NSW SURFACE COAL MINING PRELIMINARY REPORT: EXPOSURE ASSESSMENT FOR RESPIRABLE DUST AND RESPIRABLE CRYSTALLINE SILICA

Project No 20642

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Executive Summary

Silicosis is a disease which, unfortunately, is seeing a resurgence nationally in Australia, as well as internationally. Silica exposure is increasingly suspected as a driving force behind the rising incidence of coal workers' pneumoconiosis (CWP) in some jurisdictions. Silica is a major component of the earth's crust, thus any blasting, drilling, cutting, crushing or movement of rock has the potential to create and liberate respirable crystalline silica (RCS). This creates a potential risk of exposure for mine workers, both underground and surface (open cut).

In NSW, statutory monitoring of dust in coal mines is conducted under Order 42. The Order is focused on underground mines, and a large data set of exposure information has been collected. In contrast, the monitoring of surface (open cut) mines has been minimal. Order 42 requires only five samples per year be obtained from the open cut, and until recently, only one of these samples was analysed for respirable crystalline silica (RCS). Exposure sampling has been concentrated on the shotfirers and drillers, who are considered to have the highest risk for exposure to RCS. The lack of available data on exposure levels for surface coal miners left a gap in the knowledge of the actual risk they face, and what degree of health monitoring is appropriate. This study has been designed to test more extensively across a number of similar exposure groups (SEGs) to fill the gap in the literature.

A statistical analysis of the results was conducted, which confirmed a significant difference in exposure levels for blast hole drillers and the blast crews, compared to other SEGs. There were a significant number of drillers and blast crew exceeding the exposure limits for RCS at 7.4% and 4.3% respectively. The results also confirmed that the great majority of surface miners are exposed below the workplace exposure limits for both respirable dust and RCS. The rate of over-exposure for RCS in the remaining SEGs was very low (0.0% to 1.1%).

On 31 July 2019, State and Federal environment ministers met to discuss workplace RCS WES. It was reported that a move to lower the RCS exposure limit from 0.1mg/m^3 to 0.05 mg/m^3, half of the current WES, was possible. There has been no official announcement on the proposed respirable dust WES, but there is some expectation that a level of 1.5 mg/m^3 may be agreed upon. Accordingly, the results in this study were assessed against both the current and the possible WESs.

There were few results which exceeded the current and possible WESs for respirable dust. The results for RCS were much higher, with the WESs exceeded in the blast crew and blast hole driller SEGSs in 13.8% and 19.0% of the samples, respectively. In the mobile plant operator SEG, 7.4% of the results exceeded the WES, closely followed by the Maintenance SEG at 6.0% and the CHPP SEG at 1.2%.

The action level for reviewing the effectiveness of current controls is at 50% of the WES. Therefore, considerable numbers of surface miners across the SEGs involved in production, processing and maintenance will have results requiring action and health monitoring. Statistical analyses were not performed on the action level, as this level is considered best practice, but is not enforceable.

The published recommendations for health monitoring for RCS exposure vary, but generally range between two and five years. The results suggest a low exposure risk for most surface coal miners, in terms of developing a respirable dust / RCS related lung disease. There are, however, two SEGs where additional monitoring is recommended: blast hole drillers and blast crews. Furthermore, it is recommended that monitoring of surface coal miners involved in production processing and maintenance continues at a three yearly interval including a chest x-ray.

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Introduction

This project was undertaken for the Coal Service Health and Safety Trust as part of a Research Grant (Project No 20642). The reidentification and resurgence of coal mine dust lung disease (CMDLD) in the Queensland coal industry sparked a renewed interest in dust diseases and their detection and prevention in Australia. Long thought controlled, Safe Work Australia is currently reviewing occupational exposure limits for respirable crystalline silica (RCS) and respirable dust (coal).

Globally, silicosis remains a major industrial health issue which has been reported to cause the death of tens of thousands of people annually. Most of these deaths occur in developing countries; however, developed nations continue to record new cases and deaths as well. Nationally in Australia, there are new cases of silicosis and related deaths of stonemasons in multiple States. Despite the recent media attention, the overall deaths of workers attributed to silicosis have decreased around the globe. The recent rising incidence of silicosis and coal workers pneumoconiosis (CWP) in some coal mining districts in the United States demonstrate that adverse health effects from exposure to RCS still occur to this day and is not as well controlled as widely accepted.

