Occupational Health Clinics for Ontario Workers Inc. (OHCOW).

Exposure to diesel exhaust

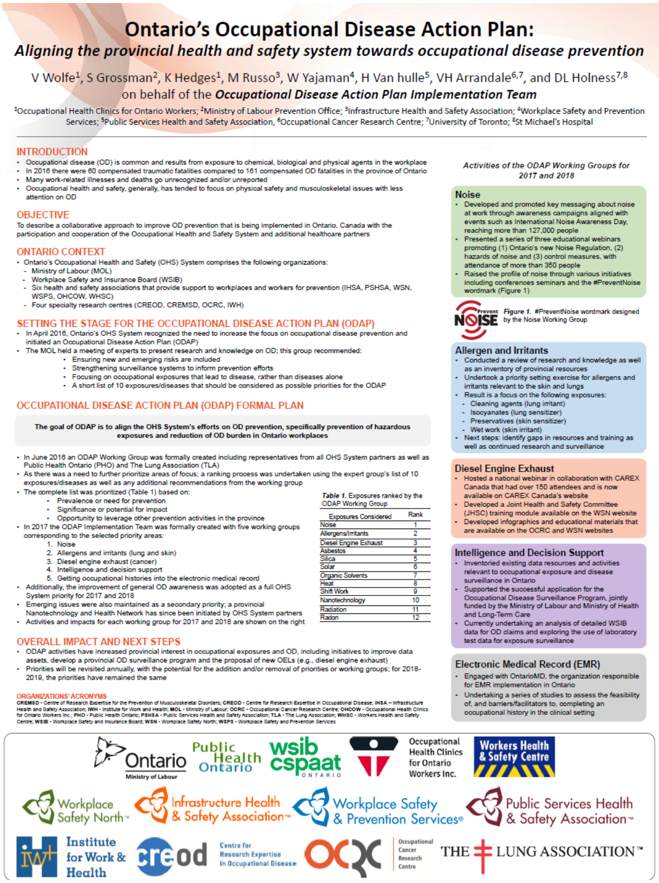
What is the health risk?

Introduction to a risk calculator.

John Oudyk, Occupational Hygienist OHCOW.

Kevin Hedges, Occupational Hygienist OHCOW khedges@ohcow.on.ca and President Workplace Health Without Borders (WHWB) (International)

[Ontario Occupational Disease Action Plan]



Ontario's Occupational Disease Action Plan:

Aligning the provincial health and safety system towards occupational disease prevention

V Wolfe[1], S Grossman[2], K Hedges[1], M Russo[3], W Yajaman[4], H Van hulle[5], VH Arrandale[6,7], and DL Holness[7,8]
on behalf of the ***Occupational Disease Action Plan Implementation Team***

[1]Occupational Health Clinics for Ontario Workers; [2]Ministry of Labour Prevention Office; [3]Infrastructure Health and Safety Association; [4]Workplace Safety and Prevention Services; [5]Public Services Health and Safety Association, [6]Occupational Cancer Research Centre; [7]University of Toronto; [8]St Michael's Hospital

INTRODUCTION
- Occupational disease (OD) is common and results from exposure to chemical, biological and physical agents in the workplace
- In 2016 there were 60 compensated traumatic fatalities compared to 161 compensated OD fatalities in the province of Ontario
- Many work-related illnesses and deaths go unrecognized and/or unreported
- Occupational health and safety, generally, has tended to focus on physical safety and musculoskeletal issues with less attention on OD

OBJECTIVE
To describe a collaborative approach to improve OD prevention that is being implemented in Ontario, Canada with the participation and cooperation of the Occupational Health and Safety System and additional healthcare partners

ONTARIO CONTEXT
- Ontario's Occupational Health and Safety (OHS) System comprises the following organizations:
  - Ministry of Labour (MOL)
  - Workplace Safety and Insurance Board (WSIB)
  - Six health and safety associations that provide support to workplaces and workers for prevention (IHSA, PSHSA, WSN, WSPS, OHCOW, WHSC)
  - Four specialty research centres (CREOD, CREMSD, OCRC, IWH)

SETTING THE STAGE FOR THE OCCUPATIONAL DISEASE ACTION PLAN (ODAP)
- In April 2016, Ontario's OHS System recognized the need to increase the focus on occupational disease prevention and initiated an Occupational Disease Action Plan (ODAP)
- The MOL held a meeting of experts to present research and knowledge on OD; this group recommended:
  - Ensuring new and emerging risks are included
  - Strengthening surveillance systems to inform prevention efforts
  - Focusing on occupational exposures that lead to disease, rather than diseases alone
  - A short list of 10 exposures/diseases that should be considered as possible priorities for the ODAP

OCCUPATIONAL DISEASE ACTION PLAN (ODAP) FORMAL PLAN

The goal of ODAP is to align the OHS System's efforts on OD prevention, specifically prevention of hazardous exposures and reduction of OD burden in Ontario workplaces

- In June 2016 an ODAP Working Group was formally created including representatives from all OHS System partners as well as Public Health Ontario (PHO) and The Lung Association (TLA)
- As there was a need to further prioritize areas of focus; a ranking process was undertaken using the expert group's list of 10 exposures/diseases as well as any additional recommendations from the working group
- The complete list was prioritized (Table 1) based on:
  - Prevalence or need for prevention
  - Significance or potential for impact
  - Opportunity to leverage other prevention activities in the province
- In 2017 the ODAP Implementation Team was formally created with five working groups corresponding to the selected priority areas:
  1. Noise
  2. Allergens and irritants (lung and skin)
  3. Diesel engine exhaust (cancer)
  4. Intelligence and decision support
  5. Getting occupational histories into the electronic medical record
- Additionally, the improvement of general OD awareness was adopted as a full OHS System priority for 2017 and 2018
- Emerging issues were also maintained as a secondary priority; a provincial Nanotechnology and Health Network has since been initiated by OHS System partners
- Activities and impacts for each working group for 2017 and 2018 are shown on the right

Table 1. Exposures ranked by the ODAP Working Group

Exposures Considered	Rank
Noise	1
Allergens/Irritants	2
Diesel Engine Exhaust	3
Asbestos	4
Silica	5
Solar	6
Organic Solvents	7
Heat	8
Shift Work	9
Nanotechnology	10
Radiation	11
Radon	12

OVERALL IMPACT AND NEXT STEPS
- ODAP activities have increased provincial interest in occupational exposures and OD, including initiatives to improve data assets, develop a provincial OD surveillance program and the proposal of new OELs (e.g., diesel engine exhaust)
- Priorities will be revisited annually, with the potential for the addition and/or removal of priorities or working groups; for 2018-2019, the priorities have remained the same

