



Occupational  
Cancer  
Research  
Centre

# Investigating Neurologic Disease from McIntyre Powder in Ontario Miners

Xiaoke Zeng, PhD Candidate, DLSPH. University of Toronto  
Paul A. Demers, Director, OCRC, Ontario Health



**Ontario  
Health**



**Ministry of Labour, Training  
and Skills Development**



**Canadian  
Cancer  
Society**

**Société  
canadienne  
du cancer**

# Disclosure

- The Authors declare no conflict of interests.
- This work is funded by the Ontario Workplace Safety and Insurance Board [grant numbers 2018-001].

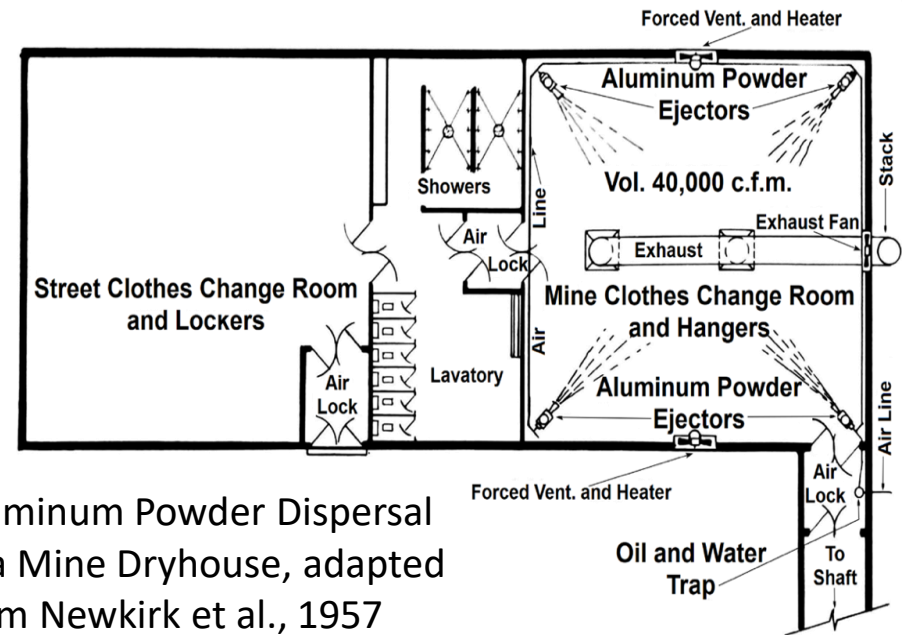
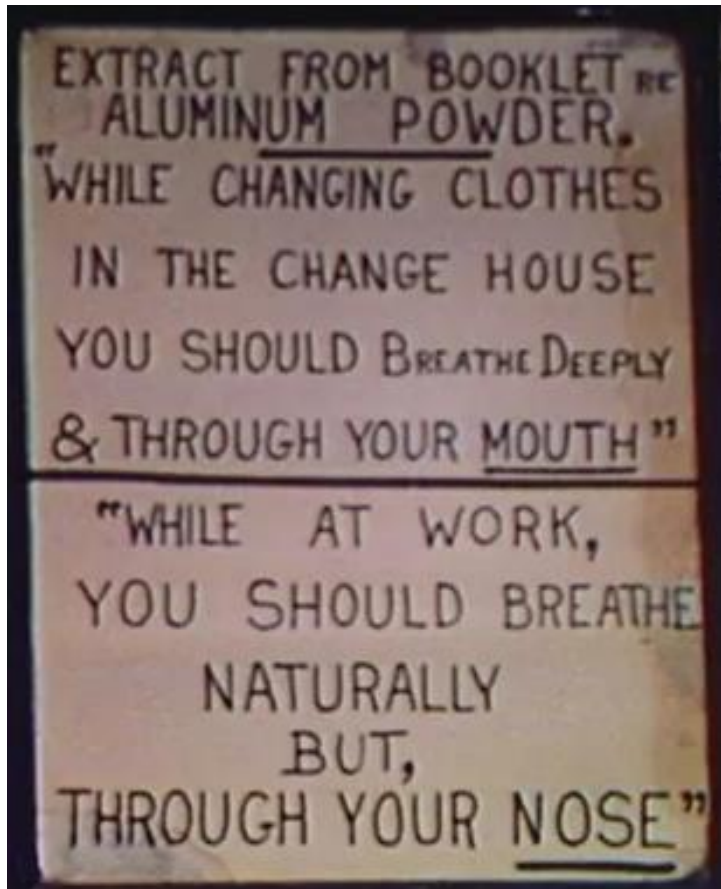


- This work is conducted at the Occupational Cancer Research Centre (OCRC), which is funded by the Ministry of Labour, Training and Skills Development and the Ontario Ministry of Health and based at Ontario Health.

# Background



- McIntyre Powder is an aluminum/aluminum oxide powder administered to miners in Ontario 1943-1979. It was thought to prevent silicosis among miners, but later was found to have no protective effect.

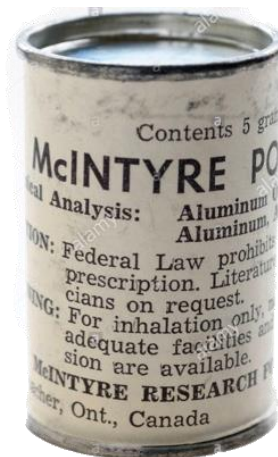


Aluminum Powder Dispersal in a Mine Dryhouse, adapted from Newkirk et al., 1957

# Background



- McIntyre powder has long been controversial.
  - In 1979, the Fifth Estate aired a program on the health risks of an aluminium powder used by miners in northern Ontario.
- WSIB contracted Intrinsik, a consulting company, to review the neurologic effects of aluminum. Their final report was delivered in April, 2017.





