Review of Respiratory Component of the Coal Mine Workers' Health Scheme for the Queensland Department of Natural Resources and Mines

Final Report

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Overview

Background

As of December 2015, when this review was being developed, six confirmed cases of coal workers' pneumoconiosis (CWP) had been identified by the Queensland Department of Natural Resources and Mines (DNRM) over a period of about seven months among coal miners in Queensland. An additional case was later notified in May 2016, making a total of seven confirmed CWP cases which could be included in this review. An 8th case was reported on 28 June 2016, but it was too late for any further details to be included in this final report.

Prior to this, the Queensland Coal Mine Workers' Health Scheme had not identified any new cases for many years and CWP was thought to have been eradicated in Queensland. Following the discovery of the initial cases, a review of the design and operation of the respiratory component of the scheme was commissioned by DNRM. A review team from Monash University and the University of Illinois at Chicago was engaged to conduct the review. This multidisciplinary review team included expertise in occupational medicine, respiratory medicine, occupational hygiene, epidemiology, radiology and respiratory science.

The aims of the review were to:

A Determine whether the respiratory component of the health assessment performed under the Queensland Coal Mine Workers' Health Scheme is adequately designed and implemented, to most effectively detect the early stages of coal mine dust lung disease (CMDLD) among Queensland coal mine workers, estimating the extent and providing feedback and, if not,

B Recommend necessary changes to correct deficiencies identified under Aim A, recommend measures to follow up cases that may have been missed as a result of these deficiencies, and identify what additional capacity is needed in Queensland to improve this scheme.

In undertaking this review, the review team accessed and reviewed data and documents from a wide range of sources, including the content of the health assessment form, the information kit given to Nominated Medical Advisers (NMAs), a sample of completed health assessment forms, a sample of spirograms, a sample of chest x-rays (CXRs) and associated radiologists' reports collected under the scheme. We examined the qualifications and geographical spread of the listed NMAs and surveyed them about their spirometry equipment, its calibration, and the technician training. We visited underground and open-cut mines and a coal handling and preparation plant (CHPP) in Queensland and spoke to DNRM, employer and Construction Forestry Mining and Electrical Union (CFMEU) stakeholders. We reviewed relevant literature and spoke to individuals involved in other similar schemes in Australia and overseas and identified other potential sources of information on CWP.

The following aspects of the scheme were identified for inclusion in the review:

1. Purpose of the respiratory component of the current scheme
2. The overall process of the current scheme
3. The scheme health assessments of the confirmed CWP cases
4. The Coal Mine Workers' Health Scheme health assessment form
5. Risk from dust exposure for the purpose of a CXR
6. Nominated Medical Advisers
7. CXR quality and reading
8. Spirometry quality and reading
9. Health assessment form data handling and storage
10. Interstate and overseas health surveillance schemes for coal miners
11. Queensland medical capacity
12. Other sources of data about the extent of CWP
13. Research framework for a survey of CMDLD prevalence among coal miners

Main findings and recommendations

This chapter outlines the main findings relating to limitations of the scheme and recommendations to make improvements, as well as documenting the relevant chapter of the review for each. We have included some supplementary detail, to correct the deficiencies identified with the current Coal Mine Workers' Health Scheme. These findings and recommendations are drawn from chapters 4-15 of this report, which contain further supporting evidence and discussion relating to these limitations and recommendations.

Chapter 4: Purpose of the respiratory component of the current scheme

- After discussion with stakeholders and reviewing the relevant documentation, it is clear that the focus of the respiratory component of the scheme is on fitness for work rather than the detection and management of early CMDLD.
- The respiratory component of the scheme is not being used for group health surveillance to monitor trends in CMDLD, and this is compounded by the exclusion of former and retired coal miners from the scheme.

Recommendation 1

The main purpose of the respiratory component of the scheme should explicitly focus on the early detection of CMDLD among current and former coal mine workers.

1.1. The purpose of the respiratory component of the scheme should be clearly stated as being to:
   - 1.1.1. Provide mandatory respiratory health screening to detect early CMDLD in coal mine workers.
   - 1.1.2. Offer participation in the scheme to former coal mine workers.
   - 1.1.3. Ensure appropriate referral for follow-up, diagnosis and management, including appropriate reductions in further exposure to dust, for coal mine workers with respiratory abnormalities indicating CMDLD.
   - 1.1.4. Collect, analyse and report group surveillance data to monitor trends in CMDLD, and to inform Government, industry and trade union reviews of dust exposure levels and occupational exposure limits for coal mines.

1.2. The purpose of the scheme should be clarified to employers, coal mine workers, doctors and other stakeholders. The roles and responsibilities of the stakeholders (the DNRM, employers unions and mine workers) under the scheme should be defined.

1.3. An information pack about CMDLD and how these conditions are identified and diagnosed should be developed for workers.

Chapter 5: Overall process of the current scheme

There are clear deficiencies with several processes and components of the current scheme, such as: the registration and training of NMAs; the role of Examining Medical Officers (EMOs); decisions about who is "at risk from dust exposure" and thus requires a CXR; the reading and reporting of CXRs; the conduct of spirometry; and the processing of health assessment forms by the DNRM, and these are expanded upon in other sections of the review.