ORGANIZATIONS' ACRONYMS
CREMSD - Centre of Research Expertise for the Prevention of Musculoskeletal Disorders; **CREOD** - Centre for Research Expertise in Occupational Disease; **IHSA** – Infrastructure Health and Safety Association; **IWH** - Institute for Work and Health; **MOL** - Ministry of Labour; **OCRC** - Occupational Cancer Research Centre; **OHCOW** - Occupational Health Clinics for Ontario Workers Inc.; **PHO** - Public Health Ontario; **PSHSA** - Public Services Health and Safety Association; **TLA** - The Lung Association; **WHSC** - Workers Health and Safety Centre; **WSIB** - Workplace Safety and Insurance Board; **WSN** - Workplace Safety North; **WSPS** - Workplace Safety and Prevention Services

Activities of the ODAP Working Groups for 2017 and 2018

Noise
- Developed and promoted key messaging about noise at work through awareness campaigns aligned with events such as International Noise Awareness Day, reaching more than 127,000 people
- Presented a series of three educational webinars promoting (1) Ontario's new Noise Regulation, (2) hazards of noise and (3) control measures, with attendance of more than 350 people
- Raised the profile of noise through various initiatives including conferences seminars and the #PreventNoise wordmark (Figure 1)

Figure 1. #PreventNoise wordmark designed by the Noise Working Group

Allergen and Irritants
- Conducted a review of research and knowledge as well as an inventory of provincial resources
- Undertook a priority setting exercise for allergens and irritants relevant to the skin and lungs
- Result is a focus on the following exposures:
  - Cleaning agents (lung irritant)
  - Isocyanates (lung sensitizer)
  - Preservatives (skin sensitizer)
  - Wet work (skin irritant)
- Next steps: identify gaps in resources and training as well as continued research and surveillance

Diesel Engine Exhaust
- Hosted a national webinar in collaboration with CAREX Canada that had over 150 attendees and is now available on CAREX Canada's website
- Developed a Joint Health and Safety Committee (JHSC) training module available on the WSN website
- Developed infographics and educational materials that are available on the OCRC and WSN websites

Intelligence and Decision Support
- Inventoried existing data resources and activities relevant to occupational exposure and disease surveillance in Ontario
- Supported the successful application for the Occupational Disease Surveillance Program, jointly funded by the Ministry of Labour and Ministry of Health and Long-Term Care
- Currently undertaking an analysis of detailed WSIB data for OD claims and exploring the use of laboratory test data for exposure surveillance

Electronic Medical Record (EMR)
- Engaged with OntarioMD, the organization responsible for EMR implementation in Ontario
- Undertaking a series of studies to assess the feasibility of, and barriers/facilitators to, completing an occupational history in the clinical setting

Prevent Occ Disease Website has officially launched!

Thu, 14 Feb 2019

Prevent Occ Disease Website has officially launched!

The Occupational Health Clinics for Ontario Workers (OHCOW) and the Canadian Centre for Occupational Health and Safety (CCOHS) have collaborated to create Prevent Occupational Disease, an online repository of current and credible occupational disease resources from Canada and around the world, reminding us to Prevent Today for Health Tomorrow. The website, aimed at reducing illness and fatalities associated with occupational sources, is intended to help employers, supervisors, safety and health practitioners, and workers alike increase their understanding of occupational diseases and ways they may be prevented.

The resources provided in Prevent Occupational Disease, relate to the science and mechanics of prevention; common hazards and their identification, exposure assessment and control; specific occupations and industries where the risk of developing occupational disease is higher; and internationally recognized occupational diseases including cancer, respiratory and skin diseases, and musculoskeletal disorders.

Prevent Occupational Disease will be continually updated with new content, and welcomes relevant submissions of free, accessible, non-commercial resources from around the world through its online form.

To read the full news release, please click here or visit the CCOHS website.

Visit the Prevent Occupational Disease website at www.preventoccdisease.ca

See Prevent Occupational Disease Website

https://www.preventoccdisease.ca/en/index.html

CAREX-OCRC Webinar on Diesel Exposure in Workplaces

This webinar conveys the importance of diesel engine exhaust as a workplace hazard and discusses ways this hazard can be assessed and controlled in the workplace. It was presented in partnership with the **Occupational Cancer Research Centre (OCRC)** and **Ontario Occupational Disease Action Plan (ODAP)** Working Group on Diesel Exhaust.

(39 min, 56 sec)

https://www.carexcanada.ca/en/videos/

Please share

Setting an Occupational Exposure Limit for Diesel Engine Exhaust in Canada: Challenges and Opportunities

Prepared by: Anya Keefe
With contributions from: Dr. Cheryl Peters, Joanne Telfer, Nicole Slot, Sandy Shergill, and Kate Jardine

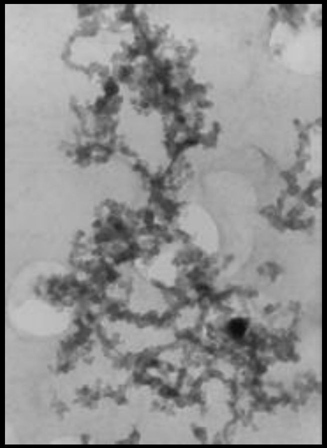
December 2019

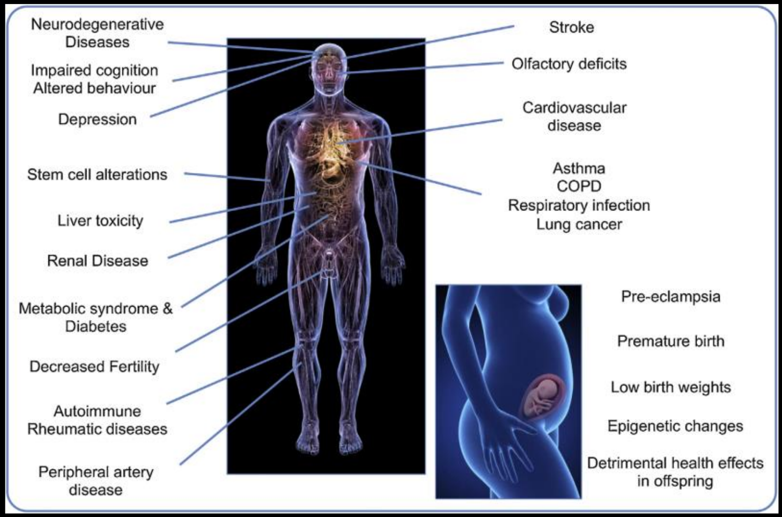
https://www.carexcanada.ca/CAREXCanada_DEE_OEL_REPORT_2019.pdf

Jennifer B. Raftis, Mark R. Miller (2019) University/BHF Centre for Cardiovascular Science, University of Edinburgh, Edinburgh, United Kingdom

Nano Today, Vol. 26, pp.8 - 12

Nanoparticle translocation
and multi-organ toxicity: A particularly small problem





high levels of DEE compared to workers exposed to low and moderate levels, from a health standpoint, these exposures are significant because cancer risk increases with level of exposure. This increased risk is reflected in the burden estimates.