## OF CHANGE

How the power of art helped transform what was once the most dangerous district in South America. **Travel, T1**



# SATURDAY STAR

WEATHER HIGH 23 C | MOSTLY CLOUDY | MAP S8

SATURDAY, APRIL 15, 2017

## 'WE WERE LIKE GUINEA PIGS'

**Miners vividly remember the drill.** They would enter a sealed room. Without warning, the doors would close, the ventilation would shut down and the room would fill with black powder. They thought they were inhaling an antidote to lung disease. They now fear it was anything but.

**SARA MOJTEHEDZADEH**  
WORK AND WEALTH REPORTER

It was a human experiment on an unprecedented scale. Its target: 10,000 Ontario miners. Its tool: a mysterious black powder they were forced to inhale in a sealed room before plunging underground to work.

From 1943 to roughly 1980, an aluminum-based prophylaxis called McIntyre Powder was sold as an apparent miracle antidote to lung disease. It was designed, historical documents suggest, by industry-sponsored Canadian scientists bent on slashing compensation costs in gold and uranium mines across the north.

The problem, experts say, aluminum is now known to be neurotoxic if significant doses get into the blood. And victims' families say those exposed to Canada's miracle McIntyre dust might be paying a devastating price.

Janice Martell has pulled together hundreds of years of research on the experi-



"Small pieces of him get taken away every day. It's hard to watch," says Martell, who works as a counselor in Elliot Lake. "I just felt so helpless."

After a year of outreach, she says she has been contacted by 268 former miners



Ten, or roughly three per cent, developed amyotrophic lateral sclerosis, a degenerative and incurable condition that slowly kills the ability to swallow, speak and breathe.

In Ontario, the prevalence of motor



random sample, Martell's numbers don't necessarily prove that miners exposed to McIntyre Powder are more likely to suffer from neurological conditions. But they are concerning enough to prompt McMaster University to start studying

**FELIX BREZENSKI**, far left, Aimo Salo and Fred Booth were Ontario miners exposed to McIntyre Powder. These pictures were taken as they reported for mandatory annual chest X-rays conducted by the workers' compensation board. Brezenski suffered a multitude of health problems, including Parkinson's and Alzheimer's, before he died.

# McIntyre Powder and the OCRC



- In August of 2017, The WSIB approached us to ask if we would be able to examine the risk of neurological disease among Ontario miners exposed to McIntyre Powder using the Mining Master File (MMF).
  - The OCRC has been using the MMF for research on cancer for many years and it had some information on McIntyre Powder.
- We said yes, but the study would have to be totally independent and transparent.
- The study was funded and started in 2018.

# 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



# Overall Study Objectives



**Assess the completeness of the electronic version of the MMF** to ensure that the file contains all available data on miners from existing paper records;

**Enhance the MMF** with additional data on McIntyre Powder from available historical records located at the OCRC, WSIB, and Ontario Provincial Archives;

**Conduct linkage** to hospital discharge, ambulatory care, and outpatient databases held at the Institute for Clinical and Evaluative Studies to identify chronic neurological diseases;

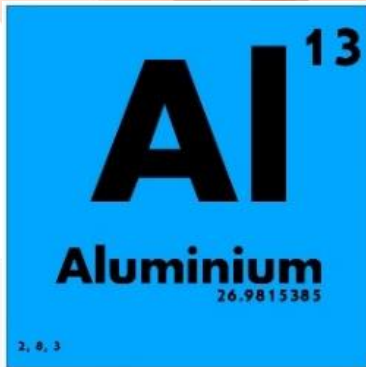
**Complete cohort analysis** to compare the risk of neurological disease in miners exposed to MP to the general population of Ontario and to miners in the cohort with no record of exposure.



# Study Team



- Xiaoke Zeng, PhD student, UofT
- Research Staff
  - Colin Berriault, Sr. Research Associate, OCRC
  - Jill MacLeod, Sr. Research Associate, OCRC
- Scientific Team
  - Dr. Victoria Arrandale, Assistant Professor, UofT
  - Dr. Nate DeBono, Scientist, OCRC (now at IARC)
  - Dr. Anne Harris, Associate Professor, Ryerson
  - Dr. Paul Demers, Director, OCRC



# Aluminum Exposure

- Most abundant metal in the Earth's crust
  - Reactive element
  - Soils, minerals, water, and air
  - Wide applications (water treatment, food, consumer products)
- Solubility (pH-dependent)
  - Soluble species: Al sulfate, Al chloride, Al nitrate
  - Insoluble species: Al oxide, Al hydroxide, Al phosphate, Al silicate

# Environmental & Occupational Aluminum Exposure

## Environmental exposure

- Dietary sources and drinking water
- Common exposure route: ingestion

## Occupational exposure:

- Primary exposure route: inhalation
- Common exposure scenario: welding Al-containing alloys, welding fumes (organic carbons & metal compounds)
- Underground mining: McIntyre powder (insoluble Al species)

# Neurological Effects of Al Exposure

## Animal studies (injected exposure):

- Al chloride, enhanced inflammatory responses, elevated aluminum levels, degeneration of cells (Platt et al, 2001)
- Al gluconate, impaired spatial memory and lower activity scores yet higher emotionality scores (Miu et al, 2003)
- Pathological changes in the brain due to Al exposure resemble hallmark changes observed among patients of Alzheimer's diseases (Chopra et al., 2011), Parkinson's disease (Inan-Eroglu & Ayaz, 2018), and motor neuron disease (Wakayama et al. 1996; Shaw & Petrik, 2009).

There's still debate re: linking AL with neurological effects.

