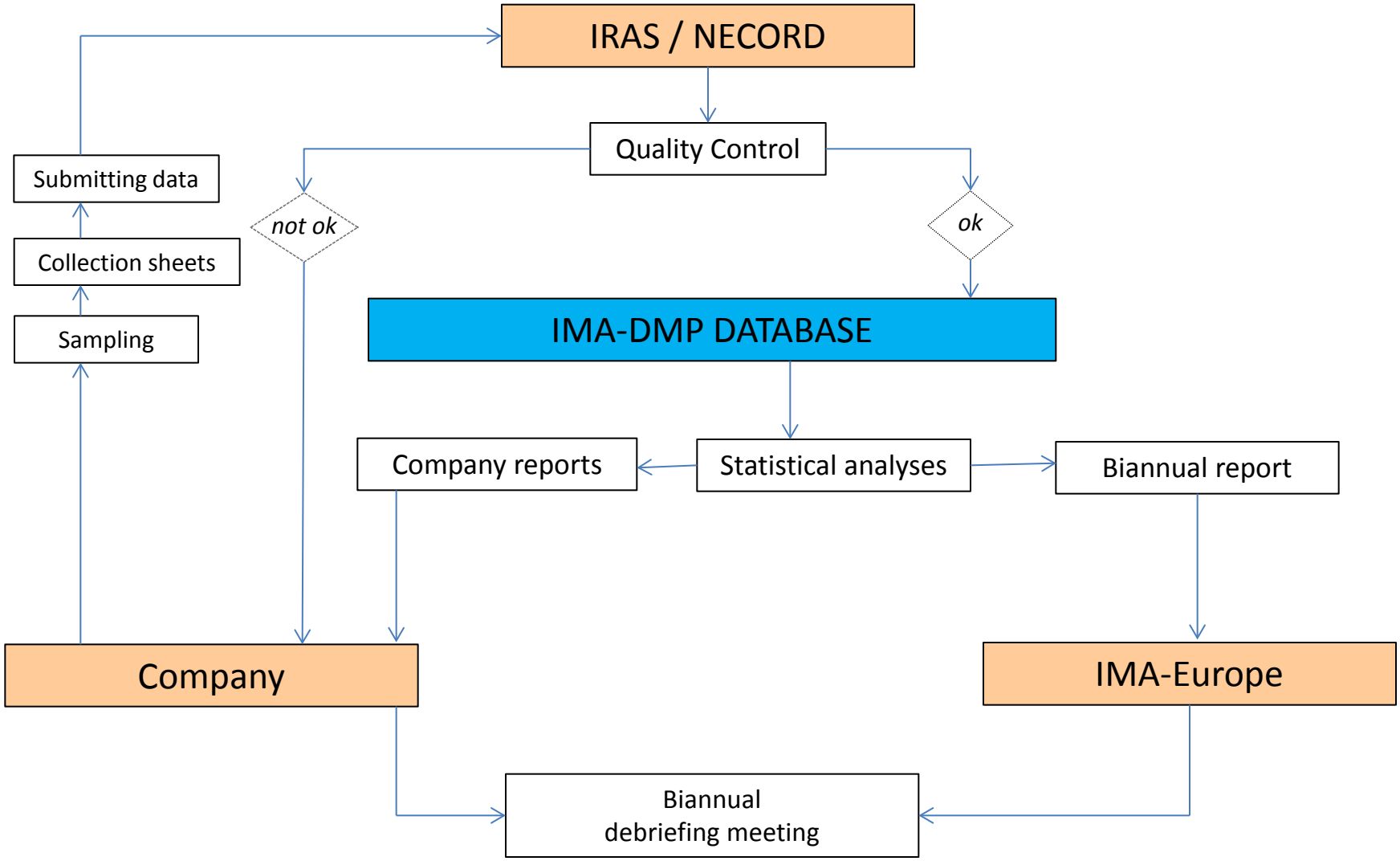
Industrial Minerals Association (IMA-Europe)