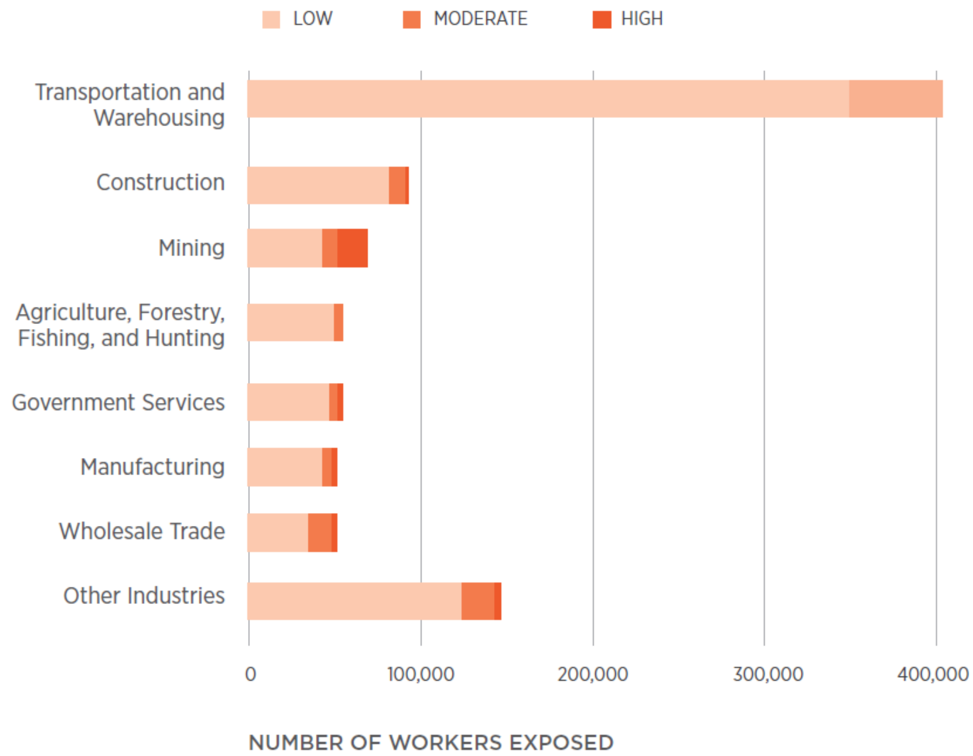


Figure 8. Number of workers occupationally exposed to DEE by level of exposure and industry in Canada in 2006.

Source: Occupational Cancer Research Centre (OCRC Sept. 2019, p. 40) – Burden of Occupational Cancer in Canada

TABLE 1: Annual burden of occupational cancer in Canada, by carcinogen

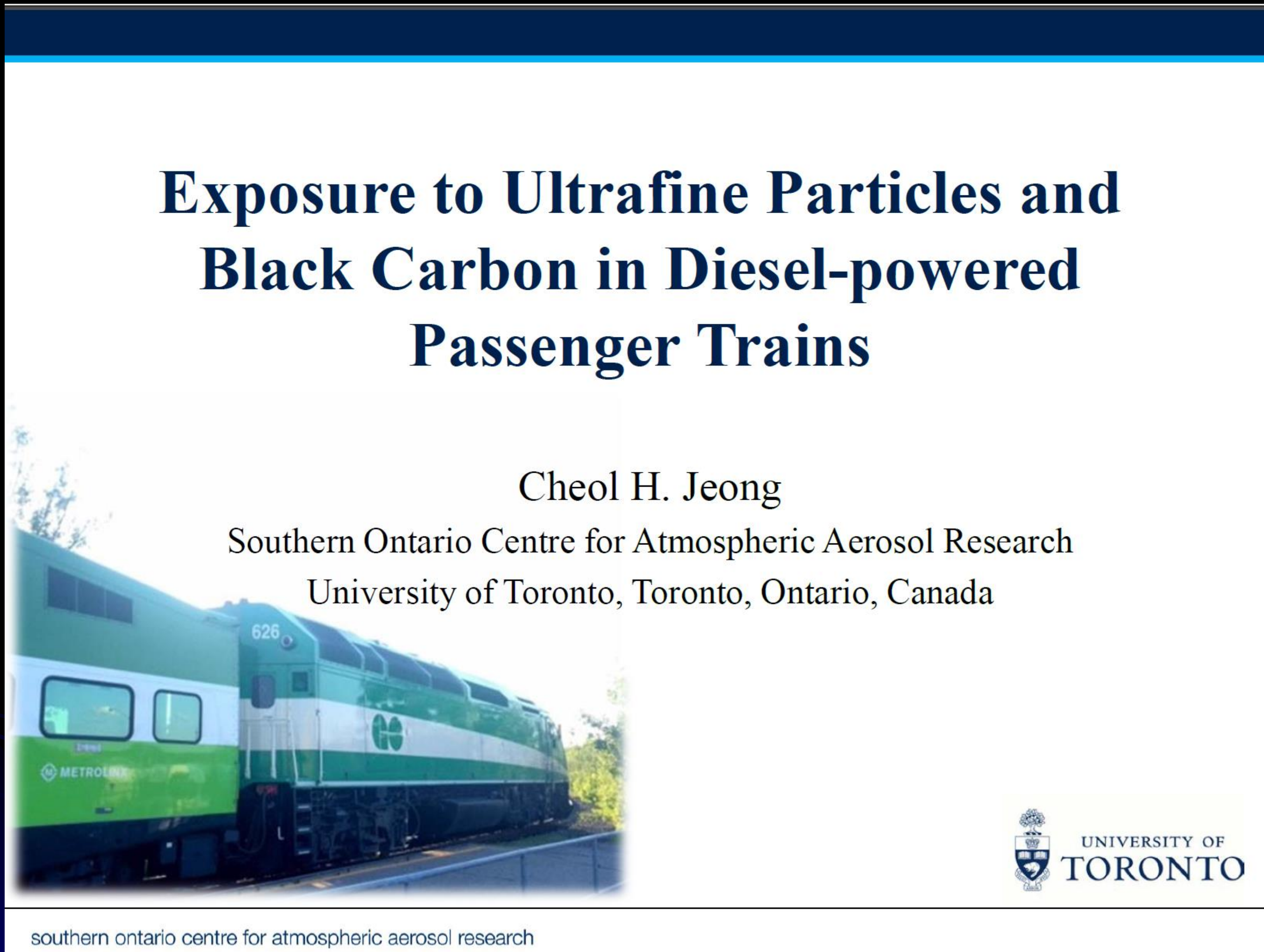
CARCINOGEN	IARC EVALUATION FOR CARCINOGENICITY	NUMBER OF CANADIAN WORKERS EXPOSED	NUMBER OF CANCERS ATTRIBUTABLE TO OCCUPATIONAL EXPOSURE (PROPORTION OF ALL CANCER CASES DUE TO OCCUPATIONAL EXPOSURE)
Solar ultraviolet radiation	Definite	1,476,000	4,600 non-melanoma skin (6.3%)
Asbestos	Definite	152,000	1,900 lung (8.0%) 430 mesothelioma (80.5%) 45 larynx (3.7%) 15 ovarian (0.5%)
Diesel engine exhaust	Definite	897,000	560 lung (2.4%) 200 bladder (2.7%)
Silica (crystalline)	Definite	382,000	570 lung (2.4%)
Welding fumes[a] Nickel compounds Chromium (VI)	Definite Definite Definite	333,000 117,000 104,000	310 lung (1.3%) 170 lung (0.7%) 50 lung (0.2%)
Radon	Definite	188,000	190 lung (0.8%)
Second-hand smoke	Definite	520,000	130 lung (0.6%) 35 pharynx (2.4%) 20 larynx (1.6%)
Night shift work	Probable	1.9 million	470-1,200 breast (2.0-5.2%)
Polycyclic aromatic hydrocarbons (PAHs)	Definite, probable, possible, unclassifiable	350,000	130 lung (0.6%) 80 bladder (1.1%) 50 skin (0.07%)
Arsenic	Definite	25,000	60 lung (0.3%)
Benzene	Definite	374,000	20 leukemia (0.5%) 5 multiple myeloma (0.2%)

