CENTRE FOR
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SILICA EXPOSURE:
PROGRESS AND PROSPECTS

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WHAT IS SILICA?

- Crystalline silica (**SiO_2**) is a basic component of soil, sand, granite, and many other minerals.
- **Quartz** is the most common form of crystalline silica.
- **Cristobalite** and **tridymite** are less common forms of crystalline silica (formed after high temperatures).
- All three forms may become **respirable size particles** when workers chip, cut, drill, or grind objects that contain crystalline silica.
- Fractured crystalline silica has **free radicals** on its surface, that can generate **reactive oxygen species** in the lung

OCCUPATIONAL EXPOSURE TO SILICA

Occupational exposures:

agriculture
mining & quarrying
construction
glass
cement
abrasives manufacture and blasting
foundries (moulding sand)
rubber, plastics, cosmetics (fillers)
hydraulic fracturing (sand used in ‘fracking’)

High risk jobs:

abrasive blasting
foundry work
stonecutting
rock drilling
quarry work and tunnelling

Tuckpointing

Cut-off saws

Jackhammer

Concrete grinder

From CDC website

SILICA – HEALTH EFFECTS

Silicosis

Lung cancer

Other
Other non-malignant respiratory diseases (pulmonary tuberculosis, COPD)
Rheumatoid arthritis
scleroderma
Sjogern's syndrome
lupus
Renal disease

"if it's silica it's not just dust"

SILICA – IARC EVALUATION

IARC evaluation 1987:
Carcinogenicity in humans: limited
Carcinogenicity in animals: sufficient
Overall evaluation: 2A

IARC evaluation 1997:
Carcinogenicity in humans: sufficient
Carcinogenicity in animals: sufficient
Overall evaluation: 1

SILICA – IARC EVALUATION

IARC evaluation 1997 somewhat controversial because:

- Increased risk not detected in all industrial circumstances
- Exposure-response trends were not always consistent

Problem:

- Exposure measures differed between studies
- impossible to compare exposure-response estimation across studies (i.e. meta-analysis)

SILICA – LUNG CANCER

Nested case-control study

0.4 mg/m^3-years	1.0
0.4-2.0 mg/m^3-years	1.0 (0.85-1.3)
2.0-5.4 mg/m^3-years	1.3 (1.1-1.7)
5.4-12.8 mg/m^3-years	1.5 (1.2-1.9)
12.8+ mg/m^3-years	1.6 (1.3-2.1)

(Steenland et al. **2001**. Cancer Causes and Control **12**: 773-784.)