A number of studies in the United States have reported CWP and progressive massive fibrosis (PMF) developing in surface miners, including those with no previous underground experience. Closer to home, the recent case series on Queensland coal miners published by the Wesley Dust Disease Research Centre, also found that 26.7% of cases worked in open cut coal mines only, with no work experience in underground mining (which is traditionally associated with CWP).

Quartz is the second most common mineral found in the earth's crust. Mining and its associated processes inevitably involve exposure to rocks containing significant percentages of crystalline silica. The respirable fraction of the dust is the main concern for developing adverse health effects. This is due to their small size (<5 micron), which enables these particles to travel down the respiratory system, and into the bronchi and alveoli where it causes

irritation of the lung, and subsequently leads to the formation of scar tissue, or fibrosis. RCS has been classified as a human carcinogen (Group 1) and is highly fibrogenic. These particles may cause nodular or diffuse patterns with disease progression continuing even after exposure ceases. Exposure to RCS can also cause a loss of lung function without other features, chronic obstructive lung disease, and has a detrimental effect on cellular immunity. There is also an increased risk of severe lung infections and tuberculosis, auto-immune diseases and kidney disease.

The likelihood of developing a disease associated with exposure to RCS, is linked to the cumulative dose. There are three forms of silicosis: acute, chronic and accelerated. Due to legislative controls on sandblasting and occupational health, we are unlikely to see acute silicosis cases in Australia. The most likely form of silicosis encountered in workplaces is chronic silicosis, which develops after 10 - 15 years of chronic low exposure and is associated with industries such as coal mining. Accelerated silicosis develops after only 5 - 10 years after first exposure, and this is what is currently occuring in the Stonemason industry.

Despite the range and seriousness of diseases linked to RCS, no “universal standard exists for the frequency of such assessment”. Locally, the Australian Institute of Occupational Hygienists (AIOH) recommends that medical surveillance should be undertaken when there is a likelihood of 50% of the WES being exceeded. Due to the multitude of potential health effects associated with this contaminant, health surveillance for workers potentially exposed to RCS is mandatory in the State of NSW.

In NSW, health surveillance is required under the Work Health and Safety Act 2011, and Work Health and Safety Regulation 2017, where a significant risk to the worker’s health is identified due to exposure to a hazardous chemical. NSW coal mine workers who are potentially exposed to respirable dust and RCS, typically undergo routine chest x-rays as part of this health surveillance.

Legislation also ensures ongoing personal respirable dust exposure monitoring is conducted at every coal mine in NSW.

The frequency and requirements of this monitoring is specified in Order 42. It is also the responsibility of the mine operator to arrange for a licenced provider to undertake statutory personal dust monitoring in locations and at a frequency as prescribed in Schedule 6 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014. Underground mines can have upwards of 10 miners for every shift (at multiple locations throughout the mine) monitored every six months. These data can be analysed and used to assist workplaces to make evidence-based decisions with which to manage and control workers' exposure. Open cut mines only require five miners monitored once every 12 months. Previously, only one sample from each similar exposure group (SEG) was analysed for RCS. This affects the amount of data available for the purposes of prevention and health surveillance. A consequence has been a lack of knowledge of what dust exposures many surface miners actually face and what health monitoring is indicated.

Safe Work Australia details national workplace exposure standards in the publication *"Exposure Standards for Atmospheric Contaminants in the Occupational Environment"*. In New South Wales, work environment regulations are administered by the Work Cover Authority, which use Time Weighted Average (TWA) concentrations set by SafeWork Australia as guides for the control of occupational health hazards. The exposure standards represent airborne concentrations of individual substances that, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers.

The exposure standards detailed refer to airborne concentrations of substances in the breathing zone of the worker, determined by personal sampling. Exposure standards do not represent 'no-effect' levels, which guarantee protection to every worker. Given the nature of biological variation and the range of individual susceptibility, it is inevitable that a proportion of those who are exposed to concentrations around or below the exposure standard may suffer effects. Table 1 lists the current statutory dust levels for respirable dust and respirable

crystalline silica, as well as the possible exposure limits, which are currently under review. Exposure standards for airborne contaminants are expressed as a time-weighted average (TWA) concentration of that substance over an eight-hour working day, for a five-day working week. During periods of continuous daily exposure to an airborne contaminant, these TWA exposures permit excursions above the exposure standard, provided they are compensated for by equivalent excursions below the standard during the working day.

