Occupational Cancer Research Centre

Occupational Diseases in Ontario Mining: An update from the Occupational Cancer Research Centre

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Ontario Ministry of Labour / Ministère du Travail

Ontario Cancer Care Ontario / Action Cancer Ontario

Canadian Cancer Society / Société canadienne du cancer

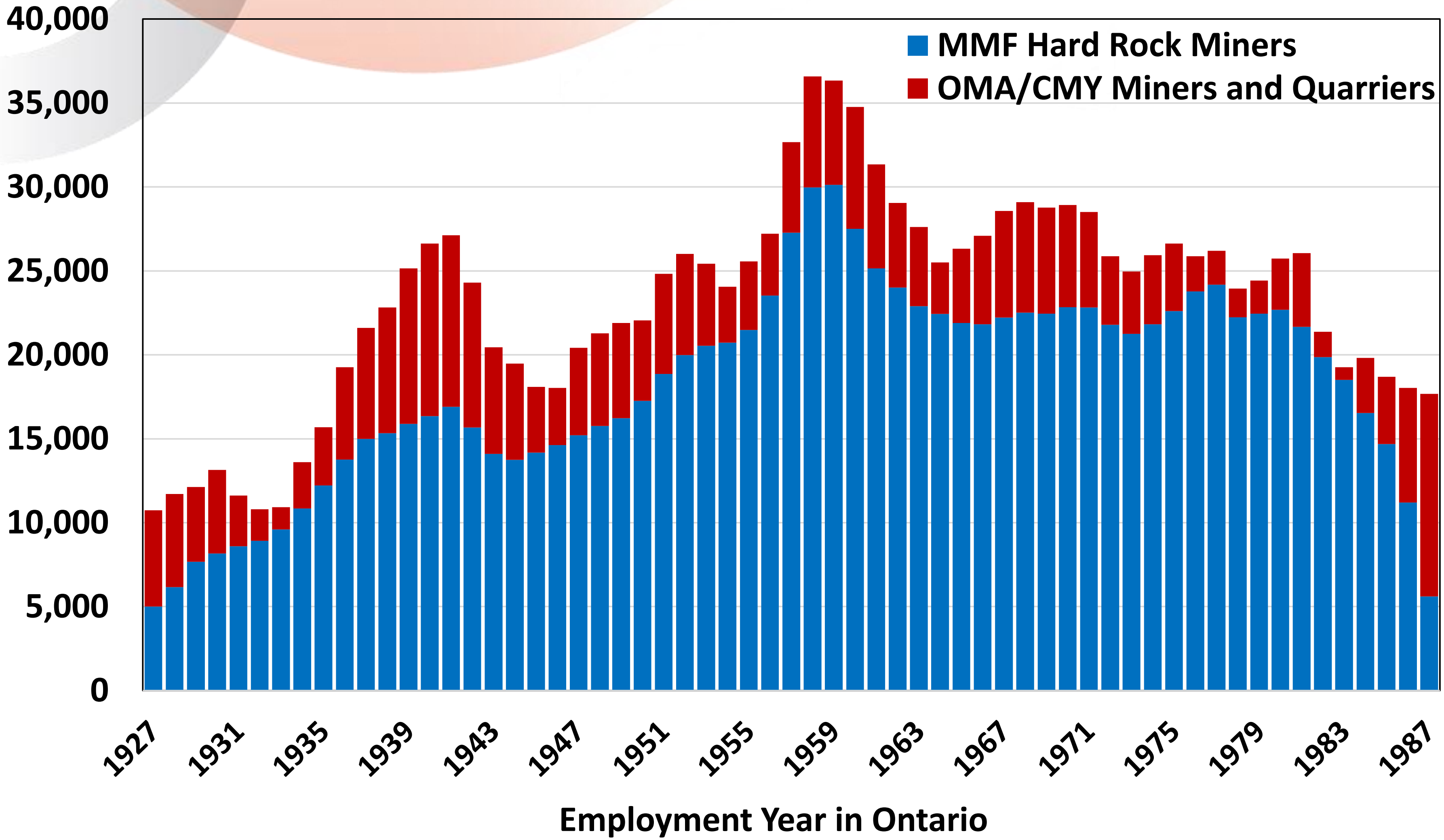
Carcinogens and Respiratory Hazards in Ontario Mining

- Diesel Engine Exhaust
- Crystalline Silica Dust
- Radon Gas
- Asbestos
- Nickel compounds
- Chromium (VI) compounds
- Arsenic & inorganic arsenic compounds

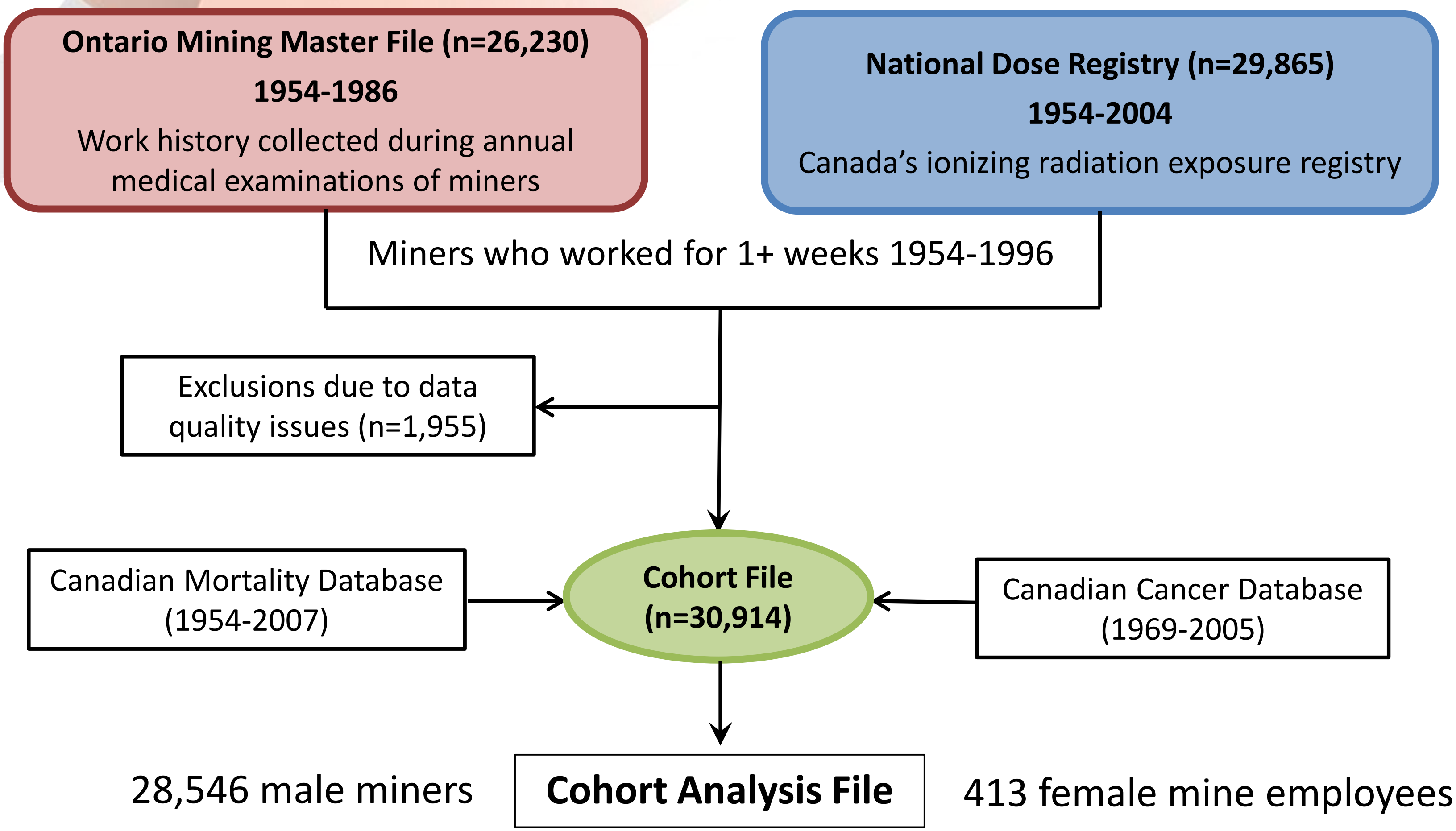
The Mining Master File (MMF)

- Ontario miners employed between 1927-1987
  - Annual medical examinations
  - Actively maintained from 1951-1987
- Over 93,000 miners included
  - Detailed job history recorded annually
  - Previously used for health research