# Environmental & Dietary Al & Neurodegenerative outcome



Authors (year)	Study design	Exposure	Outcome	OR/RR	95%CI
Rogers et al., (1999)	Case-control (23 pairs)	Daily intake of high Al-containing food	Probable & possible AD	8.6	N/A, P=0.19
Gauthier et al., (2000)	Case-control (86 pairs)	Organic monomeric Al in water	Probable or possible AD	2.67	1.04-6.90
Rondeau et al., (2000)	Cohort (n= 3,777)	Total Al in water ( $\geq$ 0.1 mg/liter)	AD	2.20	1.24–3.84
Rondeau et al., (2009)	Cohort (n=1,677)	Total Al in water ( $\geq$ 0.1 mg/liter)	AD	3.35	1.49–7.52
Virk et al. (2015)	Meta-analysis	Al containing antacid	AD	3 case-control studies <ul style="list-style-type: none"> <li>• OR 0.9, 95% CI 0.7–1.2</li> </ul> 1 cohort study <ul style="list-style-type: none"> <li>• RR 0.7, 95% CI 0.3–1.8</li> </ul>	

Note: Al: Aluminum; AD: Alzheimer’s disease; RR: relative risk; OR: odds ratio; CI: confidence interval;

# Occupational Al & Neurological outcomes



- Limited.
- Declined cognitive performance has been observed among welders and foundry workers with occupational exposure to aluminum dust and fumes (Polizzi et al. 2002; Bast-Pettersen et al. 1994 & 2000; Giorgianni et al, 2014).
- Meta analysis of 8 studies: increased risk of Alzheimer's disease associated with chronic exposure to aluminum from dietary and occupational sources (OR 1.71, 95%CI 1.35–2.18) (Wang et al. 2016).
- Workplace exposure to aluminum was not associated with an increased risk of Parkinson's disease (Semchuk et al 1993; Gorell et al 1999; Teschke et al 2011).

# MP & Neurodegenerative Disease



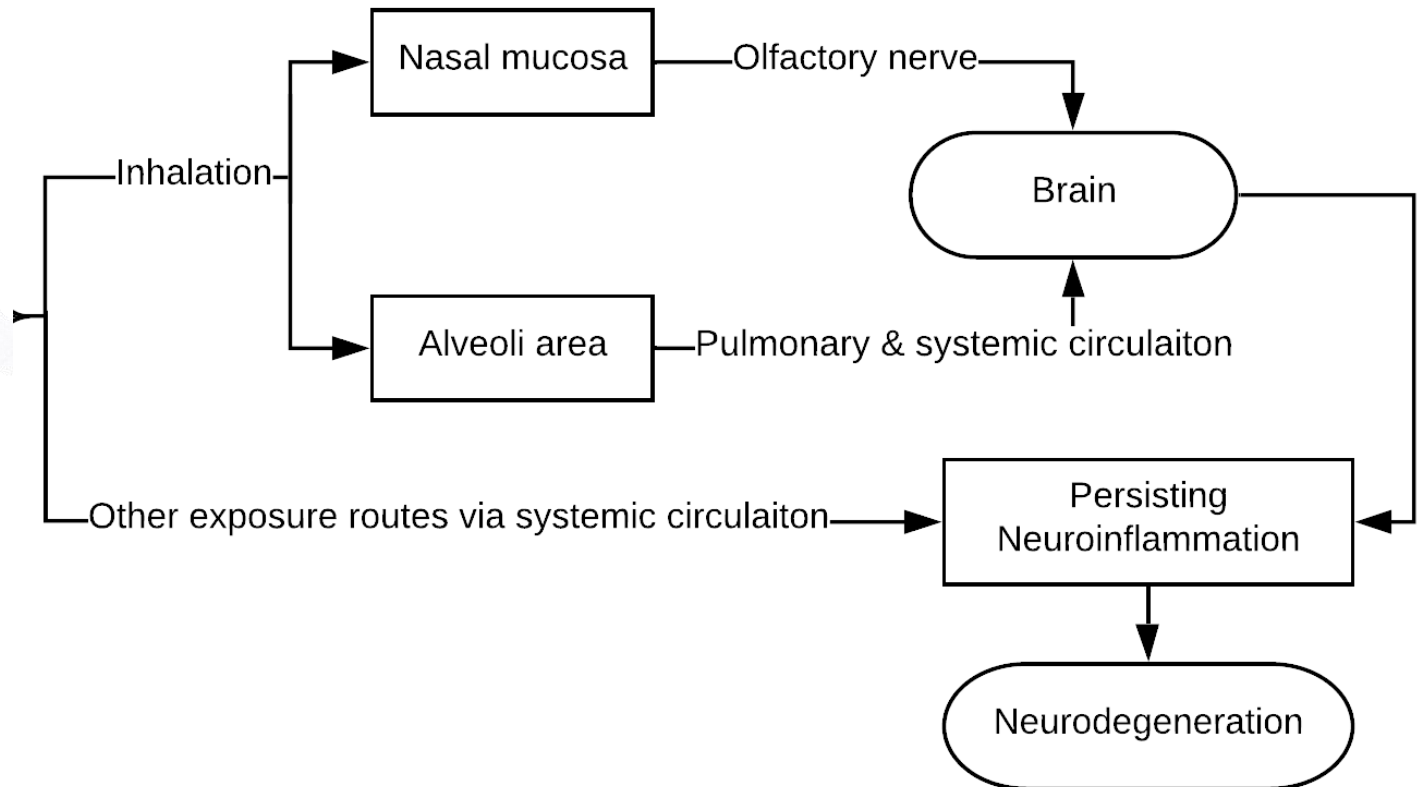
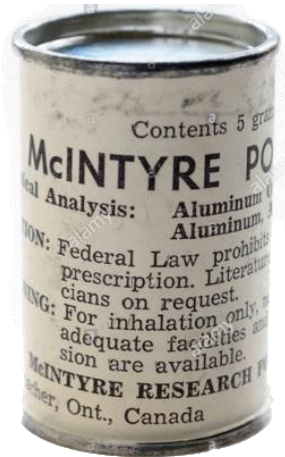
How is MP different from other Al exposures?