Table 1 Workplace Exposure Standards (WES) for Respirable Dust and RCS

Hazard	WES TWA (mg/m^3)	Possible WES (mg/m^3)
Respirable dust[1]	2.5	1.5
Respirable Crystalline Silica	0.1	0.05

In order to provide evidence-base strategies for exposure management, statistically sound exposure data is required to appropriately quantify the workers at risk, and the relevant SEGs where these exposures are likely to occur. This study aimed to obtain a statistically significant sample of the dust exposures of current NSW surface (open cut) coal miners. This could then be used to guide protective strategies and health monitoring priorities.

[1] Respirable coal dust containing < 5% respirable quartz

Research Question

Are some surface (open cut) miners exposed to levels of respirable dust and respirable crystalline silica (RCS) that would require routine chest x-rays as part of their health surveillance?

Project Aims

This projected aimed to identify areas and occupations in surface mining that are at high risk of respirable crystalline silica (RCS) exposure. The findings from this project could be used to develop an evidence-based health surveillance guideline for the Australian Coal industry. Specifically, this project aimed to:

1. Undertake a targeted exposure assessment program with which to quantify the levels of exposure to respirable dust and RCS surface mine workers are exposed to, including identification of high-risk activities.
2. Develop health surveillance programs tailored to the risk profile identified in the exposure assessment program. A statistically valid, critical analysis of the data and observations form the basis of this report and will be communicated to industry stakeholders.
3. Provide evidence-based data with which to develop appropriate education and control strategies.
4. Critical analysis of the PDM3700 in respirable dust and RCS health exposure assessments.

Project Scope

The scope of the project included:

1. Monitoring, analysis and reporting of respirable dust and RCS samples.
2. Purchase of PDM3700 real time dust monitor, filter and software for real time dust sampling.

Methodology

Historical data, experience and observations suggest that the operators at highest risk of respirable dust and RCS exposure in surface operations are most likely those that are working in close proximity to drilling, loading and stemming operations, particularly if workers spend time in these areas outside of air-conditioned cabins. It has been assumed that mobile plant operators work inside sealed cabins, reducing their risk of exposure, and maintenance crews in the workshops were removed from areas of hazardous dust levels. Consequently, very little monitoring has been done on these groups until now.

Study design and population

This was a retrospective observational study, aiming to quantify the exposures of workers employed at open-cut mines and coal handling preparation plants (CHPPs) which will allow the development of an evidence-based, strategic and representative sampling regime for respirable dust and respirable crystalline silica (RCS). These statutory monitoring regimes are put in place to ensure that a system that has protected mineworkers' health and minimised lung disease remains effective.

Under their statutory duty (Order 42), Coal Services employs appropriately trained and qualified Occupational Hygiene Technicians (OHT) who are responsible to undertake the exposure surveys and sampling of the coal mines (both underground and open cut).

The scope of the current study falls outside the statutory duties of Coal Services, and thus the mine managers of each coal mine in NSW were contacted via email and invited to participate in the study. It was intended that sampling would occur in conjunction, with the statutory sampling program, and that the results would be reported back to site.

The sampling strategy involved a random selection of samples across each open cut mine, operated in the State of New South Wales. Coal Services' OHTs attended sites as per statutory requirements and availability. The order of sites visited was dictated by the statutory compliance dates for their testing. The exact days for testing were determined by weather conditions and operational considerations at the mine site. Many of the high-risk roles tested, such as shotfirers and drillers, do not operate on every shift and parts of the mine and coal handling and preparation plant can be shut down for periods. The size of some operations and the staggering of shifts meant that some sites would require multiple visits to achieve the proposed number of samples.

All coal mines in NSW agreed to participate in the study, and sampling commenced in January 2017. It was anticipated that data collection would take approximately eight months; however, a prolonged period of wet weather and then increased statutory commitments slowed the rate of data collection, and the data collection was completed in two years (February 2019).

Personal sampling methods

Respirable dust sampling and gravimetric analysis was completed following Coal Services - Occupational Hygiene NATA accredited respirable dust sampling and analysis procedure. This procedure was drawn up in accordance with AS2985:2009 - Workplace Atmospheres – Method for Sampling and Gravimetric Determination of Respirable Dust.