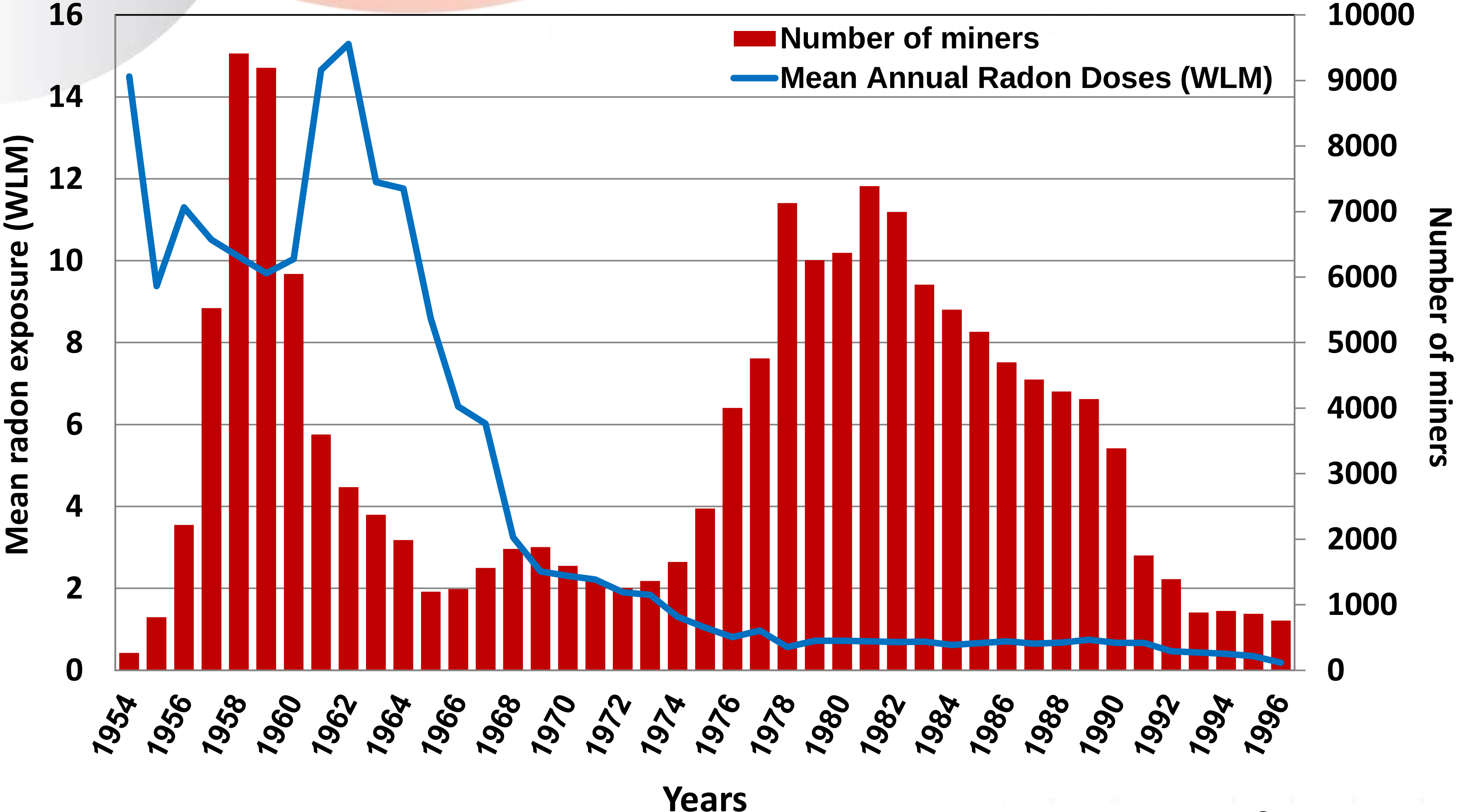
Number of Ontario Miners in MMF by Year



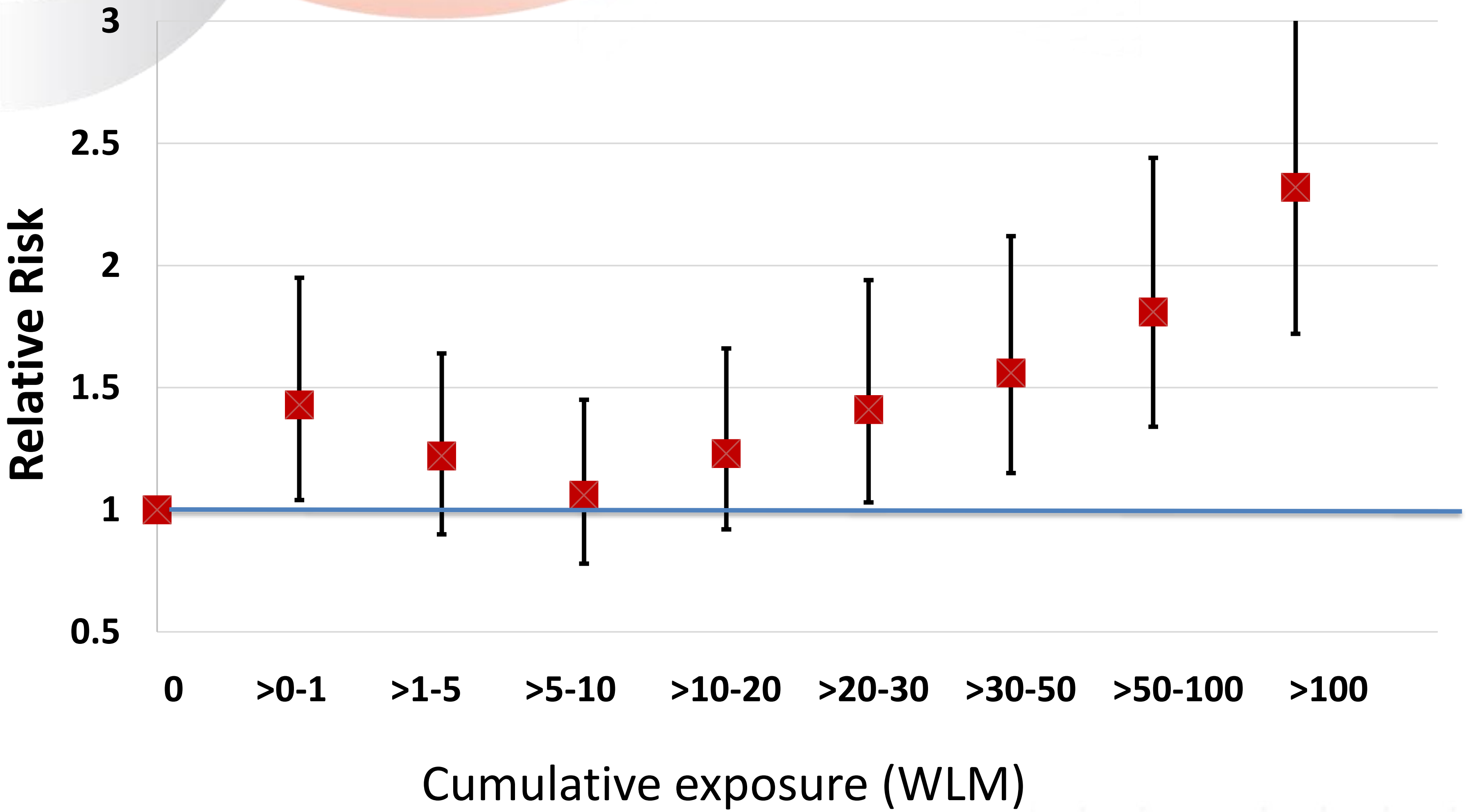
Ontario Uranium Miners Cohort
Most recent update



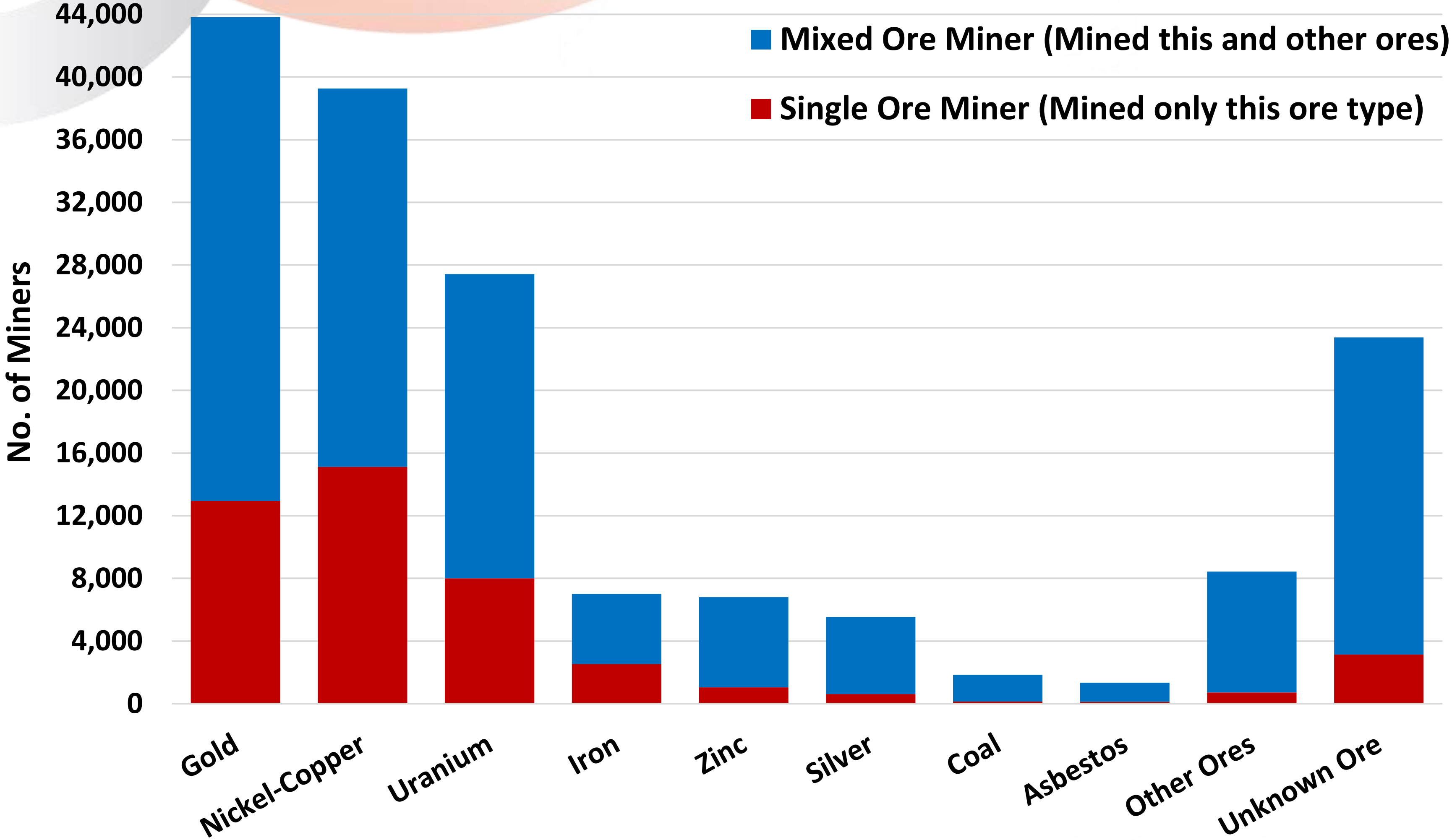
Average Annual Radon Exposure for Ontario Uranium Miners 1954-1996



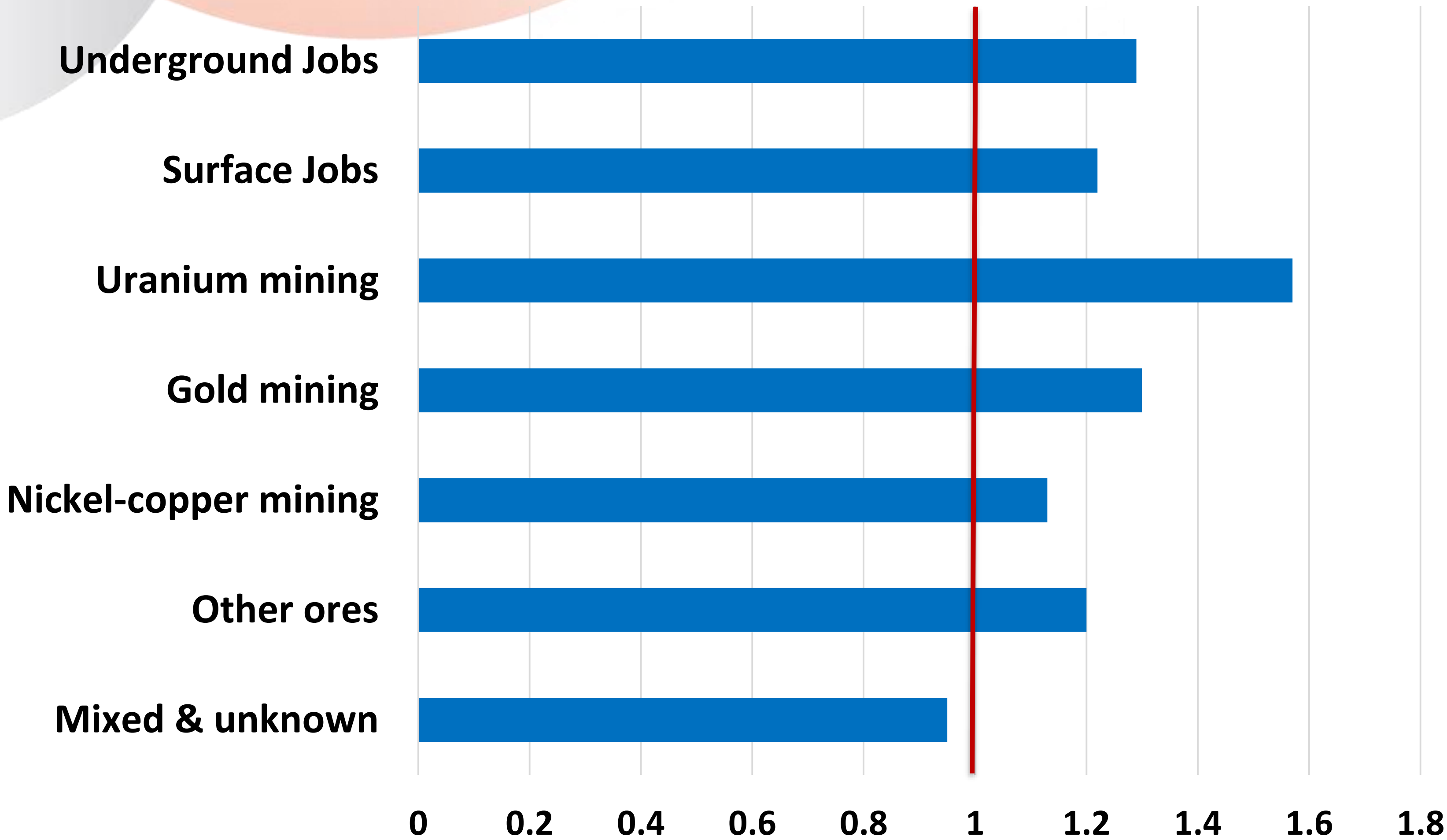
Lung Cancer Mortality by Cumulative RDP Exposure: 1954-2007, 5-year lag