McIntyre Powder: Al oxide, Al hydroxide, metallic Al

Very fine in size:

- Before 1956: 60-70% < half  $\mu\text{m}$ , smallest <200 nm (Newkirk et al., 1956)
- After 1956: nano-particles, mode 10–15 nm, range 5–100 nm (Zarnke et al., 2019)

# MP & Neurodegeneration: potential pathways





# MP & Neurodegeneration: potential pathways



- Finely divided/nano-sized particles of aluminum compounds may dissolve more readily in tissue fluids (Riihimaki, 2012)
- Al oxide nanoparticles toxic to the growth of microorganisms (bacteria, algae) in a pH range of 6.5-8.0 (Jiang et al 2009; Sadiq et al 2011; Ye et al. 2018)
  - Toxicity primarily from insoluble fraction
  - Soluble Al ions were under detection limit

# Powder Administration

(Newkirk TE, 1972)

Standing position, via mouth

Target level,

- 1 mg/ft<sup>3</sup> or 35.6 mg/m<sup>3</sup>

Workers should take

- 10 minutes under 20,000-34,000 ppcc
- 20 minutes under 10,000-20,000 ppcc

- High levels of exposure



# Occupational limit for insoluble Al compounds

Under Ontario's Occupational Health & Safety Act, occupational limit for respirable aluminum of metal and insoluble compounds adopts the threshold limit value (TLV) from 2017 ACGIH (American Conference of Governmental Industrial Hygienists).

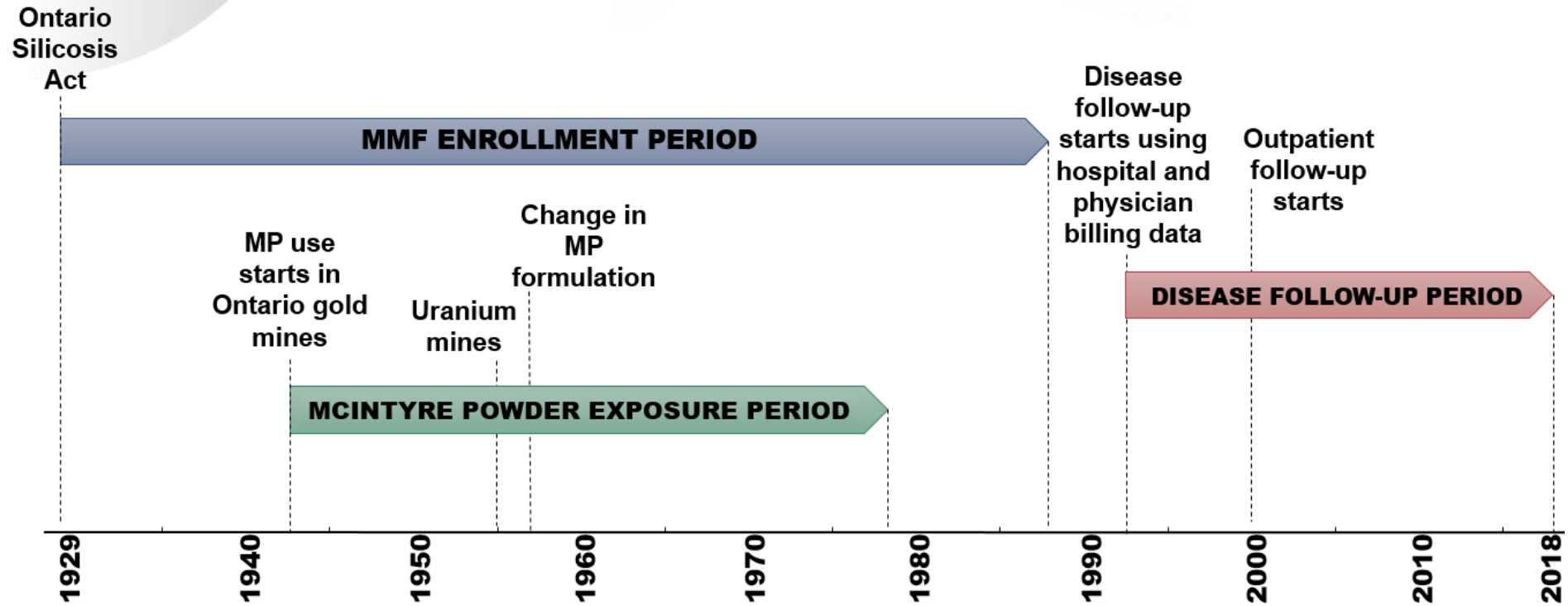
- TLV B **35.6 mg/m<sup>3</sup>, 7 times** the tract irritation, neuro
- 8-hour time weighted average (TWA) of 1 mg/m<sup>3</sup>, but no short-term exposure or ceiling limits.
- **Excursion limit**, 3 mg/m<sup>3</sup> (no exceed for any 30 minutes of workday), and 5 mg/m<sup>3</sup> (no exceeded any time of workday)