Respirable Dust sampling and Analysis was carried out in accordance with Coal Services procedures CMTS-OH2P-4 Collection of Dust Samples, and CMTS-OH2P-8 Gravimetric Analysis, which were developed by Coal Services to meet the requirements of AS2985-2009. Sampling and analysis were criteria were covered by NATA Accreditation for Methods 7.82.04 - Respirable Dust. Monitoring and reporting were completed in accordance with requirements of the NSW Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.

The dust samples were collected using Casella (Higgins-Dewell) respirable dust cyclones, equipped with 25mm filters, which were connected via sampling trail to a battery-operated air sampling pump, either a Casella Tuff or Casella Apex 2. These pumps were calibrated at a set flow rate of 2.2 L/min. Flow rates were verified (calibrated) with a calibrated SKC Field Rotameter (400 - 5000 ml/min).

At each site, workers within the SEG identified for sampling, were chosen by a mine official at the start of shift. A Coal Services OHTs on site fitted a sampling pump within the breathing zone of each randomly selected worker, according to the Australian Standard AS2985-2009. The sampling pumps were collected by the OHTs at the end of the sampling period.

The respirable dust fraction of each sample was determined through gravimetric analysis, in accordance with AS2985:2009, using either a calibrated Mettler MX5 or Mettler XP6 microbalance. Respirable crystalline silica (RCS) Quartz content was determined using the "potassium bromide disk" method in the National Health & Medical Research Council (NIOSH Method 7500): Methods for Measurement of Quartz in Respirable Airborne Dust by Infrared Spectroscopy and X-Ray Diffractometry, by the NATA accredited laboratory, Pickford & Rhyder Consulting.

The samples which were included in this study, were samples which:

1. had a minimum sampling time of 300 minutes
2. met pre- and post- shift calibration requirements (calibration within 5% of the set flow rate)
3. had intact filters (not torn, damaged or wet).

All samples where the sampling pumps were removed during the shift, or where pumps were tampered with, were excluded from the study.

Real time dust monitoring

A continuously recording real time monitor was used in conjunction with the personal gravimetric monitoring device and other data recording means to more closely discriminate and quantify the incremental exposure of mine workers due to the varying activities across a shift.

The purchase of a continuously recording real time monitor was proposed for use in conjunction with the personal gravimetric monitoring device and other data recording means to more closely discriminate and quantify the incremental exposure due to the varying activities across a shift. The Thermo Fisher PDM 3700 personal dust monitor was used to measure respirable dust exposure levels for a range of operator tasks during shot firing activities. The PDM 3700 uses Tapered Element Oscillating Microbalance (TEOM) technology to determine respirable dust levels.

This method of exposure assessment is aimed at capturing task based exposure levels and does not comply with the Australian Standard for Respirable Dust Monitoring AS2985 which requires personal gravimetric monitoring for a representative period that is greater than 4 hours. Reported results are therefore not able to be used to determine compliance to NSW Coal Mines Respirable dust exposure limit of 2.5mg/m³.

Study sample

Coal services conducted 209 occupational hygiene surveys of surface (open cut) mines and surface facilities of underground mines over 2 years. The data collection commenced on 16 January 2017 and was concluded on 14 February 2019. Monitoring was conducted during a range of environmental conditions, including seasonal variation. The data collected included personal respirable dust samples, which were analysed for respirable crystalline silica (RCS), both reported in mg/m^3. Not all samples were analysed for RCS, due to cost implications.

Data cleaning and organisation

The study sample contained 1116 records; however, 45 records with missing sample length (volume) were excluded from the analysis. Data were divided into similar exposure groups (SEGs) for reporting purposes. SEGs with less than six (6) samples are included in the results, but not discussed as these are not representative samples.

Statistical Analysis

Statistical analyses were programmed using SAS v9.4 (SAS Institute, Cary, North Carolina, USA). All data were checked for completeness and discrepancies before analysis.

Descriptive statistics are reported for all relevant variables, including frequencies and percentages for categorical variables, and means, standard deviations, medians, ranges and interquartile ranges for continuous variables. Chi-Square tests were used to compare the proportion of workers with exposures to respirable dust and Respirable crystalline silica, above the current and possible workplace exposure standards (WES). In instances where the assumption of expected cell counts was violated the Fisher's Exact Test was used instead of the pooled variance.