SILICA – LUNG CANCER

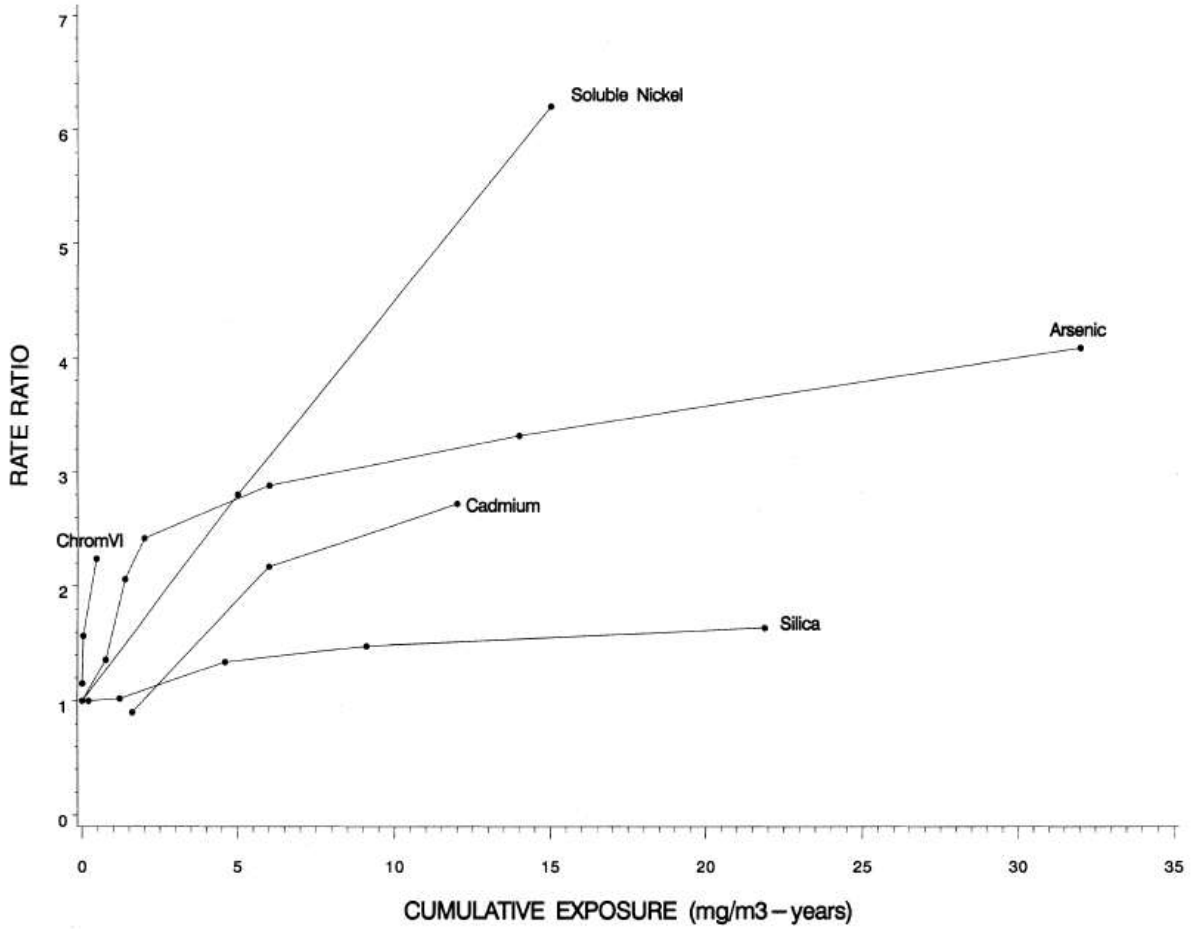

Fig. 2. Lung cancer rate ratios *vs.* cumulative exposure comparing five agents.

SILICA – LUNG CANCER

TABLE 6. Lung Cancer Risk Associated With Silica Exposure in Different Industrial Settings (20-Year Lag)

Industrial Setting/ Exposure (mg/m^3-hours)	No. Cases	No. Controls	OR*	(95% CI)	Test for Linear Trend (*P*)
Mining					
Never exposed to silica	2417	2793	1.00†		
0–17	12	8	1.10	(0.39–3.13)	
17–100	20	12	1.26	(0.57–2.79)	
>100	65	37	1.70	(1.06–2.74)	0.03
Metal					
0–17	10	9	0.91	(0.34–2.50)	
17–100	10	14	0.69	(0.29–1.66)	
>100	43	28	1.84	(1.06–3.18)	0.09
Manufacture					
0–17	16	11	2.01	(0.88–4.59)	
17–100	16	12	1.59	(0.69–3.70)	
>100	23	11	2.71	(1.23–6.00)	0.003
Construction					
0–17	80	67	1.12	(0.78–1.62)	
17–100	83	55	1.24	(0.83–1.84)	
>100	53	25	2.26	(1.31–3.88)	0.005
Agriculture					
0–17	21	9	1.64	(0.71–3.76)	
17–100	11	5	1.59	(0.48–5.23)	
>100	4	1	1.92	(0.19–19.6)	0.27
Other settings					
0–17	21	19	1.09	(0.54–2.19)	
17–100	18	25	0.69	(0.34–1.39)	
>100	20	13	1.72	(0.82–3.61)	0.61

*OR adjusted for age, sex, center, smoking, education, insulation dust, and wood dust.

†Reference category for all ORs in this table.

Cassidy et al. **2007**. Epidemiology. Jan;18(1):36-43.