- 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



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**

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

IMA-DMP database

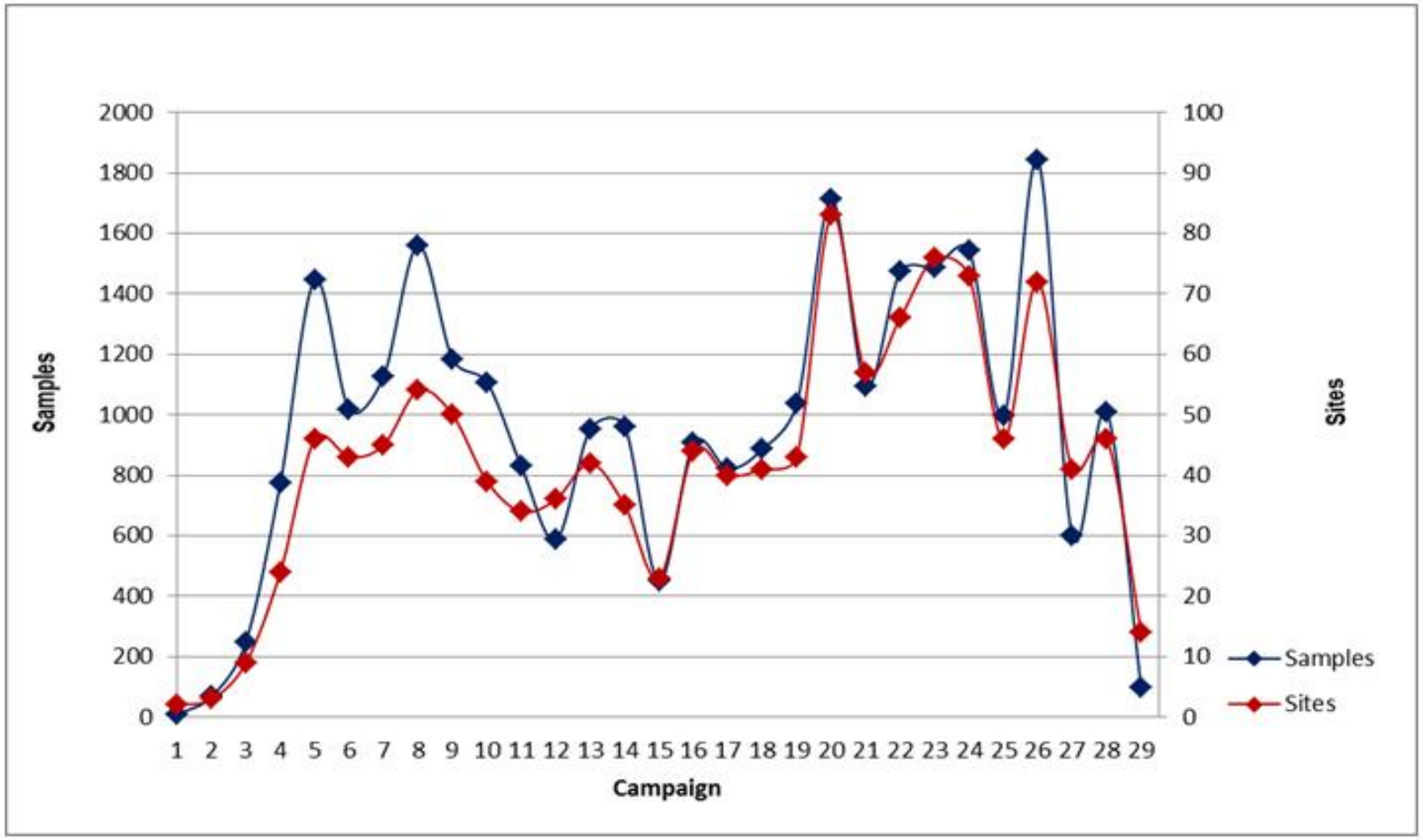
Per 01/05/2015

- 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**
- Collected prospectively during **29 sampling campaigns** (2000-2015)
- Representative for a total work force **≈ 5,000**