Results

Study Sample - Population Demographics

The distribution of open cut coal mine workers (hereafter referred to as mine workers) across the seasons and SEGs are shown in Figure 1. The p-value of <.0001 from the chi-square test indicates that there is no significant difference in the proportion of workers across different seasons (p<0.0001) (Table 2).

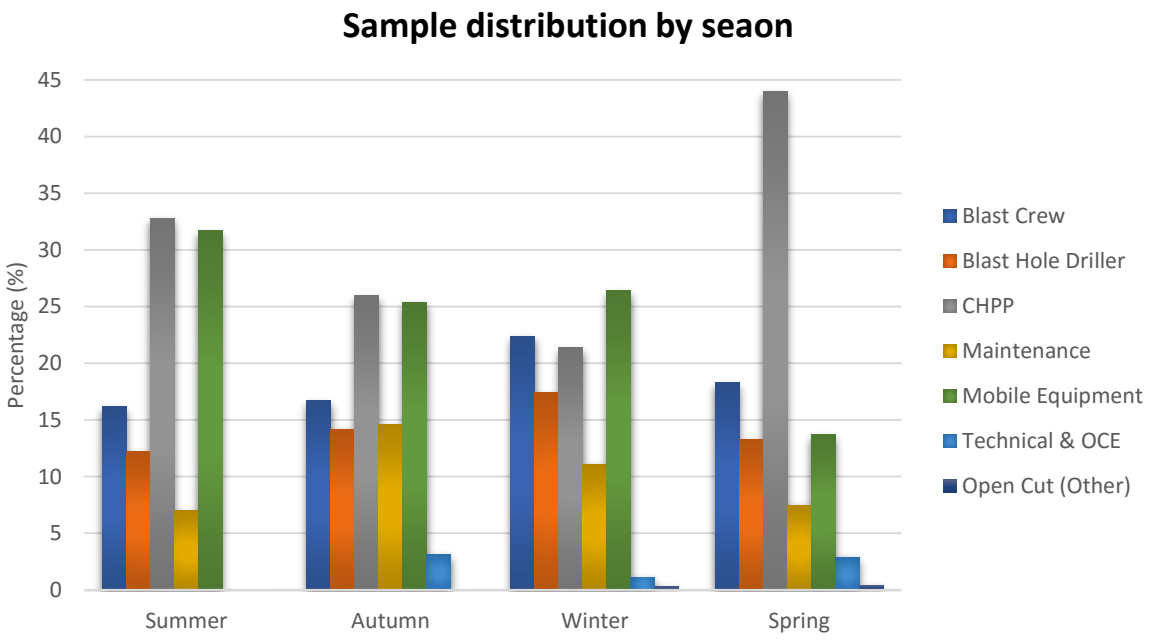

Figure 1: Distribution of surface (open cut) coal mine workers by SEG and season

Table 2: Distribution and significance of surface (open cut) coal mine workers by SEG and season

	SEG (n, %)								
Season	**Blast Crew**	**Blast Hole Driller**	**CHPP**	**Maintenance**	**Mobile Equipment**	**Open Cut (Other)**	**Technical & OCE**	**Total**	**p-value**
Summer	44 (16.2)	33 (12.2)	89 (32.8)	19 (7.0)	86 (31.7)	0 (0.0)	0 (0.0)	271	<.0001
Autumn	54 (16.7)	46 (14.2%)	84 (26.0)	47 (14.6)	82 (25.4)	0 (0.0)	10 (3.1)	323	<.0001
Winter	85 (22.4)	66 (17.4%)	81 (21.4)	42 (11.1%)	100 (26.4	1 (0.3)	4 (1.1)	379	<.0001
Spring	44 (18.3)	32 (13.3%)	106 (44.0)	18 (7.5)	33 (13.7)	1 (0.4)	7 (2.9)	241	<.0001

Table 3 and 4 detail the descriptive statistics of respirable dust and respirable crystalline silica (RCS) results, both reported as mg/m^3, for the current and possible Workplace Exposure Standards (WES).

Based on the current WES, 1077 of the 1105 results were below the WESs, for both respirable dust and RCS. Two (2) samples were over the WES for respirable dust (2.5mg/m^3), and 26 were above the WES for RCS (0.1mg/m^3).

When the possible WESs are applied, 1009 results were below the WESs, for both respirable dust and RCS. Four (4) samples exceeded the possible WES for respirable dust (1.5mg/m^3), and ninety (90) exceeded the possible WES for RCS (0.05mg/m^3).