# What's known between MP & Neurodegenerative Disease

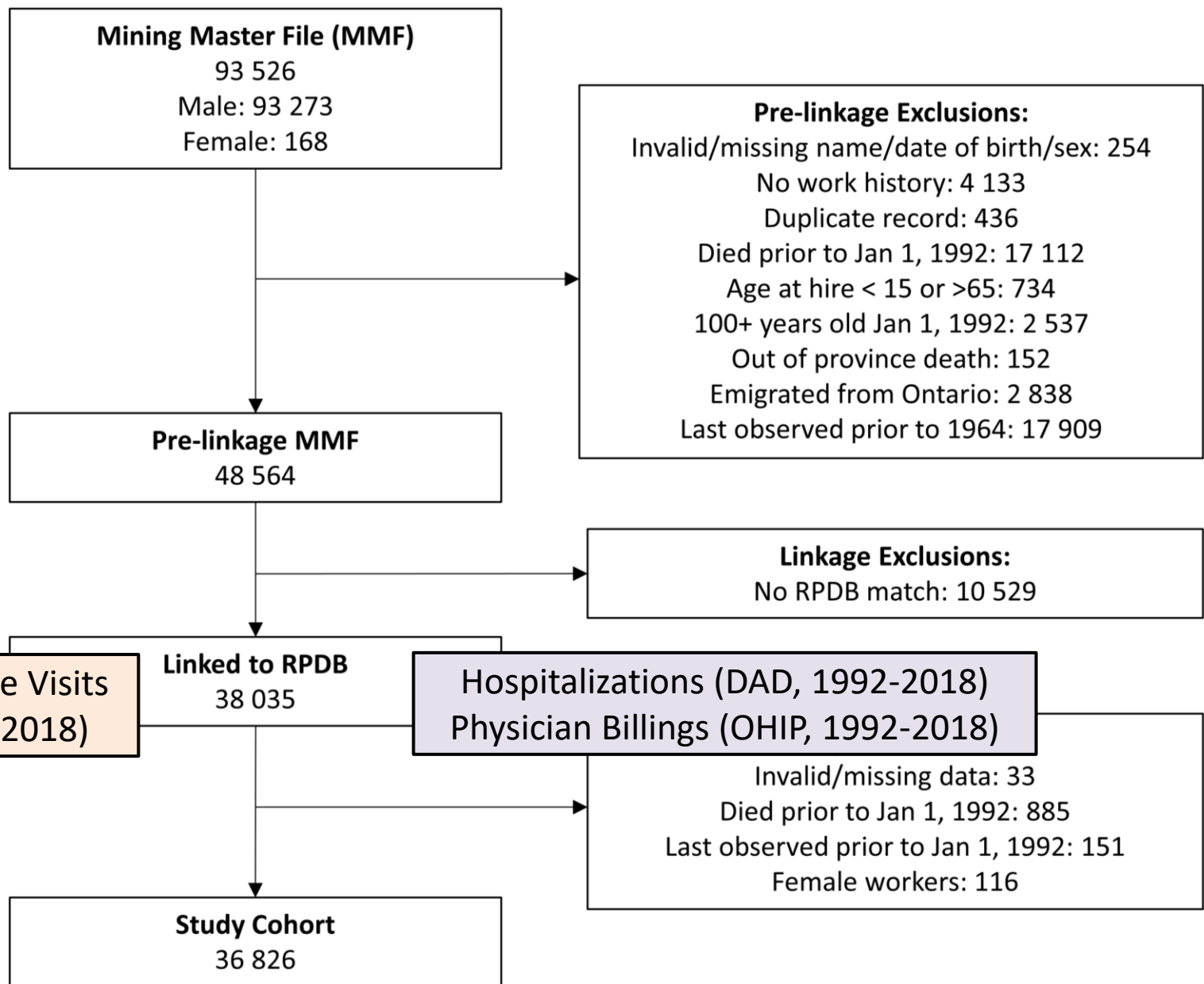


- Rifat et al. (1991) reported no significant difference in self- or proxy-reported diagnoses in neurological disorders between MP exposed (n=261) and unexposed (n=346) underground miners employed between 1955 and 1979 in Ontario.
- Peters et al. (2013) found a suggested elevation of Alzheimer's disease mortality among Australian gold miners who were ever exposed McIntyre Powder than those never exposed (hazard ratio 2.79, 95% CI 0.88-8.82).
- Both studies had limited cases.

# Cohort Timeline



# Linkage flow chart



Note: Some records met multiple exclusion criteria; RPDB: Ontario's Registered Persons Database.

# Neurological Outcome Case Ascertainment

Alzheimer's disease  
(ICD-9 331.0, ICD-10-CA G30)  
Parkinson's disease  
(ICD-9 332.0, ICD-10-CA G20)  
Motor neuron disease  
(ICD-9 335.2, ICD-10-CA G12.2)

Alzheimer's with other dementias  
(ICD-9 290, 294.1, 331.0, 331.1, 331.82; ICD-10 F00,  
F01, F02, F03, G30; Physician billing codes: 290, 331)

Parkinsonism  
(ICD-9 332.0 332.1; ICD-10 G20, G21.0-0.4, G21.8-9,  
G22, F023; Physician billing cods: 332)

At least one record with  
corresponding  
diagnostic codes in  
hospital discharge or  
ambulatory care data

At least two physician  
claims with diagnostic  
codes within 12 months

# Case Ascertainment Algorithm Reference

*Neuro  
epidemiology*

Methods in Neuroepidemiology

Neuroepidemiology 2014;43:28–37  
DOI: [10.1159/000365590](https://doi.org/10.1159/000365590)

Received: January 29, 2014  
Accepted after revision: June 6, 2014  
Published online: October 16, 2014

## A Validation Study of Administrative Data Algorithms to Identify Patients with Parkinsonism with Prevalence and Incidence Trends

Debra A. Butt<sup>a,b</sup> Karen Tu<sup>a,c,d</sup> Jacqueline Young<sup>c</sup> Diane Green<sup>c</sup> Myra Wang<sup>c</sup>  
Noah Ivers<sup>a,e</sup> Liisa Jaakkimainen<sup>a,c,f</sup> Robert Lam<sup>d</sup> Mark Guttman<sup>g</sup>

<sup>a</sup>Research Institute, Department of Family and Community Medicine, University of Toronto, Toronto, Ont.,

<sup>b</sup>Department of Family and Community Medicine, <sup>c</sup>Department of Family and Community Medicine, <sup>d</sup>Toronto Western Institute of Family and Community Medicine, Women's Sunnybrook Health Sciences Centre, Toronto,

[J Alzheimers Dis.](#) 2016 Aug 10;54(1):337-49. doi: 10.3233/JAD-160105.

Electronic Medical Record  
Administrative data Linked Database  
(EMRALD) in Ontario, Canada.

## Identification of Physician-Diagnosed Alzheimer's Disease and Related Dementias in Population-Based Administrative Data: A Validation Study Using Family Physicians' Electronic Medical Records

R Liisa Jaakkimainen <sup>1 2 3</sup>, Susan E Bronskill <sup>2</sup>, Mary C Tierney <sup>1 4</sup>, Nathan Herrmann <sup>5</sup>,  
Diane Green <sup>6</sup>, Jacqueline Young <sup>2</sup>, Noah Ivers <sup>1 7</sup>, Debra Butt <sup>1 8</sup>, Jessica Widdifield <sup>3 9</sup>,  
Karen Tu <sup>1 3 10</sup>

Affiliations + expand

PMID: 27567819 DOI: [10.3233/JAD-160105](https://doi.org/10.3233/JAD-160105)