Frequency of ever ore type experience and mixed-ore mining

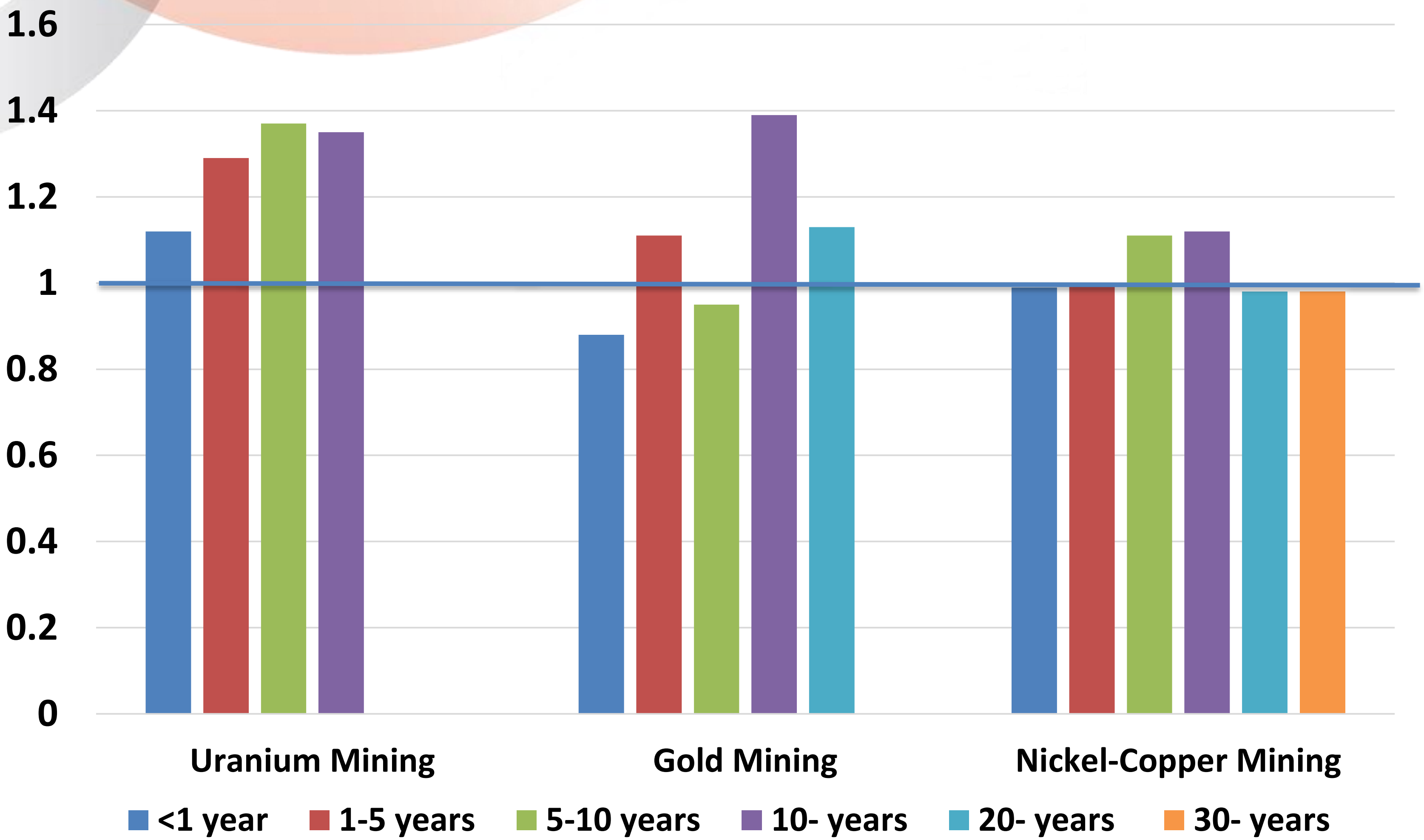


Relative Risk of Lung Cancer by Job Type & Ore (MMF linked to OCR, 2018)