Table 3: Descriptive statistics of open cut coal mine workers

	Respirable dust (mg/m^3)	**Respirable crystalline silica (mg/m^3)**
Samples (n)	1105	1035[2]
Mean (SD)	0.15 (0.18)	0.01 (0.02)
Median (min, max)	0.1 (0.005, 3.7)	0.005 (0, 0.22)
Median (Q1, Q3)	0.1 (0.07, 0.18)	0.005 (0.005, 0.02)

Respirable Dust and RCS Results by Similar Exposure Group (SEG)

Table 4 describes the distribution of mineworkers by SEG for each contaminant (exposure hazard). The only two SEGs where mine workers are exposed above the WES for respirable dust were the CHPP and Maintenance SEGs. For the CHPP, one (1) result exceeded the current WES (2.5mg/m^3) and three (3) results exceeded the possible WES (1.5mg/m^3). For the maintenance SEG, one (1) result exceeded the current WES and three (3) samples exceeded the possible WES.

As shown in Table 4, the proportion of results which exceeded the respirable dust WES significantly differs across the SEGs at $p<0.05$ (p-value= 0.61). Based on the possible WES, however, there is a significant difference between the proportion of mine workers exposed to respirable dust in excess of the current WES across the SEGs at $p<0.05$ (p-value= 0.04). The proportion of results which exceeds the WES for RCS, is significantly different across the SEGs based on both current and possible WES (p-value< 0.001).

[2] Not all samples were analysed for respirable silica quarts, hence the difference in sample numbers.

Table 4: Distribution of mine workers by the SEG, type of contaminant and WES

		SEG (n, %)								
Contaminant	**Over WES**	**Blast Crew**	**Blast Hole Driller**	**CHPP**	**Maintenance**	**Mobile Equipment**	**Open Cut (Other)**	**Technical & OCE**	**Total**	**p-value**
Respirable Dust (Current WES)	No	210 (100.0)	163 (100.0)	323 (99.7)	115 (99.1)	270 (100.0)	2 (100.0)	20 (100.0)	1103	0.61
	Yes	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	2	0.61
Respirable Dust Possible WES	No	210 (100.0)	163 (100.0)	321 (99.1)	113 (97.4)	270 (100.0)	2 (100.0)	20 (100.0)	1099	0.04
	Yes	0 (0.0)	0 (0.0)	3 (0.9)	3 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	6	0.04
Quartz (Current WES)	No	201 (95.7)	151 (92.6)	324 (100.0)	115 (99.1)	267 (98.9)	1 (50.0)	20 (100.0)	1079	<.0001
	Yes	9 (4.3)	12 (7.4)	0 (0.0)	1 (0.9)	3 (1.1)	1 (50.0)	0 (0.0)	26	<.0001
Quartz Possible WES	No	181 (86.2)	132 (81.0)	320 (98.8)	109 (94.0)	250 (92.6)	1 (50.0)	20 (100.0)	1013	<.0001
	Yes	29 (13.8)	31 (19.0)	4 (1.2)	7 (6.0)	20 (7.4)	1 (50.0)	0 (0.0)	92	<.0001

The blast hole drillers and blast crew SEGs had the highest proportion of workers exposed to RCS, with 7.4% and 4.3% of the results exceeding the current WES (0.1mg/m^3), respectively. When applying the possible WES, 19% of the blast hole drillers, and 13.8% of the blast crew SEGs results exceeded the proposed WES of 0.05mg/m^3 for RCS.

Real time monitoring results: PDM3700

The assessment involved a blast crew member wearing the PDM 3700 in the breathing zone during the assessed tasks. The CMTS-OH technician accompanied the operator, observing a range of tasks and conditions to determine likely exposure levels. There were only two (2) valid results from the real time dust monitoring, and thus not considered representative for statistical analysis.

Respiratory personal protective equipment (RPE)

Table 5 shows the distribution of results that exceeded the WES for respirable dust and RCS, for those workers who reported to have facial hair (beards, moustache etc.). Each row contains the row percentage of workers who were over-exposed to the related contaminant. The two SEGs with the highest distribution of workers exposed above the current and possible WES for RCS were the blast crew (18.2%) and blast hole drillers (20.8%).