IMA-DMP database

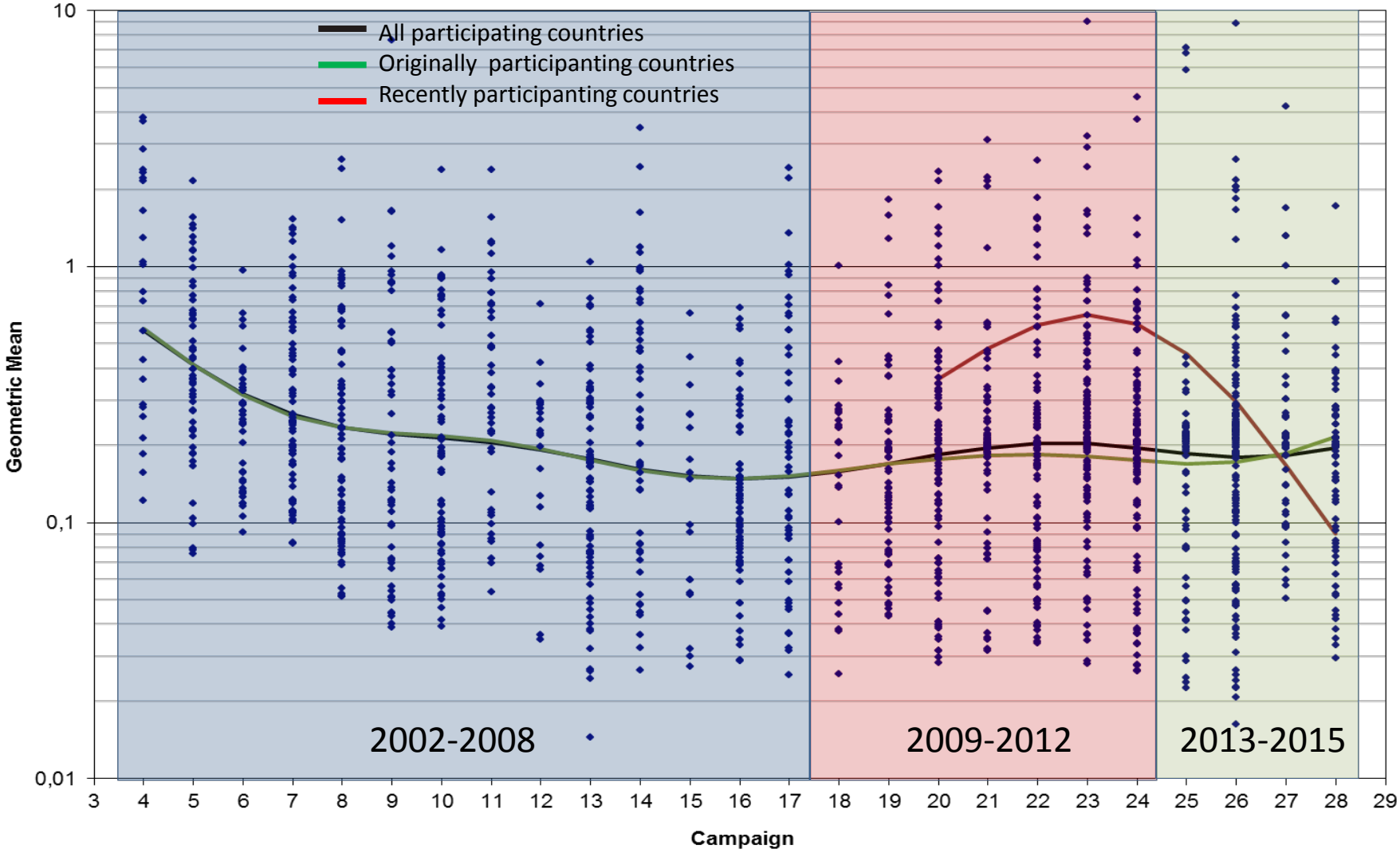
Per 01/05/2015

Temporal trends in number of measurements and sites



Results

Temporal trend in respirable dust concentration (mg/m^3)



Results

Temporal trends in exposure concentrations by time period

Time period	Trend per campaign (respirable dust)	Trend per campaign (respirable quartz)
2002 - 2015	**-5.1%*** **	**-3.1%*** **
2002-2009	-6.1%***	-5.3%***
2009-2013	**+0.9%**	**+4.9%**
2013-2015	-1.4%	-3.4%

* 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

Australian population estimates of exposure to lead

Table 1. Occupation of all probable lead-exposed respondents (number and per cent) and proportion of respondents in each occupation who were exposed to lead (males and persons – per cent)—by exposure level (per cent)

Occupation	Probably exposed respondents		Proportion probably exposed		Exposure level			
			Male	Persons	High	Medium	Low	Total
	Number[a]	%[b]	%[c]	%[d]	%	%	%	%
Managers	38	12.4	7.1	4.0	34.2	47.4	18.4	100
Professionals	17	5.5	2.2	1.0	23.5	17.6	58.8	100
Technicians and trades workers	165	53.7	26.7	23.9	57.0	31.5	11.5	100
Community and personal service workers	30	9.8	23.1	7.8	6.7	36.7	56.7	100
Machinery operators and drivers	12	3.9	5.0	4.6	66.7	25.0	8.3	100
Labourers	40	13.0	14.8	11.3	27.5	45.0	27.5	100
Other[e]	5	1.6	—	—	20.0	80.0	—	100
Total	307	100.0	10.7	6.1	43.3	35.5	21.2	100

Conclusion: 6.3% of workers or 631,000 Australians have ‘probable’ exposure to lead.