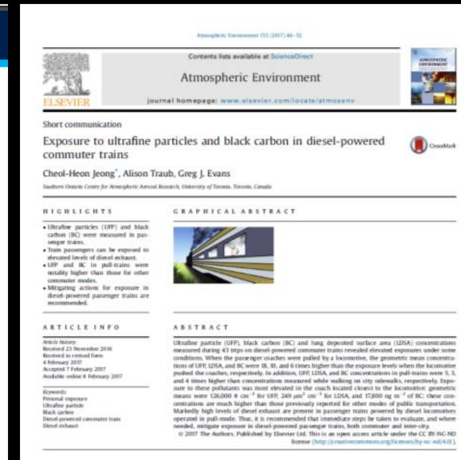
[a] Since workers may be exposed to both nickel compounds and chromium (VI) compounds through welding fumes, we have grouped these three carcinogens together. Exposure estimates for nickel compounds and chromium (VI) compounds include welders, burden estimates for exposures to nickel compounds and chromium (VI) compounds do not include welders.

Source: Occupational Cancer Research Centre (OCRC Sept. 2019, p. 11) – Burden of Occupational Cancer in Canada

Health Canada (2016) – Human Health Risk Assessment for Diesel Exhaust

Health effects	**Evidence**
Lung cancer	**Sufficient**
Acute adverse r	**Sufficient**
Chronic advers s	**Sufficient**
Acute adverse c es	**Sufficient**
Immunological	**Sufficient**
Bladder cancer	Suggestive
Chronic adverse s	Suggestive
Reproductive and developmental effects	Suggestive
Central nervous system effects based on acute neurophysiological symptoms in overexposed workers	Suggestive





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Short communication

Exposure to ultrafine particles and black carbon in diesel-powered commuter trains

Cheol-Heon Jeong*, Alison Traub, Greg J. Evans

Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, Toronto, Canada

HIGHLIGHTS

- Ultrafine particles (UFP) and black carbon (BC) were measured in passenger trains.
- Train passengers can be exposed to elevated levels of diesel exhaust.
- UFP and BC in pull-trains were notably higher than those for other commuter modes.
- Mitigating actions for exposure in diesel-powered passenger trains are recommended.

GRAPHICAL ABSTRACT

ARTICLE INFO

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Keywords:
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Black carbon
Diesel-powered commuter train
Diesel exhaust

ABSTRACT

Ultrafine particle (UFP), black carbon (BC) and lung deposited surface area (LDSA) concentrations measured during 43 trips on diesel-powered commuter trains revealed elevated exposures under some conditions. When the passenger coaches were pulled by a locomotive, the geometric mean concentrations of UFP, LDSA, and BC were 18, 10, and 6 times higher than the exposure levels when the locomotive pushed the coaches, respectively. In addition, UFP, LDSA, and BC concentrations in pull-trains were 5, 3, and 4 times higher than concentrations measured while walking on city sidewalks, respectively. Exposure to these pollutants was most elevated in the coach located closest to the locomotive; geometric means were 126,000 # cm^{-3} for UFP, 249 μm^2 cm^{-3} for LDSA, and 17,800 ng m^{-3} of BC; these concentrations are much higher than those previously reported for other modes of public transportation. Markedly high levels of diesel exhaust are present in passenger trains powered by diesel locomotives operated in pull-mode. Thus, it is recommended that immediate steps be taken to evaluate, and where needed, mitigate exposure in diesel-powered passenger trains, both commuter and inter-city.

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https://www.sciencedirect.com/science/article/pii/S1352231017300857

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Air pollution (urban) study

Air pollution particles found on foetal side of placentas – study

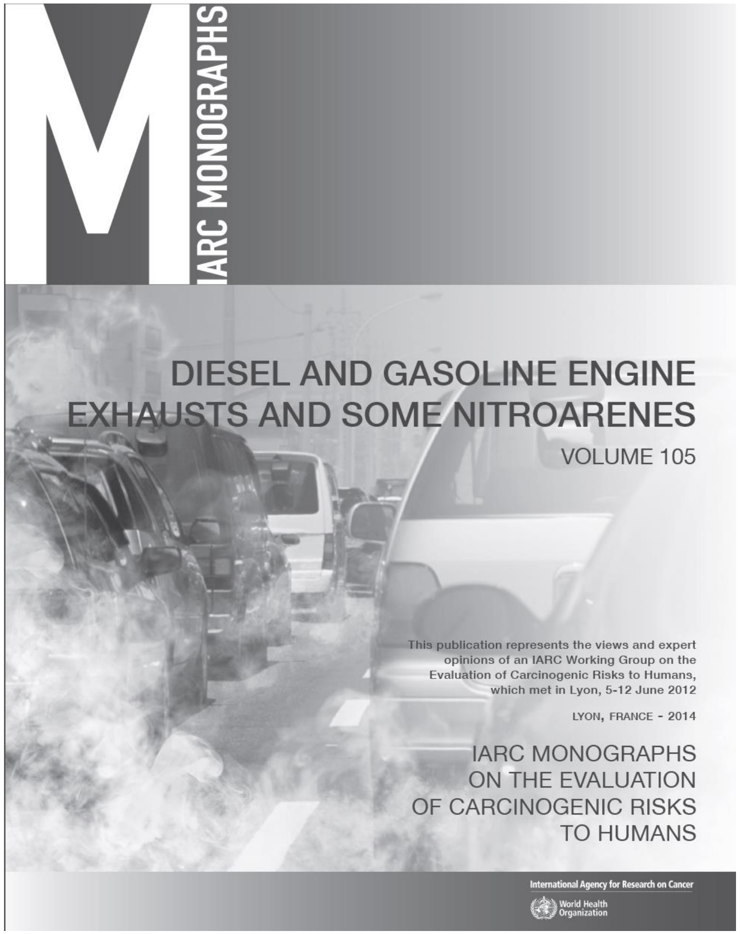
Research finds black carbon breathed by mothers can cross into unborn children

▲ The research examined 25 placentas from non-smoking women in the town of Hasselt, Belgium. Photograph: Craig Holmes Premium / Alamy/Alamy

250

Air pollution particles have been found on the foetal side of placentas, indicating that unborn babies are directly exposed to the black carbon produced by motor traffic and fuel burning.