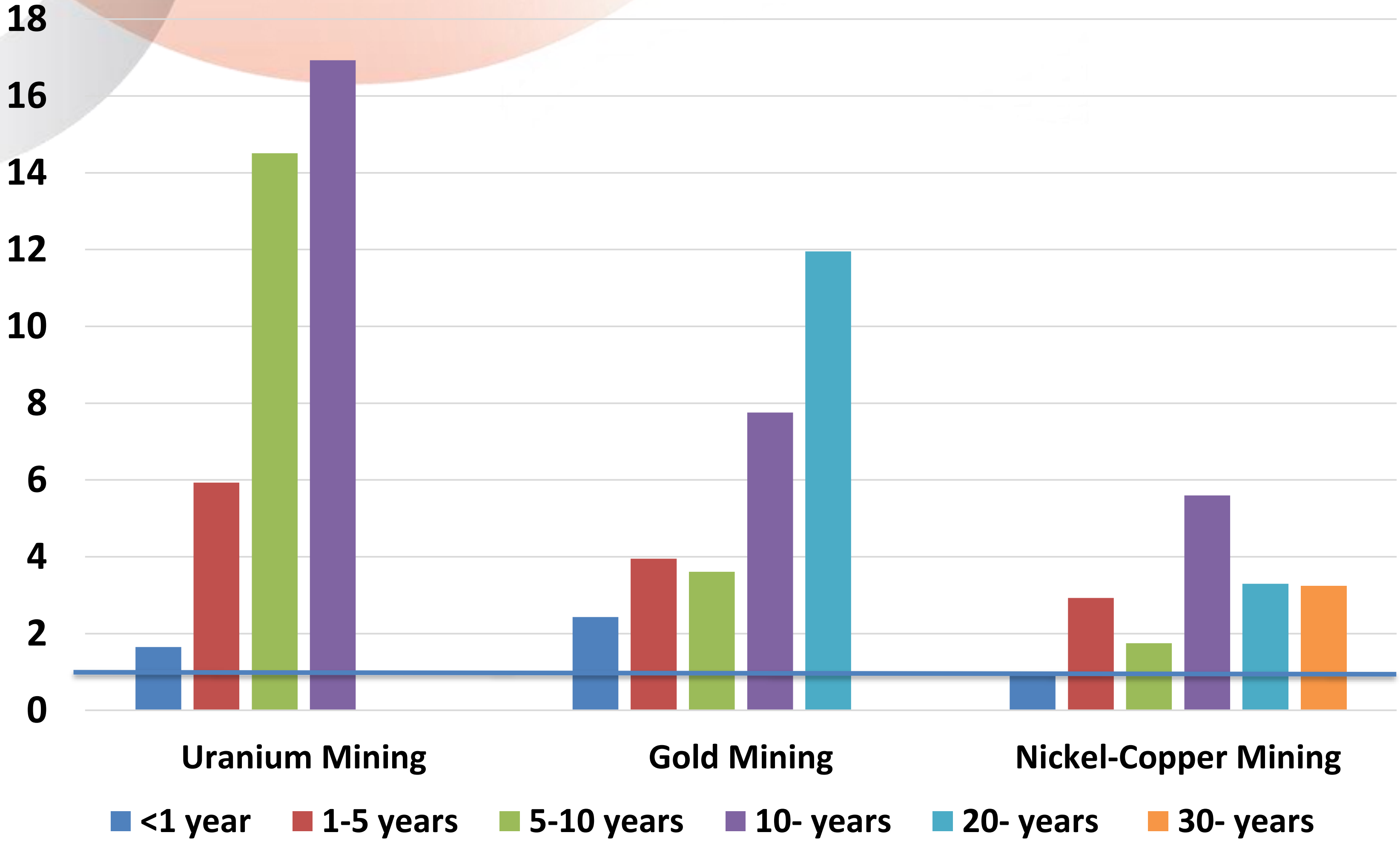
- Relative Risk of Lung Cancer

Relative Risk of Lung Cancer by Ore and Duration of Employment



Crystalline Silica Exposure

Relative Risk of Silicosis by Ore & Duration of Employment*



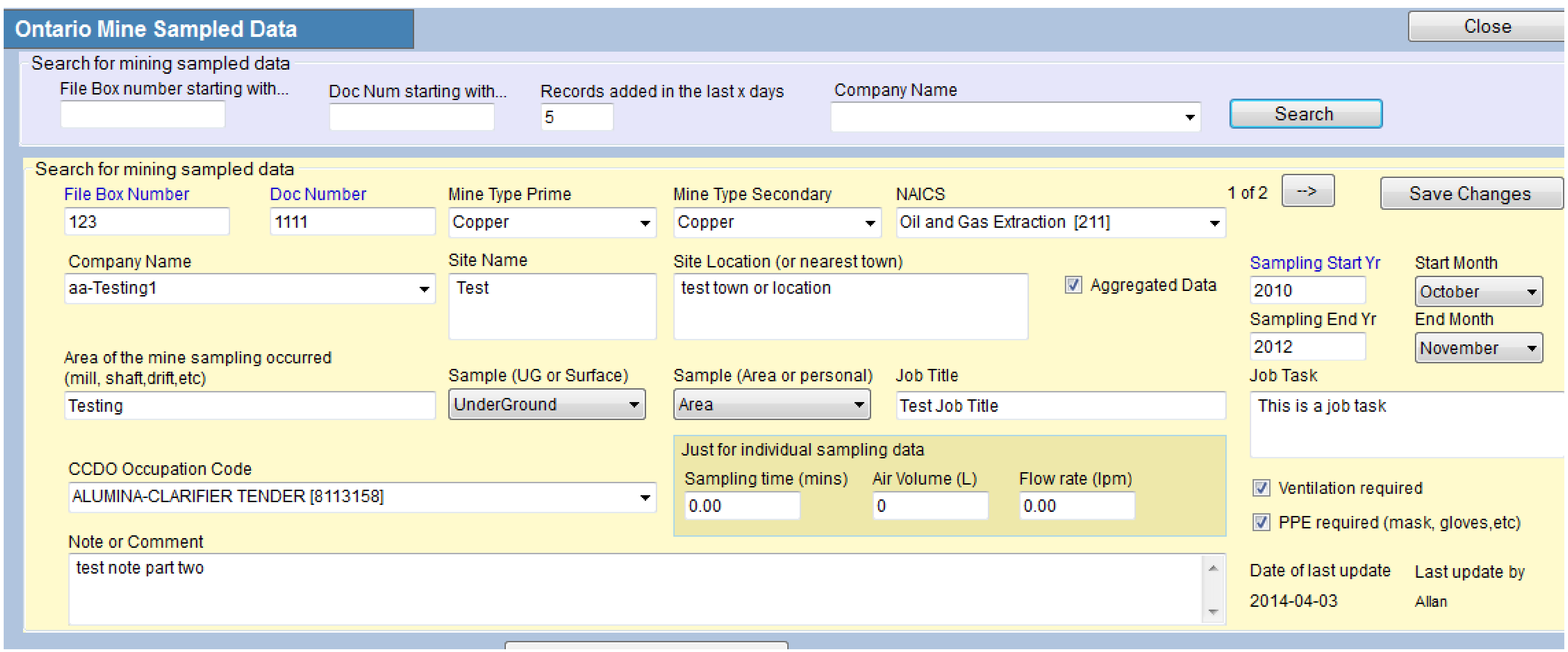
- * Compared to other miners

The Ontario Mining Exposure Database (OMED)

- 118,776 records of occupational exposure data collected in Ontario's metal and non-metal mining industry during 1950-1999
  - Some records are the summary results of sampling surveys
- Approximately 30% of the OMED data was collected by mining companies, another 30% was collected by the Ontario Ministry of Labour while the remaining 40% was collected by various other government agencies and to a lesser extent private consultants.

Creating the OMED

- The Ministry of Labour shared paper records of exposure
- Entered into MS Access



Ontario Mining Exposure Database

Top 10 hazards in OMED

Hazard	Records (%)
Dust	54,878 (46)
Silica	12,995 (11)
Radon	9,652 (8)
Arsenic	5,612 (5)
Sulfur dioxide	3,368 (3)
Copper	3,299 (3)
Carbon monoxide	2,451 (2)
Cadmium	1,929 (2)
Asbestos	1,893 (2)
Sulfuric acid	1,226 (1)

Personal Respirable Silica with Complete Data

Ore type	Samples	Mean (SD)
Overall	3,137	0.09 (0.12)
Gold	509	0.10 (0.14)
Iron	154	0.07 (0.09)
Nickel	230	0.05 (0.06)
Uranium	2,003	0.09 (0.12)
Zinc	241	0.12 (0.16)

26% of samples > ON OEL (0.10 mg/m^3)
94% of samples >ACGIH TLV (0.025 mg/m^3)

CONTROLLING DIESEL PARTICULATE MATTER IN UNDERGROUND MINES

More effective ← ELIMINATION | SUBSTITUTION | ENGINEERING CONTROLS | ADMINISTRATIVE CONTROLS | PPE → Less effective

Proactive controls — More effective

Reactive controls — Less effective

PROACTIVE CONTROLS

Reduce or eliminate diesel particulate emissions before they enter the workplace air

AVERAGE REDUCTIONS

Average particulate matter exposure reductions based on published data

- <50% ↓
- 50-85% ↓↓
- 85-99% ↓↓↓
- 100% ↓↓↓↓
- Varied/Unknown: ?

ELIMINATION

Alternative Energy

Involves replacing diesel equipment with alternatives such as electric. ↓↓↓↓

SUBSTITUTION

Replacing or repowering old equipment

Newer engines must meet much stricter emissions regulations. Replacing an engine or a piece of equipment with a newer model will significantly decrease emissions. The level of reduction depends on the old and replacement equipment. ↓↓↓

Rebuilding engines

Manufacturers often offer upgrade kits that can be incorporated into an engine rebuild to improve emissions. ↓

ENGINEERING CONTROLS

Aftertreatment systems

A variety of different aftertreatment systems are available. Emissions reductions depend on the type of filter chosen, as well as the engine and load. Particulate reductions can range from 20-95%. ↓↓

Idling technology

Idling technology works by automatically turning off the engine when the vehicle idles. The emissions reductions will be greater for equipment that spends a high proportion of time idling. ?

General ventilation

General ventilation dilutes emissions by bringing clean air into the area. The reductions vary depending on the volume of air provided. It also helps reduce ambient air concentration of non-diesel hazards, as well as helping with temperature control. ?

Enclosed cabs

When properly functioning, enclosed cabs protect the operator, but do not protect the surrounding workers. ↓↓

Tele-operating

Tele-operation allows the operator to be in a safe location, such as a filtered control room on the surface. Reductions in exposure can be up to 100% if the operator is completely removed from the site. Other workers may still be exposed if they enter the work area, or if emissions circulate to other areas of the mine. ↓↓↓

ADMINISTRATIVE CONTROLS

Preventive maintenance

Maintenance keeps all parts of the engine, as well as any emissions control systems, functioning optimally. Poorly maintained engines can produce significantly more emissions than an engine in good condition. ↓

Idling policies

Idling increases both emissions and engine wear. Idling policies limit the amount of time an engine can be idled. ?

Operator training

Training can include driving skills, how to recognize maintenance issues, proper use of diesel control technologies, and the health effects of diesel exhaust. ?

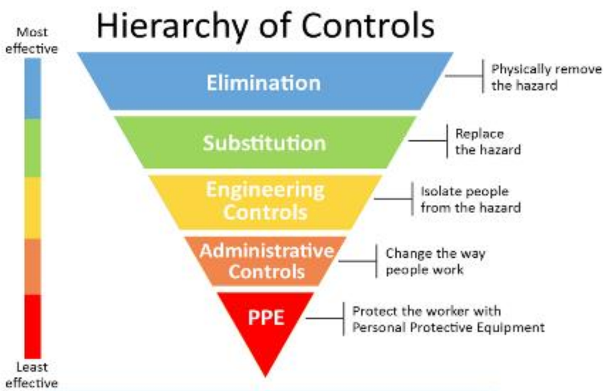
Scheduling and site planning

Control the number of diesel engines operating in an area. Schedule workers during times when fewer diesel engines are working. ?

PPE

Respirators

PPE should be used as a last resort, and is not a replacement for other controls. The concentration of diesel exhaust in the air should still fall below the regulatory limit. When used, respirators should be fit-tested, and training should be provided to wearers. ?



Source: US National Institute for Occupational Safety and Health (NIOSH)

REACTIVE CONTROLS

Remove diesel particulate emissions from the workplace air, or reduce the likelihood that workers will inhale particulate emissions

Ontario
Ministry of Labour
Ministère du Travail

Occupational Cancer Research Centre
Towards a cancer-free workplace


Where to from
here?

Next Steps

- Publish paper on exposure to gamma radiation in uranium mining and the risk of leukemia and other cancers
- Assess risk of lung cancer based on exposure to radon, crystalline silica, and other carcinogens
- More closely examine respiratory diseases other than silicosis
- Collect additional data on diesel engine exhaust exposure
- McIntyre Powder and neurologic disease analysis

MMF Code	Mining Camp	Mine Type	Mine	Qualifying Year Dieselized*	Percentage Qualifying Year	Percentage Maximum Year (1977)
240	Sudbury	Nickel	Coleman	1971	100	100
240	Sudbury	Nickel	Copper Cliff South	1970	100	100
240	Sudbury	Nickel	Copper Cliff North	1968	62	100
240	Sudbury	Nickel	Creighton 3 & 7	1968	64	100
240	Sudbury	Nickel	Creighton 5 & 9	1970	25	66
240	Sudbury	Nickel	Frood	1969	29	74
240	Sudbury	Nickel	Stobie	1969	38	99
240	Sudbury	Nickel	Garson	1970	29	57
240	Sudbury	Nickel	Levack	1968	27	47
240	Sudbury	Nickel	McCreedy West	1973	100	100
240	Sudbury	Nickel	Little Stobie	1970	100	100
240	Sudbury	Nickel	Crean Hill	1970	34	94
240	Sudbury	Nickel	MacLennan			0
240	Sudbury	Nickel	Murray	1968	46	100
240	Sudbury	Nickel	Totten			0
240	Sudbury	Nickel	Kirkwood	1969	100	100
240	Sudbury	Nickel	Victoria			0
270	Shebandowan	Nickel	Shebandowan	1972	100	100

*** Year production with diesel at minesite exceeded 25% (Roberts et al., 1983)**

McIntyre Powder & Neurologic Disease

NAME ______________________ CERTIFICATE OR X-RAY NUMBER

BIRTHPLACE ______________ DATE OF BIRTH ______________ DATE OF FIRST DUST EXPOSURE ______________

PREVIOUS EXPOSURE NOT IN ONTARIO						PREVIOUS EXPOSURE IN ONTARIO					
YEAR	MINE OR OTHER EXPOSURE	COUNTRY	ORE	JOB	MOS	YEAR	MINE	CAMP	ORE	JOB	MOS.