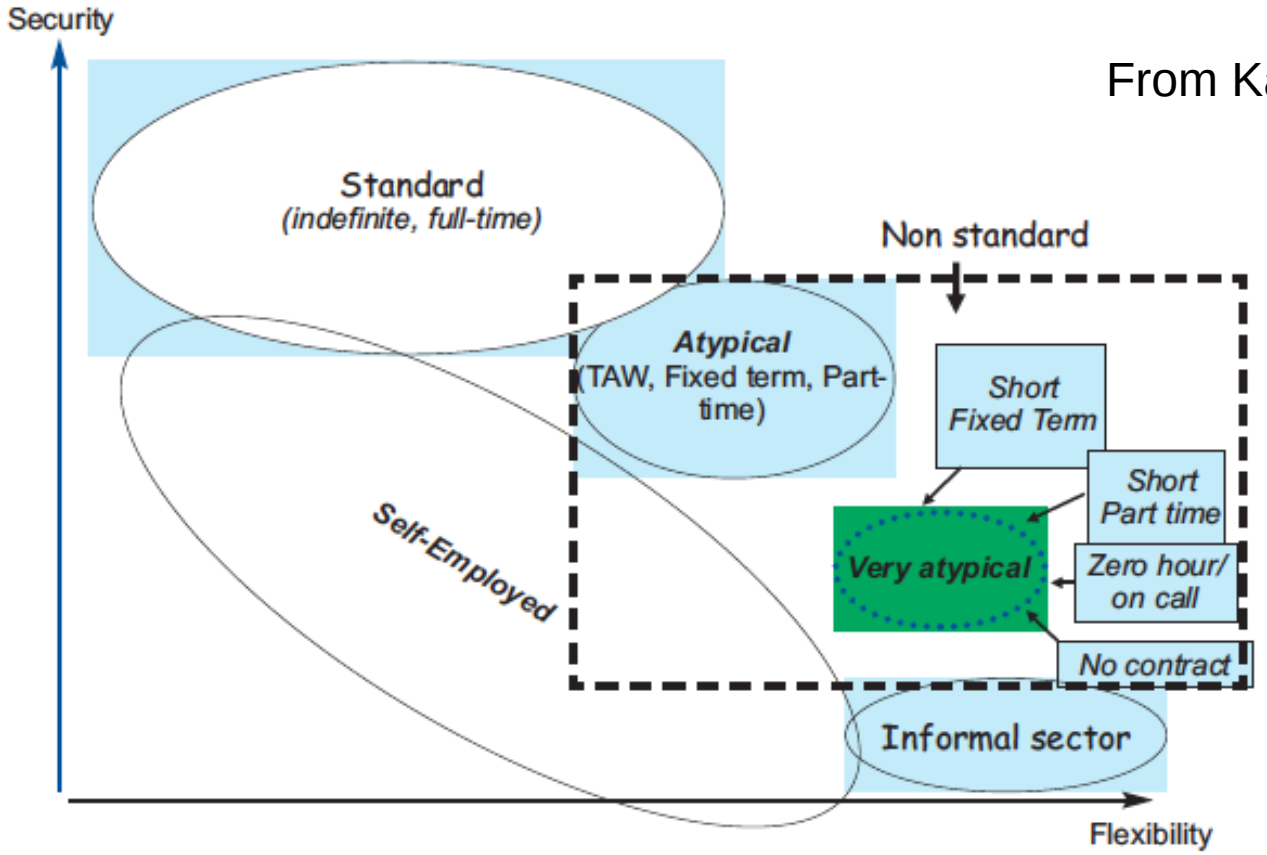
Driscoll, et al. Annals of Occup Hyg 60:113, 2016

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

Standard and Non-Standard Forms of Work

From Kalleberg



"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