Source: The Guardian 17 Sept. 2019, https://www.theguardian.com/environment/2019/sep/17/air-pollution-particles-found-on-foetal-side-of-placentas-study



6. EVALUATION

6.1 Cancer in humans

There is *sufficient evidence* in humans for the carcinogenicity of diesel engine exhaust. Diesel engine exhaust causes cancer of the lung. A positive association has been observed between exposure to diesel engine exhaust and cancer of the urinary bladder.

There is *inadequate evidence* in humans for the carcinogenicity of gasoline engine exhaust.

6.2 Cancer in experimental animals

There is *sufficient evidence* in experimental animals for the carcinogenicity of whole diesel engine exhaust.

There is *inadequate evidence* in experimental animals for the carcinogenicity of gas-phase diesel engine exhaust.

There is *sufficient evidence* in experimental animals for the carcinogenicity of diesel engine exhaust particulate matter.

There is *sufficient evidence* in experimental animals for the carcinogenicity of extracts of diesel engine exhaust particles.

There is *inadequate evidence* in experimental animals for the carcinogenicity of whole gasoline engine exhaust.

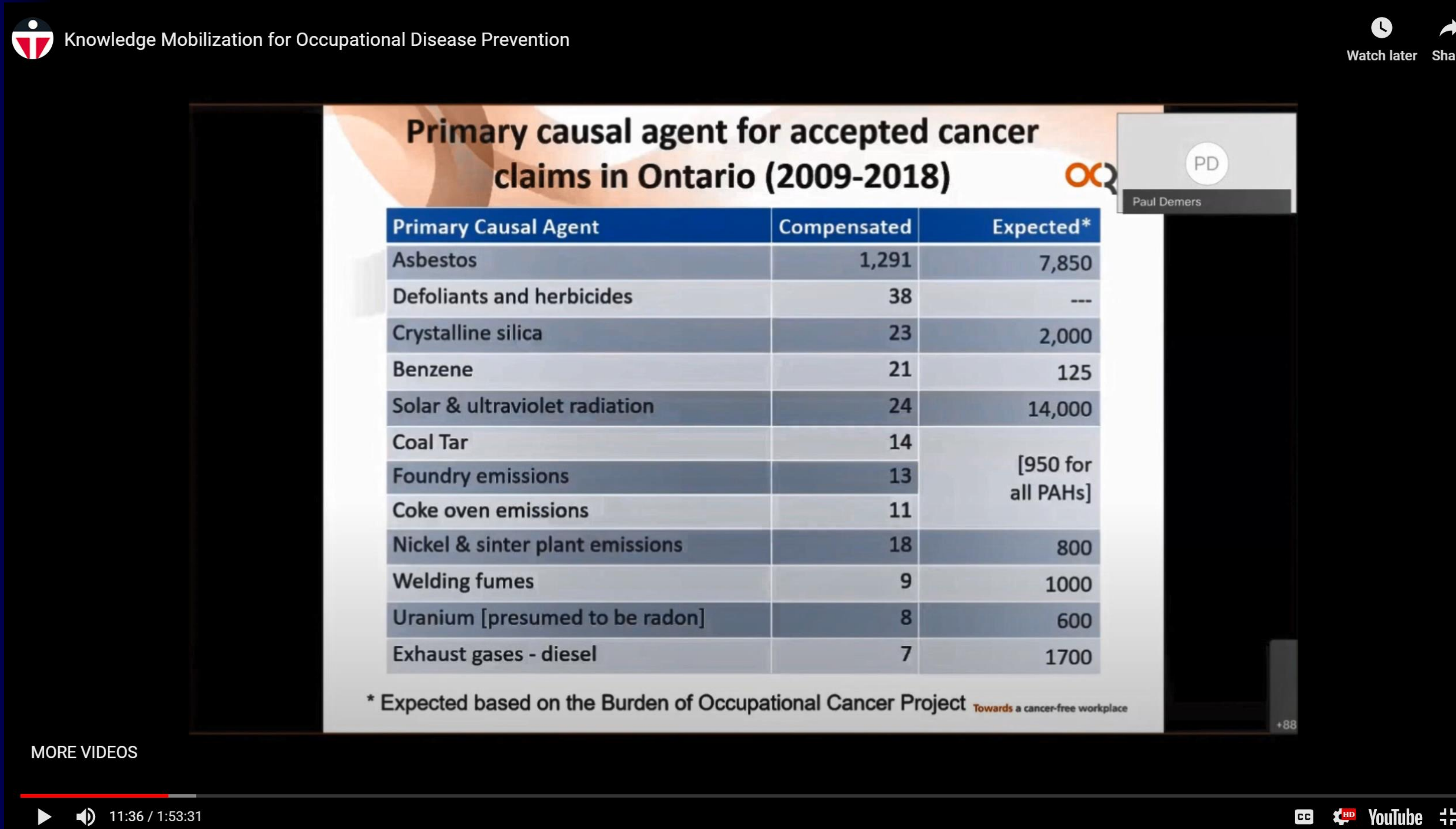
There is *sufficient evidence* in experimental animals for the carcinogenicity of condensates of gasoline engine exhaust.

6.3 Overall evaluation

Diesel engine exhaust is *carcinogenic to humans* (Group 1).

Gasoline engine exhaust is *possibly carcinogenic to humans (Group 2B).*

Diesel exhaust causes **cancer of the lung**. A positive association has been observed between exposure to diesel exhaust and **bladder cancer**.



Primary causal agent for accepted cancer claims in Ontario (2009-2018)

Primary Causal Agent	Compensated	Expected*
Asbestos	1,291	7,850
Defoliants and herbicides	38	---
Crystalline silica	23	2,000
Benzene	21	125
Solar & ultraviolet radiation	24	14,000
Coal Tar	14	[950 for all PAHs]
Foundry emissions	13	
Coke oven emissions	11	
Nickel & sinter plant emissions	18	800
Welding fumes	9	1000
Uranium [presumed to be radon]	8	600
Exhaust gases - diesel	7	1700

* Expected based on the Burden of Occupational Cancer Project

Compensated claims for cancer from exposure to diesel exhaust 2009 – 2018 : Accepted 7, expected 1700

https://www.ohcow.on.ca/news/occ-tober-2020.html

There must be a line in the sand!