SILICA IN NZ

SILICA IN NZ – EXTRACTION INDUSTRY

- In NZ: silica in relation to extraction industry
- 1915: The Miners Phthisis Act
- 1938: Data from the Pensions Office showed that since 1915, 1576 pensions had been granted to miners "said to suffer from silicosis", and of these 1508 were described as gold and quartz miners and 68 as coal miners.
- extractive industry study (1999/2000) where dust measurements were carried out by the Department of Labour: for 13% of the air samples levels of respirable quartz exceeded 0.2 mg/m3 (the current New Zealand Workplace Exposure Standard).

SILICA IN NZ – BUILDING INDUSTRY

- For the personal respirable silica samples the GM was 0.06 mg/m3 (95% CI: 0.02 – 0.24).
- All personal respirable silica samples were below the current NZ WES of 0.2 mg/m3 but above the ACGIH TLV of 0.025 mg/m3.
- Wet methods reduced exposure significantly

SILICA – EXPOSURE LIMITS

NZ TWA (cristobalite/tridymite): **0.1 mg/m3**
NZ TWA (quartz): **0.2 mg/m3**

NIOSH recommends **0.05 mg/m3** TWA up to 10h/d 40h/w

ACGIH: **0.025 mg/m3**

OSHA: PEL =**(10 mg/m3)/(%Si +2)** (general industry, higher for construction and shipyard)
0.1 mg/m3 8h TWA

"since 1971: based on research of 1960s"
"They do not adequately protect workers"
"They are outdated"
"They are inconsistent and hard to understand"

New Proposed OSHA Rule: **0.05 mg/m3 8h TWA**

Table II-12. Summary of Lifetime or Cumulative Risk Estimates for Crystalline Silica

Health Endpoint (Source)	Risk Associated with 45 Years of Occupational Exposure (per 1,000 Workers)				
	Respirable Crystalline Silica Exposure Level (mg/m^3)				
	0.025	0.05	0.100	0.250	0.500
Lung Cancer Mortality (Lifetime Risk)					
Pooled Analysis, Toxichemica, Inc (2004)[a,b]	9-23	18-26	22-29	27-34	36-38
Diatomaceous Earth Worker study (Rice et al., 2001)[a,c]	9	17	34	81	152
U.S. Granite Worker study (Attfield and Costello, 2004)[a,d]	11	25	60	250	653
North American Industrial Sand Worker study (Hughes et al., 2001)[a,e]	7	15	34	120	387
British Coal Miner study (Miller and MacCalman, 2009)[a,f]	3	6	13	37	95
Silicosis and Non-Malignant Lung Disease Mortality (Lifetime Risk)					
Pooled Analysis (Toxichemica, Inc., 2004) (silicosis)[g]	4	7	11	17	22
Diatomaceous Earth Worker study (Park et al., 2002) (NMRD)[h]	22	43	83	188	321
Renal Disease Mortality (Lifetime Risk)					
Pooled Cohort study (Steenland et al., 2002a)[i]	25	32	39	52	63
Silicosis Morbidity (Cumulative Risk)					
Chest x-ray category of 2/1 or greater (Buchanan et al., 2003)[j]	21	55	301	994	1,000
Silicosis mortality and/or x-ray of 1/1 or greater (Steenland and Brown, 1995b)[k]	31	74	431	593	626
Chest x-ray category of 1/1 or greater (Hnizdo and Sluis-Cremer, 1993)[l]	6	127	773	995	1,000
Chest x-ray category of 1or greater (Chen et al., 2001)[m]	40	170	590	1,000	1,000
Chest x-ray category of 1or greater (Chen et al., 2005)[n]					
Tin miners	40	100	400	950	1,000
Tungsten miners	5	20	120	750	1,000
Pottery workers	5	20	60	300	700

SILICA – CONCLUSIONS

- Silica exposure does occur in NZ workplaces
- Measurements indicate levels can be above workplace standards
- Awareness of the presence and risks of silica is low
- Current exposure standards are based on very old data
- New data give a better picture of risks involved with silica exposure, including lung cancer
- More silica exposure measurements in NZ workplaces needed
- Good options for exposure control are available

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