EXAMINATIONS

NO.	DATE	STATUS	MINE	JOB	EXPOSURE S.L.E.	AL.	X-RAY	FINDINGS	CLAIM COMP.	REMARKS

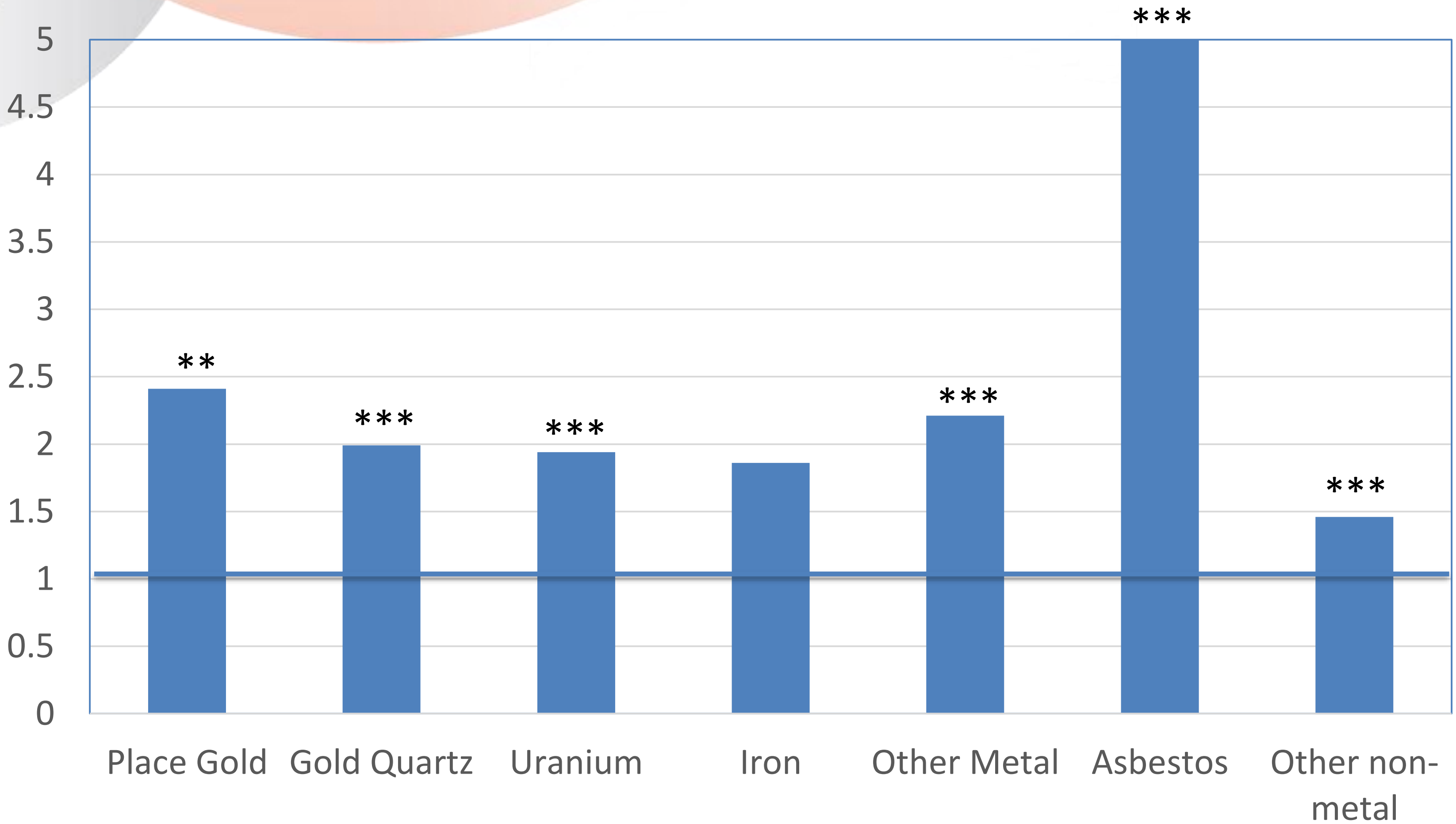
WCB/MSU MC 1 MASTER EXAMINATION RECORD JANUARY, 1951

- 27,500 miners reported McIntyre powder exposure, based on records from 1951 and forward.

Tracking the Introduction of Diesel

MINE	ORE_LABEL	MINE_CAMP	FIRST_YR	LAST_YR
Dome Mines Ltd (Dome)	Gold	Timmins	1970	1988
Aunor Gold Mines Ltd (Aunor)	Gold	Timmins	1970	
McIntyre-Porcupine Mines Ltd (McIntyre)	Gold	Timmins	1968	1988
Pamour Porcupine Mines Ltd (Pamour #1)	Gold	Timmins	1968	1987
Kerr-Addison Mines	Gold	Kirkland Lake	1966	1988
Dickenson Red Lake	Gold	Red Lake	1974	1990
Bethlehem Steel (Marmoraton)	Iron	Tweed	1968	1978
INCO Ltd	Nickel-Copper	Sudbury	1968	1987
INCO Ltd (Copper Cliff South)	Nickel-Copper	Sudbury	1970	1979
INCO Ltd (Copper Cliff North)	Nickel-Copper	Sudbury	1968	1977
INCO Ltd (Creighton)	Nickel-Copper	Sudbury	1968	1992
INCO Ltd (Frood*)	Nickel-Copper	Sudbury	1969	1985
INCO Ltd (Garson)	Nickel-Copper	Sudbury	1970	1978
INCO Ltd (McCreedy West, was Levack W)	Nickel-Copper	Sudbury	1973	1981
INCO Ltd (Coleman)	Nickel-Copper	Sudbury	1971	1977
INCO Ltd (Stobie)	Nickel-Copper	Sudbury	1969	1977
INCO Ltd (Levack)	Nickel-Copper	Sudbury	1968	1977
INCO Ltd (Little Stobie)	Nickel-Copper	Sudbury	1970	1977

Risk of Lung Cancer among Men in Ontario Mines (ODSS results)



Statistical significance: * P<0.05, ** p<0.01, *** p<0.001

Thank you

This research was primarily funded by the:

Ontario
Ministry of Labour
Ministère du Travail

Our radiation research was funded by:

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

Core funding for our Centre is from:

Ontario
Ministry of Labour
Ministère du Travail

Ontario
Cancer Care Ontario
Action Cancer Ontario

Canadian Cancer Society
Société canadienne du cancer

MMF Cohort Demographics

	Cohort
N	93,526
Male, n (%)	93,069 (99.5)
Age (yrs) at first employment, mean (range)	25.9 (12–72)
Year of first employment, median (range)	1952 (1890–1987)
Duration of employment - mean yrs (range)	15.4 (0.0–65.4)
Mining experience outside Ontario, n (%)	20,665 (16.4)
Aluminum prophylaxis, n (%)	27,493 (30.8)

Record Linkage Variables

- ✓ Name (given, surname, and alternates)
- ✓ Birthdate and birthplace
- ✓ Death date and death location
- ✓ Last year known alive if not indicated as dead
- ✓ Last geographic area where miner worked

Known Ontario Mines McIntyre Powder Beginning and Discontinuation Dates

Mine	Ore	Workers Receiving Aluminum Powder	Start Year	Start Month	Start Day	End Year	End Month	End Day
Aunor	Gold	Underground, Surface yard, sane shop mechanics, welders (There are 2 changehouses, 1 without aluminum).	1945	Apr		1964	Dec	
Bonetal	Gold	Underground	1943	Jun		1952	Jan	
Broulan Reef Broulan Shaft Area	Gold	Underground, Crusher Assay Office	1943	Jun		1965	Jan	
*Broulan Reef Reef Shaft Area	Gold	Underground and Yard Crews, or men who handle Rock	1947	Sept		1953	Jan	
Buffalo Ankerite	Gold	Underground workers and Crushermen	1944	Feb	5	1953	Jan	24
Campbell Red Lake	Gold	Underground	1952	Nov	1	1979	Oct	
Castle Tretheway	Gold	Underground	1954	Nov	1			
Chesterville	Gold	Underground	1944	May		1952	Nov	4
Cochenour Willans	Gold	Underground, Mill	1944	Mar	10			
Coniaurum	Gold	Underground, Mill, Mechanical and Electrical Shops (Assume Plate Shop also)	1945	Feb		1965	Mar	
Delnite	Gold	Underground, Mill and Assay, or other men who handle Rock	1944	Feb	14	1964	Oct	
Dome	Gold	Underground	1944	Feb	3	1979	Sept	
Hallnor	Gold	Underground	1944	Mar				
Hasaga	Gold	Underground	1944	Apr	3	1952	May	31
Hollinger Cons.	Gold	Underground, Deckman S, Cagetenders, Timber Yard S, Mine Toolroom Men S, Lampmen S, Sawmill (Mine) Operators S	1944	Jan	24			
Kerr Addison (Started own D. Drill in 1941)	Gold	Underground Men Crusher, Mill and Assay, Supervisory Staff	1944	Jan	21			
Kirkland Lake Gold (Kirkland Minerals)	Gold	Underground	1944	Feb	24			
Lake Shore (Outside Contractors supply D. Drill requirements)	Gold	Underground (1 Dozen Surface Employees use Mine Dry)	1944	Feb	1	1965	Dec	
Little Long Lac	Gold	Underground, Crusher	1944	Mar		1954	Aug	1
Leitch	Gold	Underground	1944	Apr	4	1965	Apr	5
Macassa	Gold	All Underground and Deck S; Crusherhouse; Assay Office Crusherrnan	1944	Feb				
McLeod Cockshutt	Gold	Underground, Crusnermen, Assay Office Surface Work except Mill	1944	Mar		1953	Oct	
Madsen Red Lake	Gold	Underground	1944	May	23			
Matachewan Cons.	Gold	Underground, Shops, S and Mill	1945	Sept	9			
McIntyre Porcupine	Gold	Underground Assay Office - Crusher, Mill - Rock House only	1943	Nov	30	1951	Feb	
McKenzie Red Lake	Gold	Underground	1944	Mar	18	1953	Apr	
New Dickenson (Dickenson Mines Ltd.)	Gold	Underground	1952	Apr		1976	Dec	
Pamour Porcupine	Gold	Underground	1944	May	1	1979	Sept	
Paymaster	Gold	Underground	1943	Sept	10			
Pickle Crow	Gold	Underground	1944	Apr				
Preston East Dome	Gold	Underground	1944	Apr				
Renabie	Gold	Underground	1948	Dec	1			
Ross (Hollinger)	Gold	Underground, Deckman, Shift Bosses, Crushermen, But not Assay	1938	May				
Sylvanite	Gold	Underground and Crusher employees	1944	Apr	12			
Teck Hughes (Started own D. Drill in August/50)	Gold	Underground, Crusher	1943	Sept				
Tobum	Gold	Uhderground and Crusher workers (including Crushermen in the Assay)	1940	Jan				
Upper Canada	Gold	Underground (Crushing section prior to Jan. 1 1969)	1946	Mar				
Young Davidson (Hollinger Operated)	Gold	Miners, Crushermen, Assayer, Electricians, Mach. Shop Servicemen, (Assume all Machine Shop Workmen), Underground Hoistmen	1944	Dec	1			
Wright Hargreaves (Outside Contractors supply D. Drill requirements)	Gold	Underground	1944	Mar		1965	Mar	
Denison	Uranium	Underground and Supervision (Mining, Mechanical and Electrical), Crusher and Grinding Plants	1957	Apr	10	1979	Sept	
Lake Nordic (Lacnor) (Rio Algom Nordic Lake operation)	Uranium	Underground	1957	Dec	27	1979	Jun	
Milliken (Rio Algom)	Uranium	Underground	1958	Jan	17	1964	Jun	
Panel	Uranium	Underground	1957	Dec	25			
Pronto (Rio Algom)	Uranium	Underground	1955	Jul	1			
Quirke Lake operation (Rio Algom)	Uranium	Underground	1967			1979	Jun	