Is setting a suitably protective occupational exposure limit (OEL) or target for diesel particulate matter (DPM) a **"key driver"** to reduce exposure?

Mining Diesel Emissions Council (MDEC 2017)

Why is exposure to diesel exhaust an issue (the latest)?

Organisation	Year	Comments
BHPB[6]	November 2015	After reviews by a leading Australian Epidemiologist and the IOM[7] BHPB (Global Standard) – Exposure must be **as low as technically feasible**. Interim target set at **0.03mg/m³** (measured as EC NIOSH 5040)
Health Canada[8]	2017	Human Health Risk Assessment for Diesel Exhaust. **Causal lung cancer, suggestive bladder cancer.**
OCRC[9]	2017	Burden of Occupational Cancer in Ontario. Policy Recommendations For Diesel Engine Exhaust: 1. Adopt occupational exposure limits of **0.02mg/m³ (elemental carbon EC) for the mining industry and 0.005 EC mg/m³ for other workplaces).** 2. Upgrade or replace old on-road and off-road trucks and diesel engines. (OCRC, 2017 p.25).

Occupational Cancer Research Centre

Report Release: Burden of Occupational Cancer in Ontario (2017)

POLICY RECOMMENDATIONS FOR DIESEL ENGINE EXHAUST

1. **Adopt occupational exposure limits of 20 μg/m³ elemental carbon for the mining industry and 5 μg/m³ elemental carbon for other workplaces.** The Ontario Occupational Health and Safety Act (OHSA) prescribes occupational exposure limits for many of the gases and particulates found in DEE.[57] Limits for exposure to total carbon and elemental carbon, which is used as a surrogate for the carcinogenic effects of DEE, have been set for underground mines under Regulation 854 (Mines and Mining Plants).[56] However, the OHSA does not currently prescribe limits for elemental carbon. Other jurisdictions, including Finland, have implemented standards of 100 μg/m³ elemental carbon.[58] The Finnish Institute for Occupational Health recommends occupational exposure limits of 20 μg/m³ elemental carbon for the mining industry and 5 μg/m³ elemental carbon for other workplaces,[59] based on evidence of health effects and feasibility considerations. These more stringent limits would substantially reduce exposure and protect worker health given the large number of workers occupationally exposed to DEE in Ontario and growing scientific evidence demonstrating adverse health effects of DEE, even at low concentrations.[60,61]

2. **Upgrade or replace old on-road and off-road trucks and diesel engines.** Engine replacement and/or installation of engineering controls are better able to reduce overall DEE emissions than administrative controls, such as maintenance.[51] Regulations that outline allowable emissions for new models of on-road vehicles and engines were implemented under Canada's Environmental Protection Act from 2001 to 2012.[62] However, immediate significant decreases in diesel particulate matter are not expected, since older engines are not covered under these regulations and can continue to be used until they need replacement.[48] For off-road diesel engines, there are regulations that limit emissions, such as Off-Road Compression-Ignition Engine Emission Regulations (SOR/2005-32), and Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations.[63,64] Upgrading or replacing old off-road diesel engines is a larger challenge than on-road diesel engines. There is a precedence of mandating the transition to upgraded or newer on-road engines in other jurisdictions, such as California.[65] Upgrading old engines or vehicles may be costly, so regulations could be rolled out incrementally and accompanied with financial supports for companies affected (e.g., through financial awards or tax credits).[66]

The Finnish Institute for Occupational Health recommends occupational exposure limits of 20 μg/m³ elemental carbon for the mining industry and 5 μg/m³ elemental carbon for other workplaces, based on evidence of health effects and feasibility considerations.

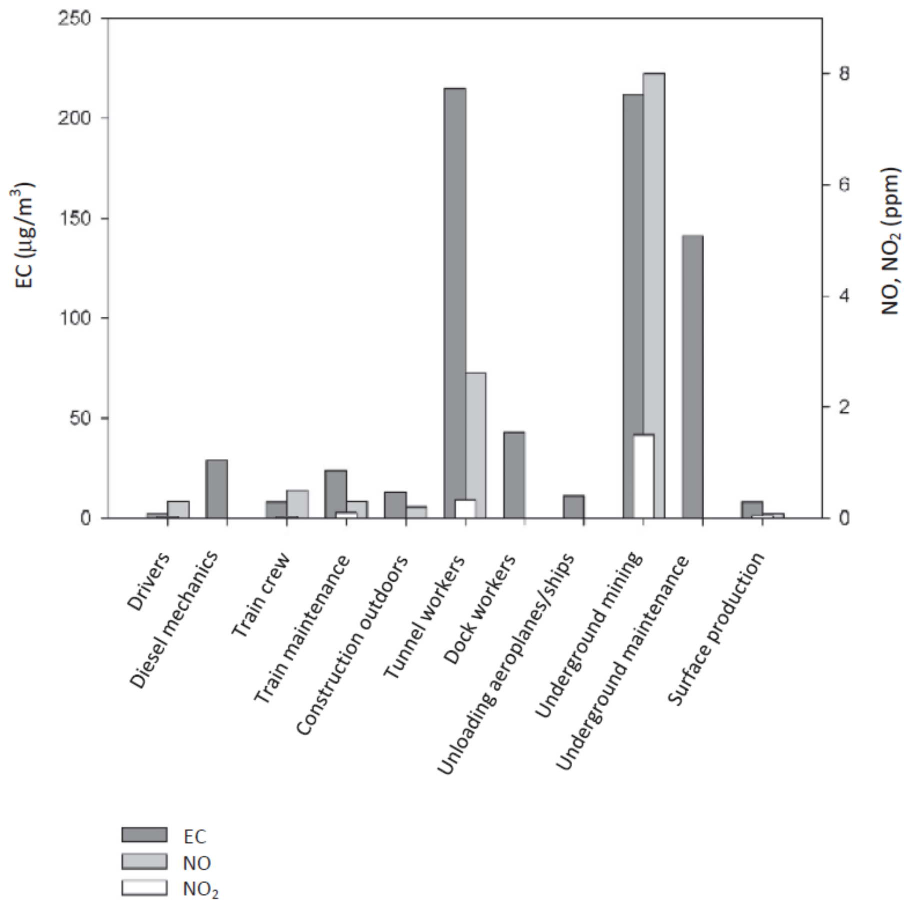
Latest from Ministry of Labour [(March 20 2018) current and proposed exposure limits]**:** On and off-road diesel engines are widely used in other industries such as construction, transportation and warehousing. As an important first step in minimizing and controlling worker exposures to DPM in these sectors, the MOL is proposing to add a new listing and OEL for DPM measured as total carbon, in the Ontario Table (Table 1) in **Regulation 833 based on the revised MSHA limit of 160 µg/m^3, (0.16mg/m^3)total carbon (~0.1 mg/m^3 Elemental Carbon)(MOL, 2018). 45 day consultation period due May 4, 2018.**

For the first time in Canada, an Occupational Exposure Limit (OEL) for diesel particulate matter (DPM), is being proposed, which applies to all workplaces in Ontario.