# MP Assessment Approaches

## First assessment approach: **Self-reports**

## Second assessment approach: **Historical records**

- Self-reported aluminum prophylaxis (yes/no, in the past 12 months) in miners' annual medical fitness exams
- Cross checked with licensed mines' powder use period

- Assigned 'yes' for underground miners who worked at a licensed mine site during their powder use periods

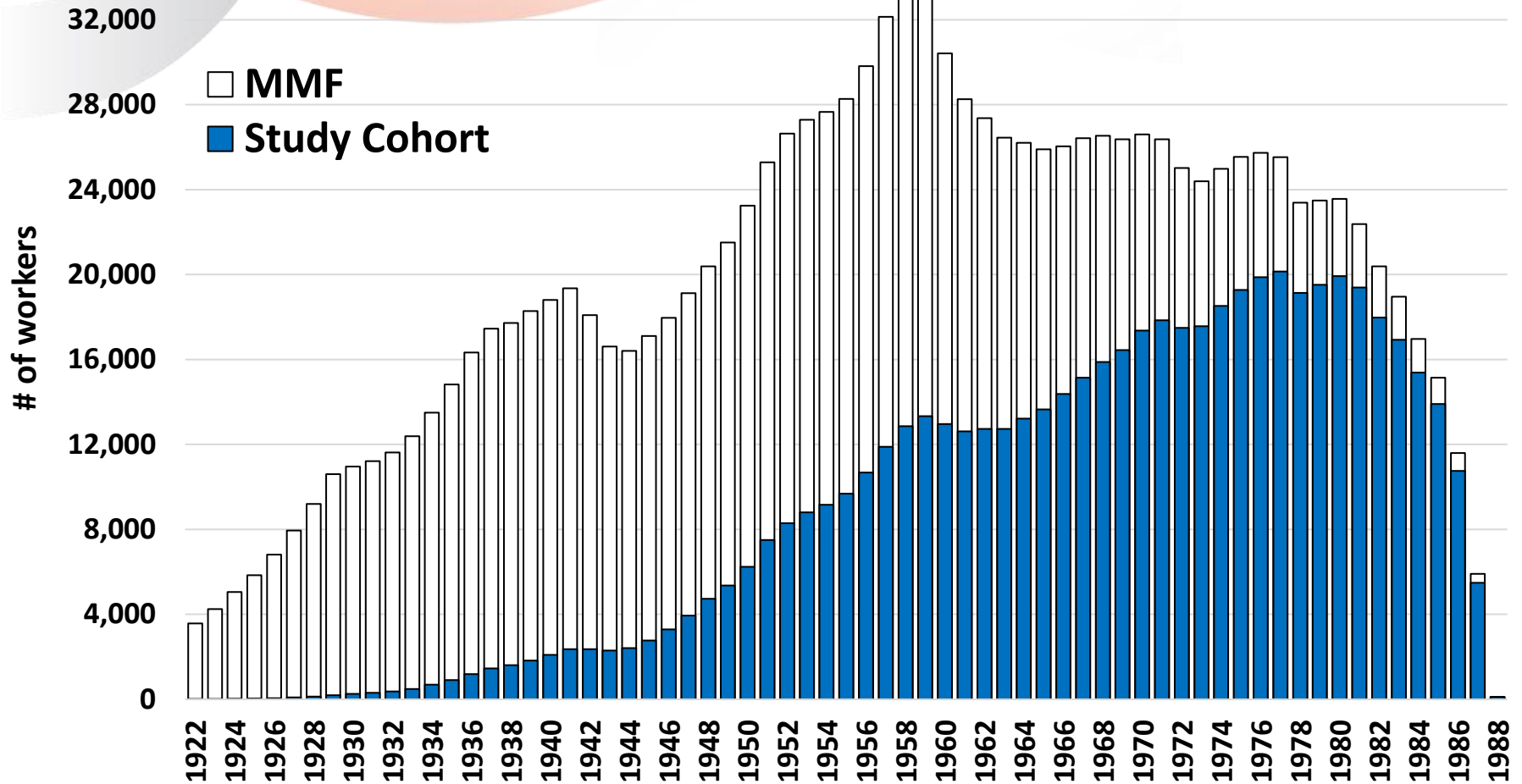
- Approximately **26%** of miners (n= 9,458) self-reported as exposed

- Approximately **38%** of miners (n=13,828) estimated as exposed

# Statistical analyses

- Poisson regression models: incidence rate ratios (95% confidence interval) for estimates between MP exposure and neurodegenerative disease
- Age-Period-Cohort Analysis
- Adjusted by mean attained age, age<sup>2</sup>, and mean birth year throughout the follow-up period.

# Full MMF vs Study Cohort



# Characteristics (median, Interquartile range) of workers in the study cohort and workers with ever and never exposure to MP

	Study cohort (N=36 826)	MP-exposed		MP-unexposed	
		Self-reports (N=9 548)	Historical records (N=13 827)	Self-reports (N=27 278)	Historical records (N=22 999)
Year of birth	1938 (1927–1949)	1932 (1923–1941)	1937 (1927–1949)	1941 (1929–1951)	1939 (1927–1949)
Year of first hire	1963 (1952–1971)	1955 (1948–1964)	1958 (1951–1970)	1966 (1954–1973)	1965 (1953–1972)
Duration of employment (years)	11 (6–18)	13 (7–23)	10 (6–19)	10 (6–17)	11 (6–18)
Years of follow-up	23 (11–26)	18 (8–26)	21 (10–26)	25 (12–26)	24 (12–26)
Age at end of follow-up (years)	73 (65–81)	77 (68–83)	73 (65–81)	72 (64–80)	73 (65–81)