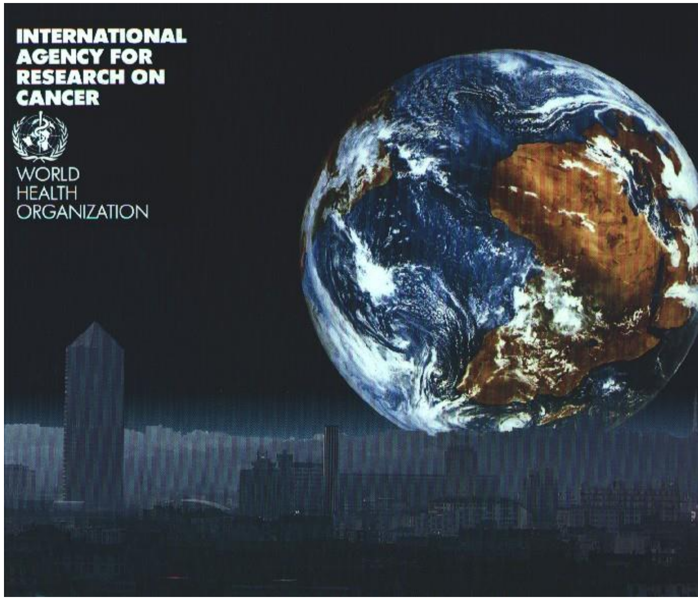
- MMF (what it is, descriptives, U-miners, cancer and silicosis, McIntyre powder)
- OMED (what it is, descriptives, silica)
- ODSS (what it is, cancer, silicosis)
- Diesel infographic

Mining Master File and the Exposure Database

- Together a valuable tool for prevention research
- Exposure can be estimated over a career
  - Multiple mines, different ore types
- Can answer many unresolved questions:
  - What is the effect of multiple exposures?
  - What is the impact of moving between sectors?
  - How long does the increased risk persist?
- Ethics approval in place, funding application to be submitted Fall 2014

Diesel Engine Exhaust, IARC 2012

- IARC Group 1, human carcinogen
  - Sufficient evidence: Lung cancer
  - Limited evidence: Bladder cancer
  - Based on studies of miners, railroad workers & trucking industry workers
  - Key human studies used particulate matter as a measure of diesel engine exhaust
  - Animal studies positive for particulate, not gas phase exhaust

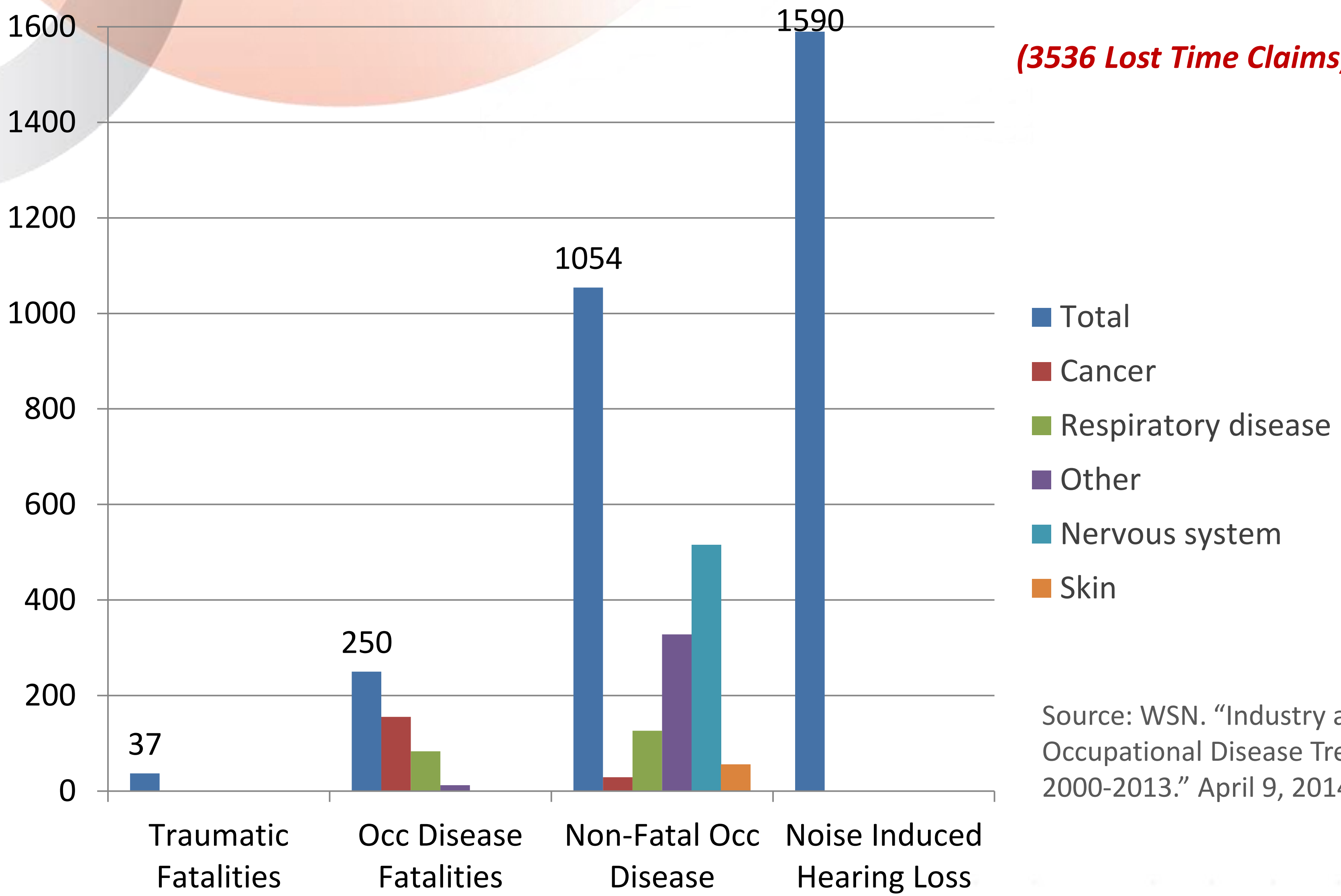


In Closing

- The Burden of Occupational Cancer project is helping to describe the extent of occupational cancer in Canada
- Occupational diesel engine exhaust exposure is an important risk factor for lung cancer and possibly bladder cancer
- These results can be used to promote the prevention of occupational cancer and other diseases
- Next step is to look forward, assess impact of preventive actions on future cancer burden


Crystalline
Silica
Exposure

Occupational Disease in Mining, 2000-2013



(3536 Lost Time Claims)

Source: WSN. "Industry and Occupational Disease Trends 2000-2013." April 9, 2014

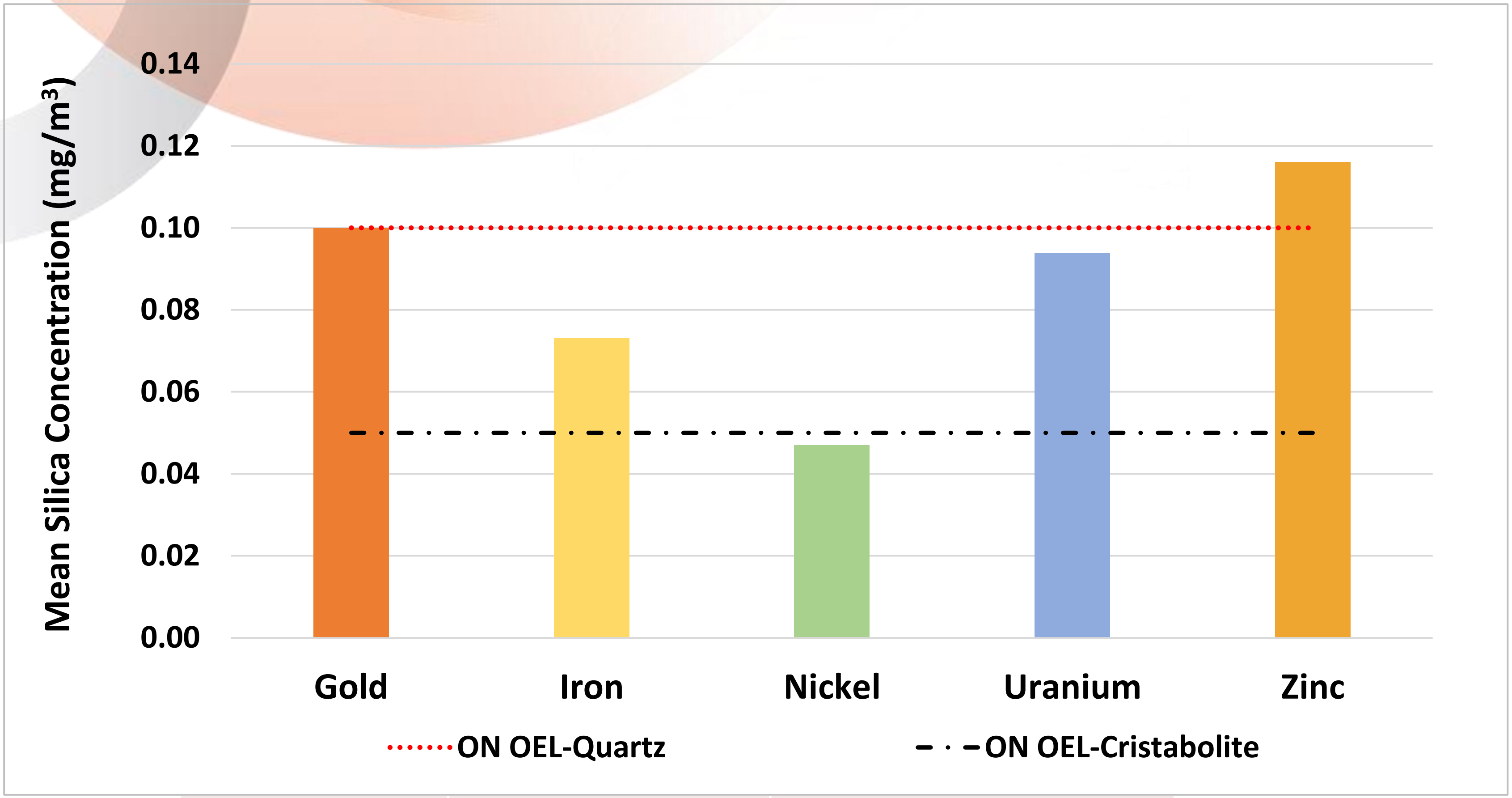
The Ontario Mining Exposure Database (OMED): A tool for mining research in Ontario, Canada

Colin J. Berriault, Vicky Tran, Nicola Blagrove-Hall, Katherine J. Jardine, Victoria H. Arrandale, Paul A. Demers

International Scientific Conference and Workshop on Occupational Health and Safety in Formal and Informal Mining