Are regulators setting occupational exposure limits, **at levels low enough,** to drive continuous improvement and provide the impetus for newer technology such as higher tier engines and / or battery powered vehicles?

IARC MONOGRAPH – 105

Fig. 1.17 Average personal exposures to elemental carbon, and nitric oxide and nitrogen dioxide by major occupational group predominantly exposed to exhaust from diesel engines



Compiled by the Working Group
EC, elemental carbon; NO, nitrogen oxide; NO_2, nitrogen dioxide

Current ON mining OEL for diesel particulate matter

MOL proposal based on MSHA (mining) 2008 OEL

MOL proposed OEL for all work places (160 µg/m³ TC equivalent to ~ 100 µg/m³ EC)

EU OEL (50 µg/m³)

OCRC (20 µg/m³ mining and 5 µg/m³ other workplaces)

https://www.occupationalcancer.ca/2014/iarc-monographs-volume-105/

Measure using NIOSH 5040

Or perhaps qualitative assessment

1) Did you have diesel powered machinery in your workplace?
2) If so: little, big, a couple of engines, lots of engines?
3) Was there a smoky-looking haze when diesel engines were used?
4) Was there a blue or black smoke coming from diesel exhaust?
5) Did you notice any sooty deposits on walls or permanent fixtures?
6) Did you smell exhaust during your work day?
7) Did you notice it first thing in the morning?
8) Was it intermittent or was it there all the time?
9) Did you find yourself coughing more at work than away from work?
10) Did your eyes water or become itchy when diesel machinery was operating?

Based on the feedback once we know there is a problem – what do we do?

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. ?

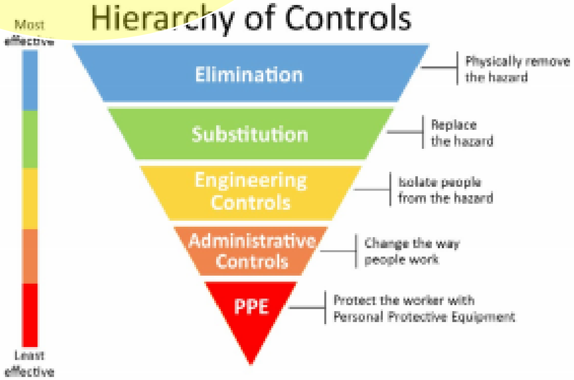
Scheduling and site planning
Control the number of diesel engines operating in an area. Schedule workers during times when fewer diesel engines are working. ?

Monitoring emissions
An emissions monitoring program is critical for ensuring that diesel controls are functioning properly. ?

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. ?

Hierarchy of Controls



REACTIVE CONTROLS

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

Occupational Cancer Research Centre

Towards a cancer-free workplace

Reproduced with permission from OCRC

After treatment Solutions for Portable & Off Highway Equipment

((Diesel particulate filters (DPFs))

DCL

YouTube video

https://www.youtube.com/watch?v=NihE9g5r4nI

https://www.dcl-inc.com/products/diesel-particulate-filters/

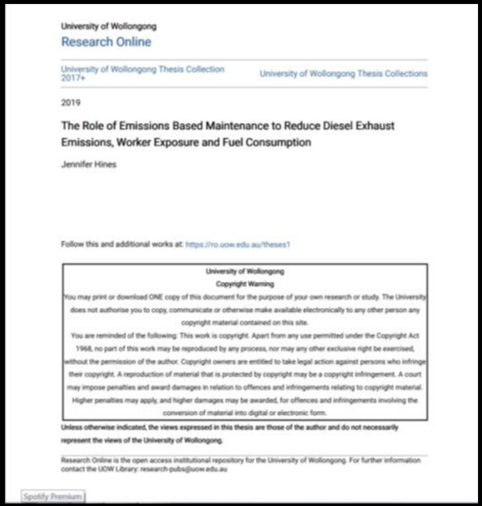
Mammoth Equipment

Mammoth ad

https://mdec.ca/2020/ad_mamoth.pdf

https://www.mammothequipment.ca/

Refer to Mining Diesel Emissions Council (MDEC)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The Role of Emissions Based Maintenance to Reduce Diesel Exhaust Emissions, Worker Exposure and Fuel Consumption

Jennifer Hines

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Spotify Premium

Dr. Jennifer Hines
PhD. Thesis, 2019

The Role of Emissions Based Maintenance to Reduce Diesel Exhaust Emissions, Worker Exposure and Fuel Consumption

The proactive maintenance of diesel engines, known as **Emissions Based Maintenance (EBM)**, to reduce workplace exposures to diesel exhaust is one type of control strategy. This type of maintenance is **above, and beyond 'normal' logbook/warranty style maintenance recommended by the OEM and uses data measured from an individual engine to determine maintenance required.** This is a preferred, higher order control as it reduces emissions at the source, preventing contaminants from reaching the workplace environment and exposing workers.

EBM has the potential to have a significant return on investment with respect to reducing exposures to workers and reducing fuel consumption, and therefore costs. This thesis also provides evidence that maintenance of existing diesel exhaust emissions aftertreatment devices contributes to a significant proportion of this reduction. If sites are not monitoring the effectiveness of controls fitted to vehicles, they cannot ensure emissions are maintained at a level that is as low as reasonably practicable. **Research in Canada and Australia has shown that an effective EBM programme within mining operations could potentially reduce employee exposures to diesel particulate matter (DPM) by up to 50%.**

How low is low enough?

The Dutch Committee on Occupational Safety (DECOS) has estimated so-called health-based calculated occupational cancer risk values (HBC-OCRVs) The DECOS estimates that the exposure concentrations of respirable elemental carbon in the air, which serve as parameter for exposure to diesel engine exhaust powered by petroleum-diesel fuels, and which corresponds to:

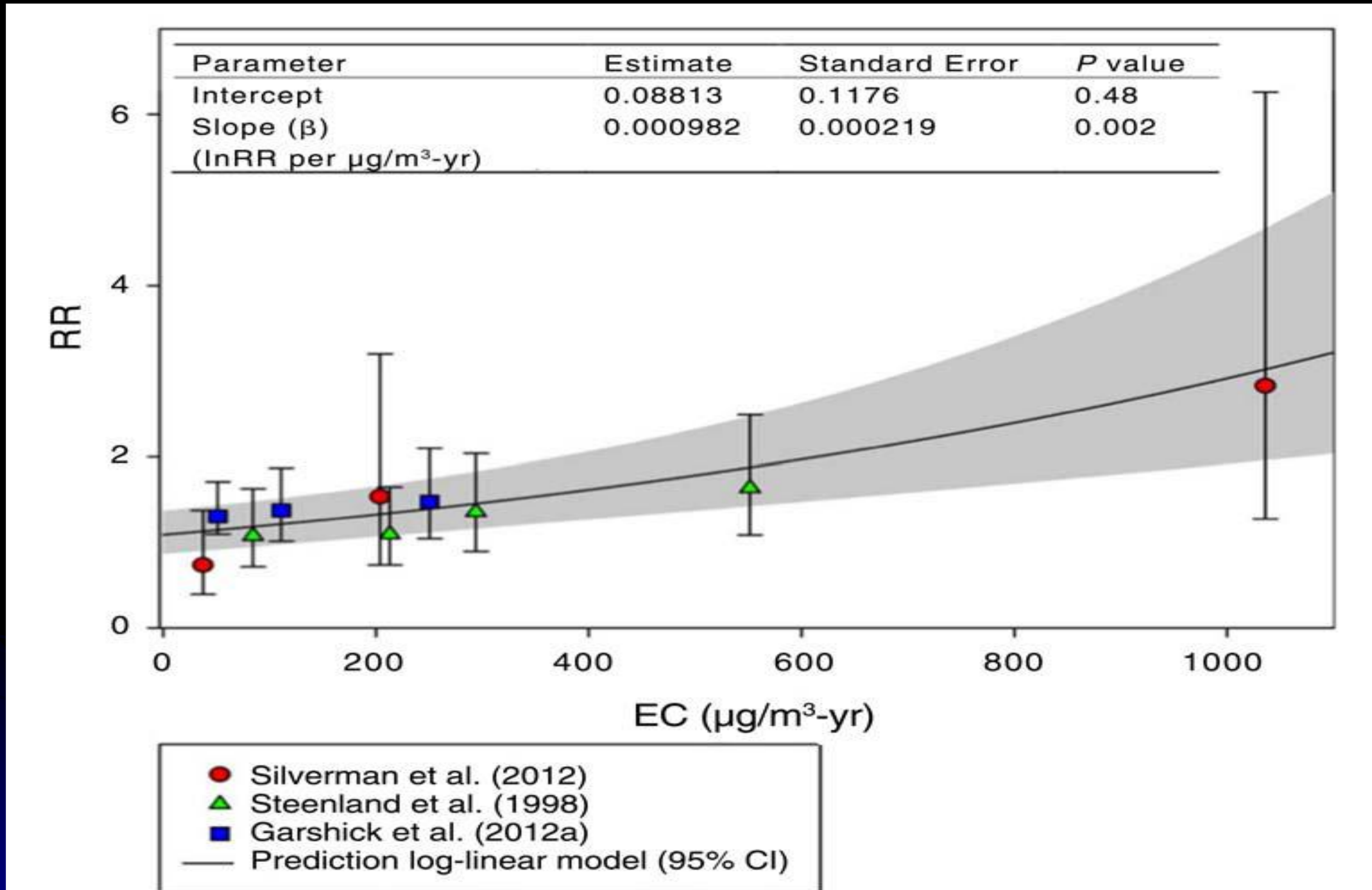
- 4 extra death cases of lung cancer per 100,000 (target risk level), for 40 years of occupational exposure, equals to 0.011 µg REC/m^3,

- 4 extra death cases of lung cancer per 1,000 (prohibition risk level), for 40 years of occupational exposure, equals to 1.03 µg REC/m^3.

Occupational health and safety legislation and regulations are a method for the primary prevention of injury and disease at the societal level. They are intended to establish a minimum level of protection either for all workers or for those in specific industries.

Regulatory approaches to preventing occupational disease include: limits on levels of exposure

A performance-based regulation establishes the endpoint and allows the employer to identify the most suitable means of achieving it. A prescriptive regulation specifies the endpoint and the means by which it is to be achieved.



Relative risks were estimated using exposures lagged 15 years in Silverman et al. (2012) and 5 years in both the Garshick et al. (2012a and Steenland et al. (1998), based on the best model fit in each study. The authors presented sensitivity analyses to lag choices in supplemental material, available online. Elemental carbon was measured as REC in DEMS, as SEC in Garshick et al. (2012a), and as EC in Steenland et al. (1998). SOURCE: Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. 2014b. Exposure–response estimates for diesel engine exhaust and lung cancer mortalitybased on data from three occupational cohorts. Environ Health Perspect 122:172–177. doi: 10.1289/ehp.1306880.

Diesel Engine Exhaust Exposure, Smoking, and Lung Cancer Subtype Risks

A Pooled Exposure–Response Analysis of 14 Case–Control Studies

August 1, 2020

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Measurements and Main Results: Our study included 16,901 lung cancer cases and 20,965 control subjects. In men, exposure response between EC and lung cancer was observed: odds ratios ranged from 1.09 (95% CI, 1.00–1.18) to 1.41 (95% CI, 1.30–1.52) for the lowest and highest cumulative exposure groups, respectively. EC-exposed men had elevated risks in all lung cancer subtypes investigated; associations were strongest for squamous and small cell carcinomas and weaker for adenocarcinoma. EC lung cancer exposure response was observed in men regardless of smoking history, including in never-smokers.

Lung cancer excess lifetime risks (ELR) associated with **45 years of EC exposure at 50, 20, and 1 μg/m3 were 3.0%, 0.99%, and 0.04%,** respectively, for both sexes combined.

American Journal of Respiratory and Critical Care Medicine Volume 202 Number 3 August 1 2020, p.402.

Diesel Exhaust Lung Cancer Risk Calculator

years of exposure	**25**	years
average respirable elemental carbon (REC) exposure (in µg/m^3)	**5**	µg/m^3
15-year lagged cummulative respirable elemental carbon exposure (in µg/m^3-yrs)	**50**	µg/m^3 - years
model estimated relative risk (RR) =	**1.15**	
95% confidence interval:	0.89	1.48

(model based on 0-1000 µg/m^3-yrs range)

model taken from: Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. 2014. "Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts". Environ Health Perspect 122:172–177; http://dx.doi.org/10.1289/ehp.1306880

http://jnci.oxfordjournals.org/content/suppl/2012/01/28/djs034.DC1/Supp_methods_and_tables_4-30-12.pdf

John Oudyk, Occupational Hygienist OHCOW

Diesel Exhaust Lung Cancer Risk Calculator

years of exposure	**25**	years
average respirable elemental carbon (REC) exposure (in µg/m^3)	**100**	µg/m^3
15-year lagged cummulative respirable elemental carbon exposure (in µg/m^3-yrs)	**1000**	µg/m^3 - years
model estimated relative risk (RR) =	**2.92**	
95% confidence interval:	1.51	5.64

(model based on 0-1000 µg/m^3-yrs range)

model taken from: Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. 2014. "Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts". Environ Health Perspect 122:172–177; http://dx.doi.org/10.1289/ehp.1306880

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