# Number and proportion of workers exposed to MP in the study cohort

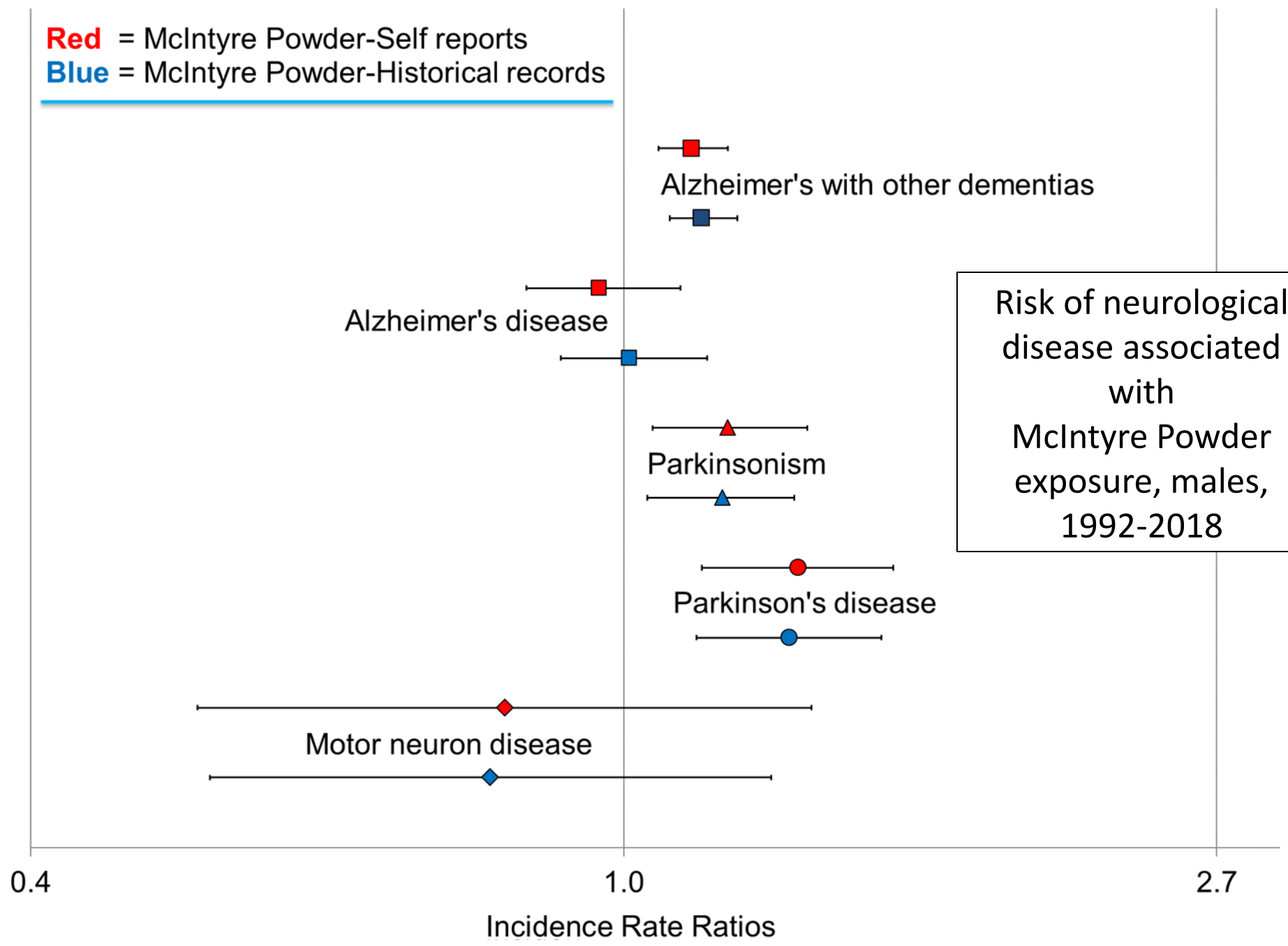


MP exposure	Self-reports, N (%)	Historical records, N (%)
Ever exposed	9548 (26)	13 827 (38)
Only before 1956	862 (2)	966 (3)
Ever after 1956	8686 (24)	12 861 (35)
Only after 1956	6459 (18)	10 187 (28)
Never exposed	27 278 (74)	22 999 (62)
Cumulative duration (years) of MP exposure		
> 0–1	2296 (6)	4507 (12)
> 1–5	3833 (10)	4503 (12)
> 5–10	1655 (4)	2433 (7)
> 10	1764 (5)	2384 (6)

# Risk of neurological disease associated with McIntyre Powder exposure, males, 1992-2018

Disease	Self-reported MP exposure			MP assessed by historical records		
	Cases: Exposed N=9,548	Cases: Unexposed N=27,278	RR (95% CI)	Cases: Exposed N=13,828	Cases: Unexposed N=22,998	RR (95% CI)
Alzheimer's disease	334	728	0.96 (0.85-1.10)	399	663	1.01 (0.90-1.15)
Alzheimer's with other dementias	1721	3294	1.12 (1.06-1.19)	2011	3004	1.14 (1.08-1.21)
Parkinsonism	364	667	1.19 (1.05-1.36)	426	605	1.18 (1.04-1.33)
Parkinson's disease	251	393	1.34 (1.14-1.57)	284	360	1.32 (1.13-1.54)
Motor neuron disease	20	61	0.82 (0.49-1.37)	26	55	0.80 (0.49-1.37)