Table 5: Distribution of over exposed workers by the type of contaminant, WES, SEG and facial hair

		SEG (n, %)							
Contaminant	**Facial Hair**	***Blast Crew***	***Blast Hole Driller***	***CHPP***	***Maintenance***	***Mobile Equipment***	***Open Cut (Other)***	***Technical & OCE***	***Total***
Respirable Dust (Current WES)	No	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.00%)	1
	Yes	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.9)	0 (0.0)	0 (0.0)	0 (0.0)	1
Respirable Dust (Possible WES)	No	0 (0.0)	0 (0.0)	1 (0.5)	2 (2.5)	0 (0.0)	0 (0.0)	0 (0.0)	3
	Yes	0 (0.0)	0 (0.0)	2 (1.7)	1 (2.9)	0 (0.0)	0 (0.0)	0 (0.0)	3
Respirable crystalline silica (Current WES)	No	6 (4.3)	7 (8.0)	0 (0.0)	1 (1.3)	2 (1.3)	0 (0.0)	0 (0.0)	16
	Yes	3 (4.6)	5 (6.9)	0 (0.0)	0 (0.0)	1 (0.9)	1 (100.0)	0 (0.0)	10
Respirable crystalline silica (Possible WES)	No	17 (12.1)	16 (18.2)	2 (1.0)	4 (5.0)	14 (9.3)	0 (0.0)	0 (0.0)	53
	Yes	12 (18.2)	15 (20.8)	2 (1.7)	3 (8.6)	6 (5.5)	1 (100.0)	0 (0.0)	39

Table 6 shows the distribution of mineworkers who were over exposed to the contaminants by the type of contaminants, SEG and using RPE (where data was available). Each row contains the row percentage of workers who were over-exposed to the related contaminant. It's worth noting that for the blast crew workers who reported facial hair and who are using RPE, 31.3% and 56.3% were exposed above the current and possible WES for RCS respectively.

Table 6: Distribution of over exposed workers by the type of contaminant, WES, SEG and facial hair

		SEG (n, %)							
Contaminant	**RPE**	**Blast Crew**	**Blast Hole Driller**	**CHPP**	**Maintenance**	**Mobile Equipment**	**Open Cut (Other)**	**Technical & OCE**	**Total**
Respirable Dust (Current WES)	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.00%)	0
	Yes	0 (0.0)	0 (0.0)	1 (3.50)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	2
Respirable Dust (Possible WES)	No	0 (0.0)	0 (0.0)	1 (0.3)	2 (1.8)	0 (0.0)	0 (0.0)	0 (0.0)	3
	Yes	0 (0.0)	0 (0.0)	2 (6.9)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	3
Respirable crystalline silica (Current WES)	No	4 (2.1)	12 (7.8)	0 (0.0)	1 (0.9)	3 (1.2)	1 (50.0)	0 (0.0)	21
	Yes	5 (31.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5
Respirable crystalline silica (Possible WES)	No	20 (10.3)	30 (19.5)	4 (1.36)	7 (6.4)	18 (6.9)	1 (50.0)	0 (0.0)	80
	Yes	9 (56.3)	1 (11.1)	0 (0.0)	0 (0.0)	2 (22.2)	1 (100.0)	0 (0.0)	12

Evaluation and discussion

This project aimed to identify areas and occupations in surface (open cut) mining that are at high risk of respirable crystalline silica (RCS) exposure in order to develop an evidence-based health surveillance guideline for the Australian Coal industry.

Population Demographics

Sampling was undertaken over all seasons to ensure a representative spread of results across all the seasons (Summer, Winter, Autumn and Spring). Dust sampling was not undertaken on wet or rainy days, to prevent data skewing and under-estimating potential exposures. The results indicate that samples were distributed evenly across seasons for all SEGs, and thus considered a true representation of worker exposure to respirable dust and RCS. The only two SEGs who were over or under sampled, were the CHPP SEG during Spring, and the Open Cut (Other) SEG, which were completely at random. Regardless, the chi-squared test results indicate that there are no statistically significant differences in proportion of workers sampled across the seasons.

Respirable dust and respirable crystalline silica exposures and health

The results of the exposure assessments suggest that current dust minimisation and control strategies at NSW surface coal operations are largely effective in keeping exposures to respirable dust and respirable crystalline silica below current exposure limits.