Odense, Denmark
August 23, 2017

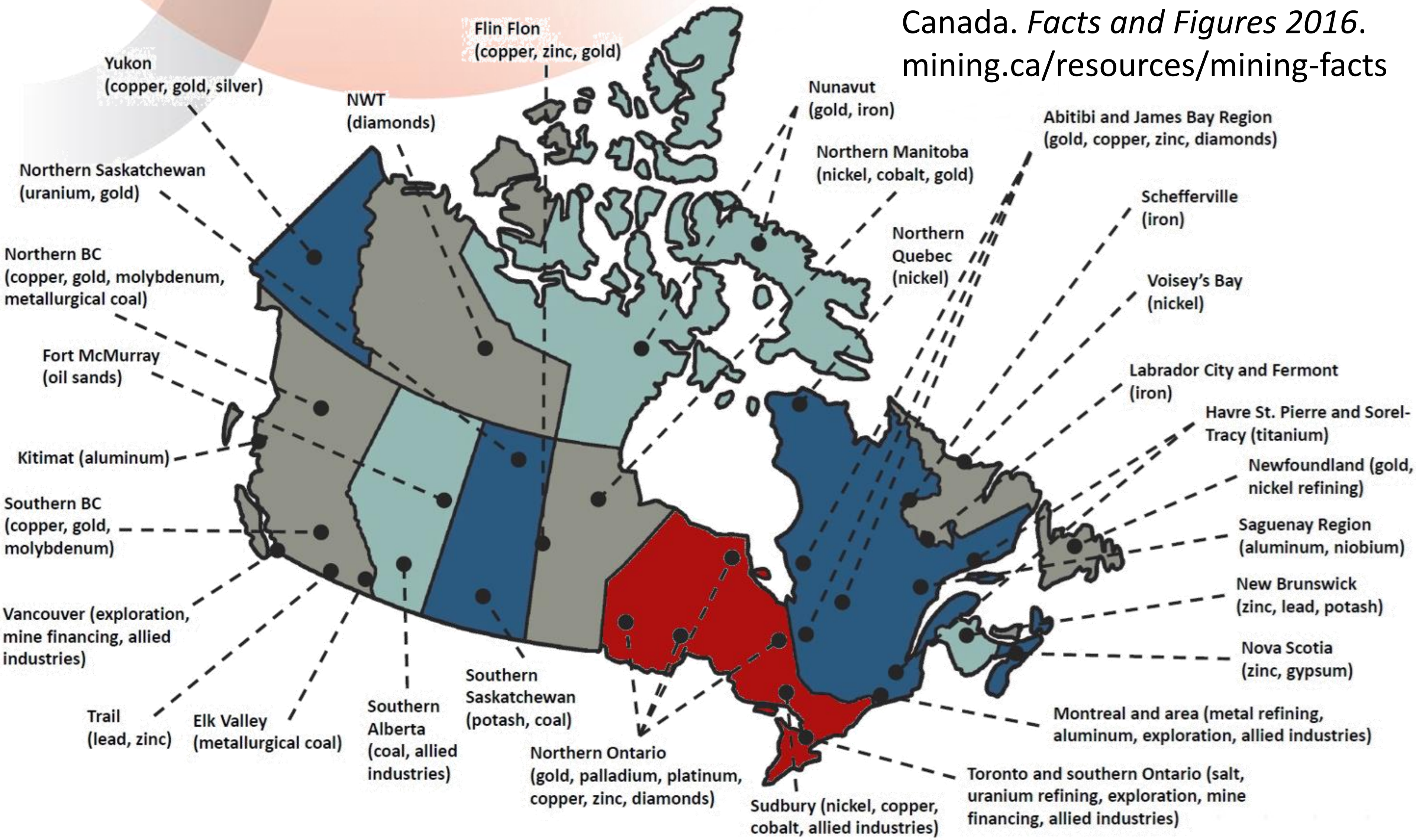
Personal Respirable Silica Exposure



Mine Type	Number of Records	Mean Silica Concentration
Gold	509	0.10
Iron	154	0.07
Nickel	230	0.05
Uranium	2001	0.09
Zinc	239	0.12

Mining in Canada

The Mining Association of Canada. *Facts and Figures 2016*. mining.ca/resources/mining-facts



What is the OCRC?

An applied research centre established to generate new knowledge to help prevent occupational cancer

- Created in 2009 and is currently funded by:
  - Ontario Ministry of Labour
  - Canadian Cancer Society
  - Cancer Care Ontario

Ontario Cancer Care Ontario

Canadian Cancer Society Société canadienne du cancer

Ontario Ministry of Labour Ministère du Travail

WSIB Ontario CSPAAT

United Steelworkers USW Unity and Strength for Workers

OCRC Mining Research

Exposure

Ontario Mining Exposure Database

118,756 exposure records

1950s to 1990s

↑

Ontario Mines Database

Detailed information on mine operations over time

Industry Cohort

Ontario Mining Master File (MMF)