**Red** = McIntyre Powder-Self reports  
**Blue** = McIntyre Powder-Historical records



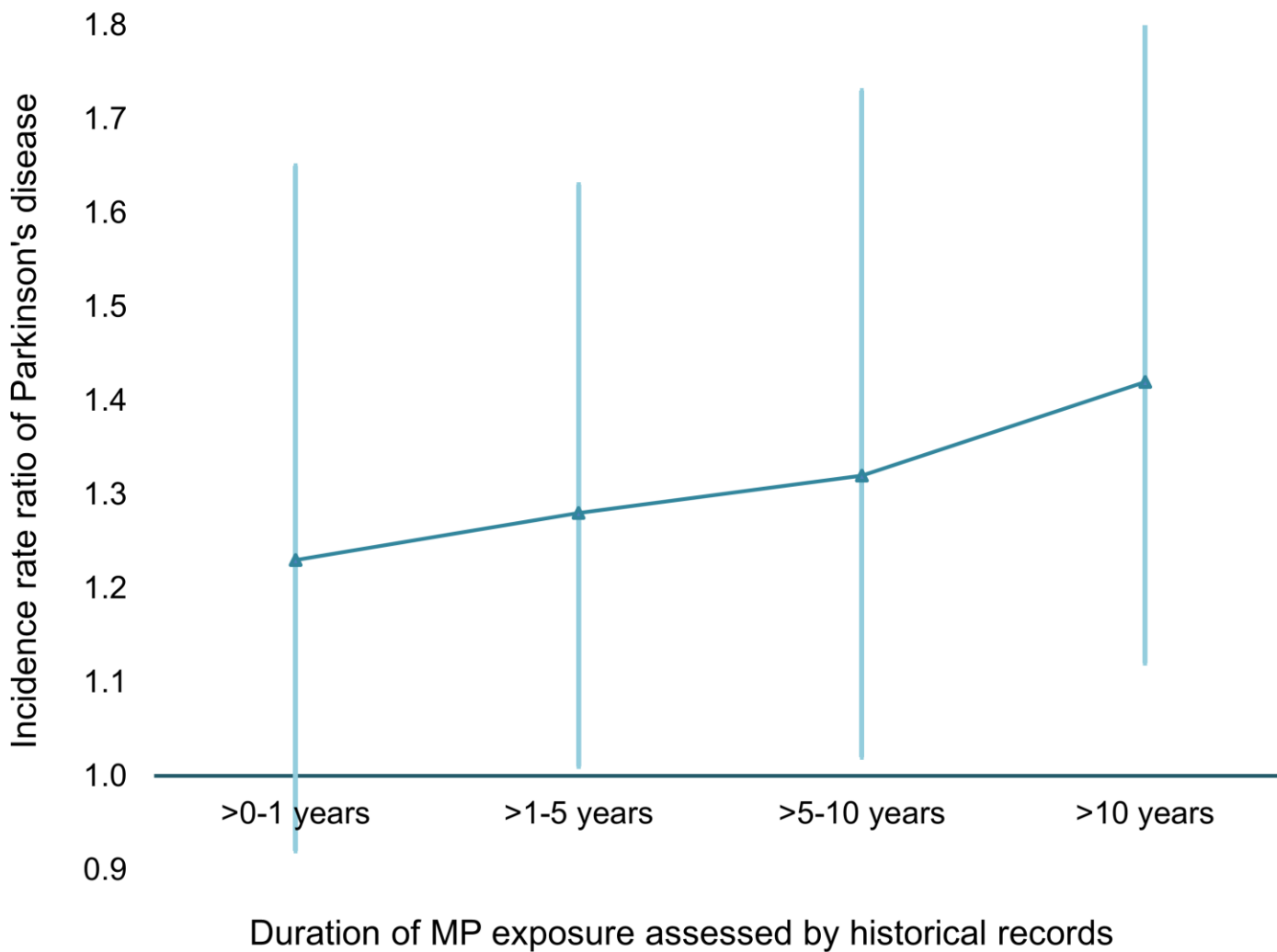
Risk of neurological disease associated with McIntyre Powder exposure, males, 1992-2018

# Risk of neurological disease among MP-exposed workers, by period of exposure

Period of employment	Number of workers	Parkinsonism		Parkinson's disease	
		Cases	RR (95% CI)	Cases	RR (95% CI)
MP exposed Only <1956	853	45	1.08 (0.80-1.48)	34	1.18 (0.83-1.69)
Ever 1956+	8,695	319	1.21 (1.06-1.38)	217	1.36 (1.16-1.61)
Only 1956+	6,459	192	1.16 (0.99-1.37)	125	1.34 (1.09-1.64)



# Risk of Parkinson's disease by duration of MP exposure



# Strengths and Limitations

- Study comprises largest cohort of MP-exposed miners to date
- Neurological disease incidence records provide better ascertainment of outcomes than previous mortality studies
- Gaps between exposure and case follow-up period allows possible cases to be missed prior to 1992
- MP exposure information in the MMF is limited and no direct measurements were available for dose-response analyses

# Conclusions



MP exposure was associated with higher risks of Parkinson's disease

- Highest among those exposed >1956
- Increased risk observed with increased duration of MP exposure assessed by historical records

No association observed for Alzheimer's disease or motor neuron disease

Similar results are found compared to general population

# The Study and its Impact



- The Final Report was delivered to the WSIB March 12, 2020.
- The report was publicly released by WSIB early May, 2020.
- Changes began happening quickly.
- WSIB began reviewing and accepting Parkinson's disease claims in August.

# McIntyre Powder update

**Update: February 4, 2022**

To gain a better understanding of the relationship between the use of McIntyre Powder in Ontario mines and the development of neurological health outcomes in former miners, we engaged Dr. Paul Demers from the Occupational Cancer Research Centre (OCRC), based at Ontario Health (Cancer Care Ontario), to conduct an independent study in August 2017.

By partnering with Dr. Demers, we were able to leverage anonymized historical information on thousands of former Ontario miners to examine the potential neurological effects of McIntyre Powder exposure on miners who were exposed to it.

The results of this study, [Investigation of McIntyre Powder Exposure and Neurological Outcomes in the Mining Master File Cohort: Final Report](#) (PDF), the largest ever conducted on this topic, showed a statistically significant increased risk of Parkinson's disease in McIntyre Powder-exposed miners compared to miners with no McIntyre Powder exposure.

Based on the study results and the unique nature of this cohort, Parkinson's disease has been added as a new occupational disease to [Schedule 3 in the General Regulation](#), effective January 27, 2022.\*

This means that if anyone was exposed to McIntyre Powder through work in the mining industry and develops Parkinson's disease, the disease is presumed to be work-related, unless the contrary is shown.

# Thank You!



For more information:

- Zeng X, Macleod J, Berriault C, DeBono NL, Arrandale VH, Harris AM, Demers PA. Aluminum dust exposure and risk of neurodegenerative diseases in a cohort of male miners in Ontario, Canada. *Scand J Work Environ Health* 2021;47(7):531-539.
- <https://www.wsib.ca/en/mcintyre-powder-update>