The exposures of shotfirers, drillers and blast crew are higher compared to other SEGs, and these workers are potentially at risk to develop adverse health effects if their exposures are not further reduced and managed. It is recommended that the exposure sampling frequency for these workers, as detailed in Order 42, be reviewed to enable adequate health risk assessment and monitoring.

The exposure to levels above the current WES within these SEGs ranges between 4.3% to 7.4%. Should the possible WES for respirable crystalline silica be reduced to 0.05 mg/m^3, the non-compliance (over-exposure) of workers increases to 13.8% - 19%. The likely change in the

RCS WES will also see a significant proportion of workers in the mobile plant operators and maintenance SEGs exceeding the WES at 7.4% and 6.0% respectively.

PDM3700 Real time monitoring

One of the project aims was to investigate the capacity of the PDM3700 as a device to assist understanding of real time dust exposures of workers and guide subsequent health monitoring. There are a number of real time (or near real time) dust monitoring instruments available currently, some of which are worn by the worker, and some are and hand-held by an OHT. The PDM3700 was chosen over other instruments, for the following reasons:

1. It is a wearable device.
2. The TEOM technology is known to provide results with a high degree of accuracy.
3. The PM3700 is currently used by the US underground coal industry for compliance monitoring.

During the project, significant barriers were identified with the wearability of the instrument. Its physical size (24.31cm x 8.26cm x 17.15cm) and weight (2.0kg) made it uncomfortable for workers, and difficult to wear. Surface operators, compared to their underground counterparts, are not required to hang wearable devices (such as a self-rescuer and cap lamp battery) on their belts as part of their everyday role. They reported that the instrument made them feel unbalanced and made it hard to perform their duties in and around vehicles.

Coal Services concluded that the identified impracticality of using the device in its current state, presents a significant barrier to ongoing effective utilisation in surface coal operations. Further research into smaller and lighter alternatives is currently underway.

Respiratory Protective Equipment (RPE) use

The results indicate minimum use of RPE by surface (open cut) coal miners, particularly where the results exceed the WES. This is further compounded by the large proportion of surface coal (open cut) miners who were reported to have facial hair (beards, moustaches etc.). The

reason this is important is due to the fact that facial hair compromises the seal for the respirator, thus reducing (or eliminating) the protection factor of the respirators, creating a 'false' sense of protection.

Order 43 introduced by the NSW coal industry in 2018 now requires fit testing and RPE education for all miners with their routine medical assessments. This study did not investigate whether workers were provided with training and fit testing for their RPE, neither their attitudes nor understanding of dust exposure and health. The results, however, suggest a significant proportion of workers do not use, or effectively use, their RPE.

Future Directions

This study considered the implications for health monitoring with regard to respirable dust and respirable crystalline silica (RCS) in surface (open cut) mine operations in NSW. Due to the recent resurgence of coal miner's pneumoconiosis, the WES for both respirable dust and respirable crystalline silica is currently under review. The date of any change and the final WES has not been confirmed; however, recent statements following a meeting of relevant State ministers indicate that a WES for respirable crystalline silica of 0.05 mg/m³ is possible. It remains unknown if there is a "no observable adverse effect level" for RCS, but due to the known health effects associated with respirable crystalline silica exposure, such as lung cancer and pneumoconiosis, a WES as low as reasonably practicable is desirable.

Setting an action level for intervention and reviewing the effectiveness of current controls at 50% of the WES, means that even more surface (open cut) coal miners will potentially be exposed to respirable dust and respirable crystalline silica levels where monitoring is recommended.

In NSW, health monitoring of coal miners is required every three (3) years. This is within the 2 – 5 year range recommended internationally[3]. Whilst there is potential merit in delaying

[3] Above at 33.

chest x-rays until a certain number of years of exposure, as recommended by the Health and Safety Executive (HSE). This is dependent upon an accurate account of the exposure, which is not always available. There is also the difficulty posed by coal miners transitioning in and out of different mining and non-mining jobs, as well as the reality of accelerated disease with even short periods of increased exposure. It is thus recommended that the schedule of health surveillance for surface (open cut) coal miners involved in production processing and maintenance continues at the current three-year interval including chest x-ray. It is also recommended that there be a review into the statutory personal exposure monitoring requirements for the high risk SEGs identified in this study.

Limitations

This is an exposure assessment study, and thus the effect of factors such as ATSI, alcohol and drug involvement, mental health issues and recurrent admission on the development of adverse health effects, were not assessed.

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