93,263 miners

1950s to 1980s

↓

Ontario Uranium Miners Cohort

28,546 miners

+ National Dose Registry Data

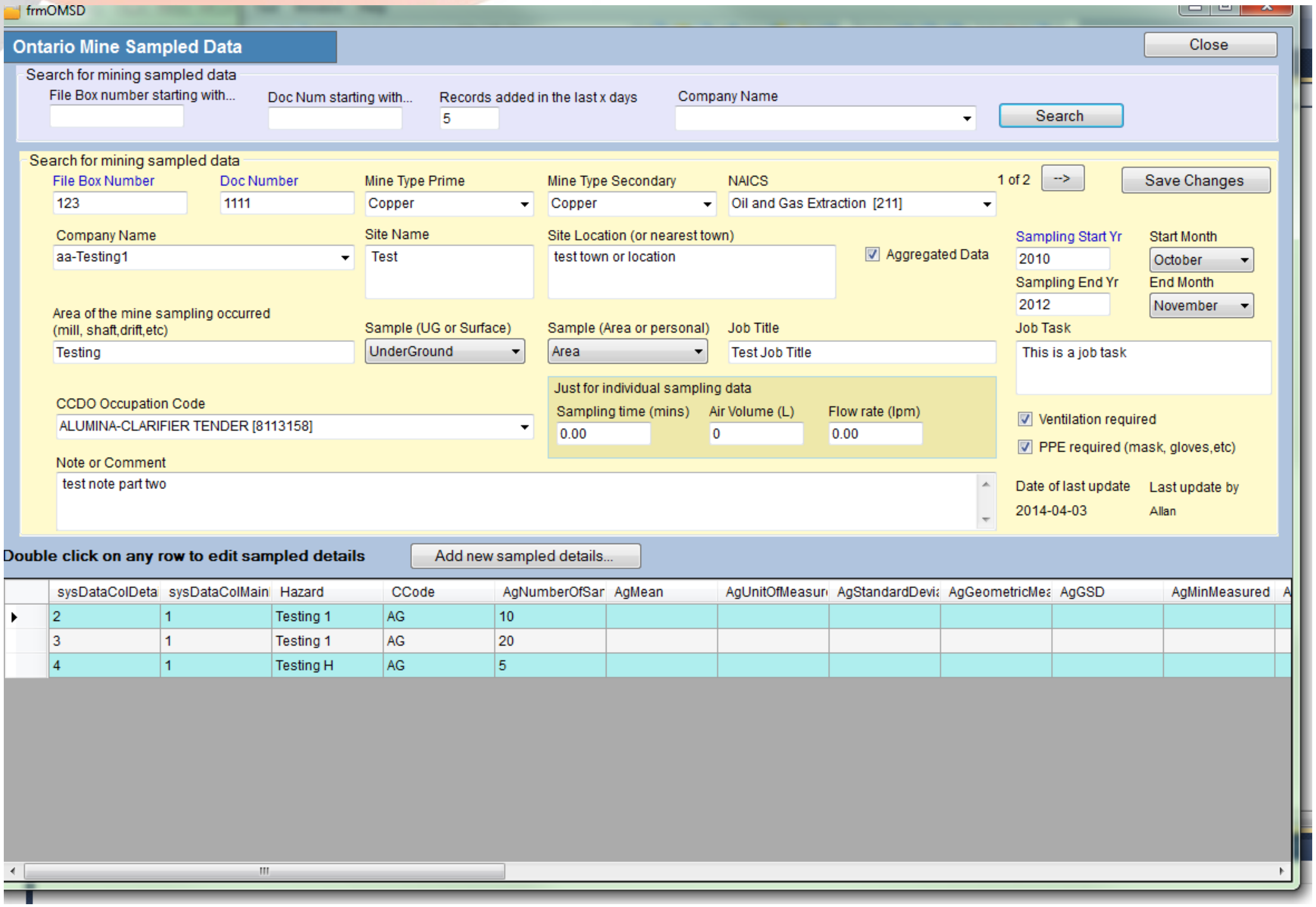
Surveillance

1991 Long-form Census Linkage
***Canada-wide**
Xx workers

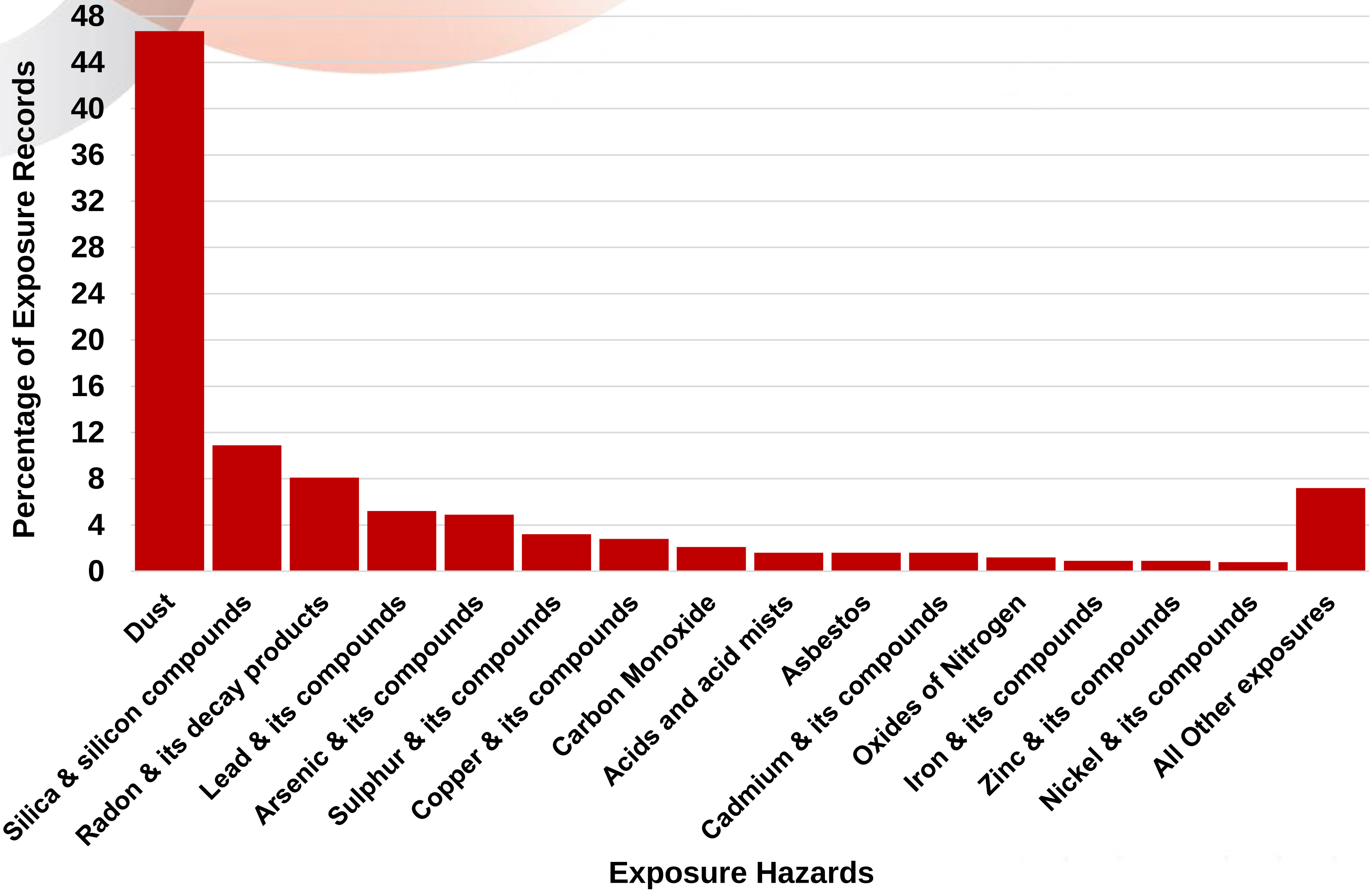
Compensation Claims Linkage
Xx workers

** 1991 Census is all of Canada, the other projects focus on Ontario*

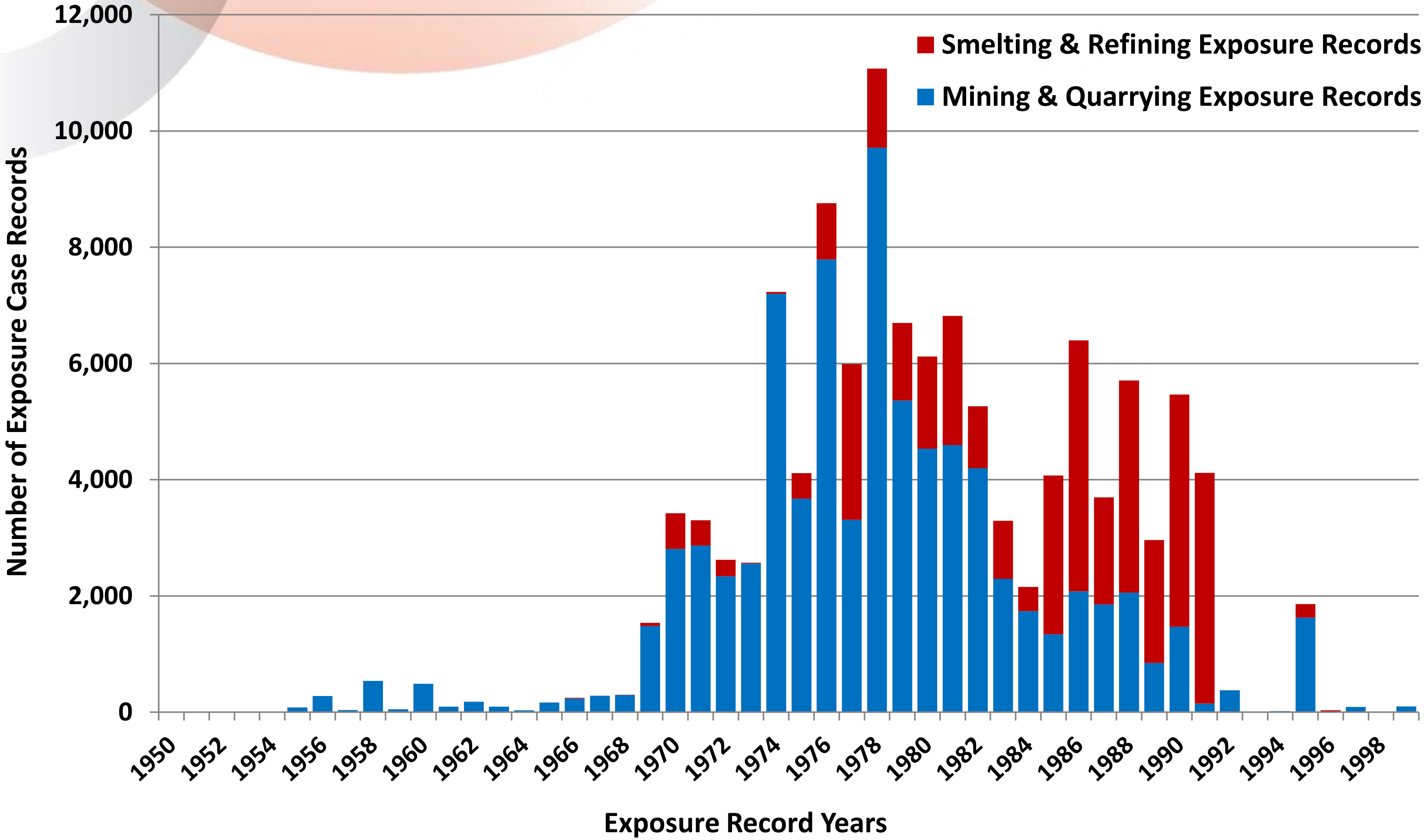
Ontario Mining Exposure Database



Most Common OMED Exposures



Exposure Records by Year



The Ontario Mining Exposure Database (OMED): A tool for mining research in Ontario, Canada

Colin J. Berriault 1; Victoria H. Arrandale 1,2; Nicola Blagrove-Hall 1; Katherine J. Jardine 1; Paul A. Demers 1,2

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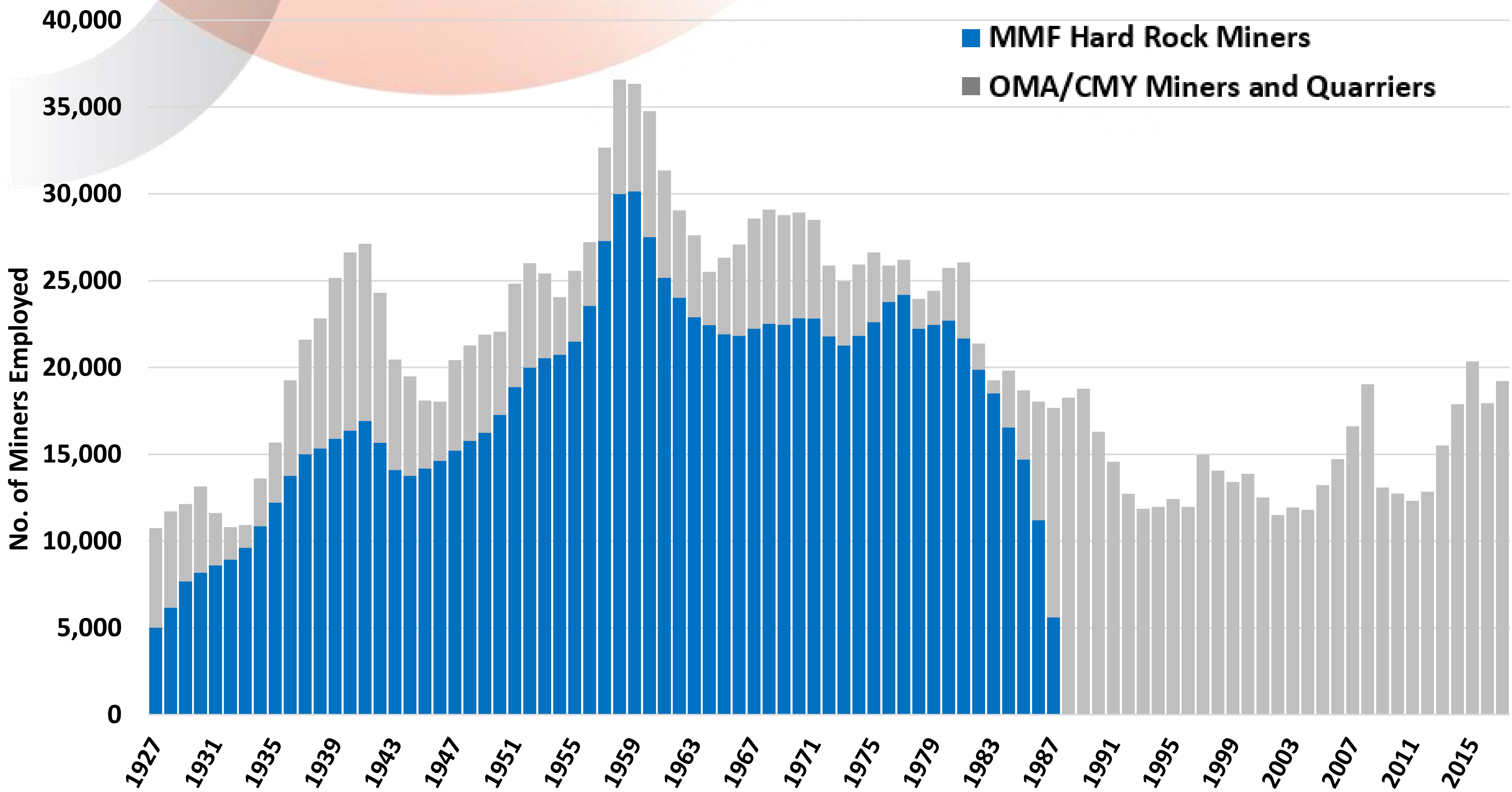
2 Dalla Lana School of Public Health, University of Toronto, Toronto ON

Background: Many jurisdictions have constructed large exposure databases to examine workplace exposures across occupations and industries. Historical exposure data can be used to examine trends in exposure over time, to evaluate the effectiveness of major historical interventions or to improve exposure assessment in epidemiological studies. In order to better understand potential risks to workers in the mining industry, an electronic database of historical exposure measurements was constructed for the province of Ontario, Canada, a region with a long history of mining. The database is known as the Ontario Mining Exposure Database, or OMED.

Methods: Researchers worked closely with regulators, workers representatives and employer groups to locate and retrieve exposure data. Hard copy data was entered into a secure electronic database. The constructed database is compatible with other existing Canadian exposure databases but incorporates additional mining-specific data such as information on ore type(s), ventilation, personal protective equipment and whether the sample was collected above or underground, for example.

Results: The complete OMED contains 147,236 lines of data representing 884,313 measurements (some data entries are summary measures of multiple samples). In total 165 hazards are included in the exposure data. Measurements were collected between 1950 and 1997 in mines, smelters, refineries as well as gravel and sand pits. The most common exposures present in the database to-date are: dust n.e.c (58.1%), silica (11.1%), radon (6.6%), arsenic (4.2%), and lead (4.2%).

Conclusions: The OMED database is a tool for mining research in Ontario, Canada and beyond. The OMED is currently being used to describe the historical exposures to specific hazards in the Ontario mining industry. Results can be used to determine whether former miners are at risk of cancer or chronic respiratory disease and will also be used for exposure assessment in future epidemiological studies of occupational cancer in the mining industry.



40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
No. of Miners Employed
MMF Hard Rock Miners
OMA/CMY Miners and Quarriers
1927
1931
1935
1939
1943
1947
1951
1955
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015

Occupational Disease Surveillance System

- Pilot work funded by WSIB, MOL and PHAC
- Created February 2017 through a meeting of MOHLTC & MOL with CCO and others to establish a collaboration on occupational disease prevention
- Linkage of 2.2 million time loss claimants (1983-2014) to:
  - Ontario Cancer Registry
  - Physician visits (OHIP)
  - Ambulatory care visits (NACRS)
  - Hospital visits (DAD)

Ontario Ministry of Labour / Ministère du Travail

Public Health Agency of Canada / Agence de la santé publique du Canada

Ontario Ministry of HEALTH AND LONG-TERM CARE