Other notable limitations of the current scheme's overall process include:

- The lack of a clear follow up and clinical referral pathway for investigation, diagnosis and management of coal mine workers and former coal miners with respiratory abnormalities consistent with CMDLD detected during scheme health assessments.
- The lack of clear process to advise mines to review dust exposure levels if respiratory abnormalities are identified.
- The absence of an established mechanism whereby a diagnosis of CMDLD identified under the scheme is formally reported to DNRM.
- The potential for preclinical changes in respiratory health over serial assessments to be overlooked as previous health records are not readily available to NMAs.

Recommendation 2
Clinical guidelines for follow-up investigation and referral to an appropriately trained respiratory or other relevant specialist of suspected CMDLD cases identified among current and former coal miner workers should be developed and incorporated into the scheme.

Recommendation 3
DNRM should require the reporting of detected cases of CWP and other CMDLDs in current and former coal miners identified by the scheme.

Chapter 6: Confirmed CWP cases

We examined the Health Scheme records for the confirmed CWP cases to identify where the scheme had failed to identify and/or act on early respiratory abnormalities indicative of CMDLD.

- There was poor documentation and inconsistent follow-up of abnormal results which were not always recognised by the NMAs, and workers with indications of early CMDLD were still deemed fit to work underground with no restrictions on further coal mine dust exposure.
- Where abnormal spirometry results were thought suggestive of chronic obstructive airways disease, this was attributed to tobacco smoking rather than coal mine dust exposure.
- CXRs referral slips were often not specified as being for coal mine worker screening purposes and the CXRs were not reported using the International Labour Organization (ILO) classification and, for at least two cases, early CXR changes were not identified.

Chapter 7: Heath assessment form

We reviewed the content and design of the respiratory component of the seven page health assessment form and assessed the completeness of a sample of 91 submitted forms.

- The current form lacks a comprehensive respiratory medical history and respiratory symptom questionnaire.
- There is no specific section where information from respiratory medical history and symptoms, respiratory physical examination, spirometry and CXRs are consolidated.

- An earlier version of the health assessment form included a CXR reporting section consistent with the ILO classification, but this was removed many years ago.
- There is no specific section where the final conclusion about the presence or absence of CMDLD is recorded, and if present, the implications for mitigating further coal mine dust exposure.
- Section 1 (the employer's section) was poorly completed, with generic similar exposure groups (SEGs) provided in only a few health assessment forms and company SEGs not provided in any of the forms examined.

Recommendation 4

There should be a separate respiratory section of the health assessment form which includes all respiratory components, including the radiology report using the ILO format and the spirogram tracings and results.

Recommendation 5

The form should include a comprehensive respiratory medical history and respiratory symptom questionnaire.

The new health assessment form should include:

5.1 A detailed respiratory symptom questionnaire and past medical history.

5.2 Revised and expanded questions about smoking history to better identify current/former/never smokers and cumulative smoking exposure (pack-years).

5.3 Occupational history which allows identification of job categories or industries where high coal dust and/or mixed dust exposure is likely to occur.

5.4 A specific reference to the absence or presence of symptoms/signs and CXR or spirometry changes consistent with CMDLD, the follow-up required and frequency of subsequent health assessments.

5.5 Determination of any restrictions on work capacity for individuals with CMDLD, including ability to use respiratory protective equipment (RPE).

<u>Chapter 8: Risk from dust exposure for the purposes of requiring a surveillance CXR</u>

We visited an underground and an open-cut coal mine and a CHPP, and interviewed mine company and Union representatives to understand the development and application of SEGs. While the review team recognises that SEGs have an important role to play in dust monitoring and control and in risk assessment, their use in informing decisions about whether a CXR is required for mine workers was the focus for this review.

- The criteria to determine jobs "at risk from dust exposure" and thus which coal mine workers should have a CXR are not explicit in the Regulations, and the DNRM do not specify which generic SEG categories fulfil these conditions.
- "At risk from dust exposure" is meant to be applied to workers in underground coal mines, open-cut coal mines and CHPPs, but this criterion is most clearly recognised and applied to workers in underground mines.
- The SEGs approach does not adequately account for mobile workers, for example contractors employed in a range of jobs across various mines, who can transition between different SEGs and lower and higher dust exposure jobs.
- The current SEG does not consider dust exposure from previous jobs in other SEGs, which are important to consider when considering the risk of CMDLD.

- While useful for coal dust exposure monitoring and control, the SEGs approach is too complex and has not been used extensively to decide which individual mine workers require a CXR.

Recommendation 6

The criteria to determine workers "at risk from dust exposure" should be based on past and current employment in underground coal mines and designated work categories in open-cut coal mines and CHPPs.

6.1 The criteria to determine job categories "at risk from dust exposure" should be standardized across the Queensland coal mining industry.

6.2 All job categories involving underground work in underground mines, and designated jobs in open-cut mines (e.g. blasting, drilling, rock screening) and CHPPs (e.g. some production and laboratory workers) should require a CXR.

6.3 For workers currently not involved in such jobs, but who have had significant dust exposure in past jobs, the approved medical practitioner undertaking the health assessment should decide whether a CXR is required, and whether the frequency should be more often than five years, based on discussion with the mine worker, including a full occupational history of exposure to coal dust. This is particularly important for former mine workers.

6.4 The criteria to determine dust exposure job categories should be reviewed and/or revised regularly to reflect changes in level of risk, for example due to changes in coal mining technology.

Chapter 9: NMA registration and training

We examined the qualifications and geographical coverage of NMAs currently listed with DNRM, and reviewed the information kit provided to newly-registered NMAs.

- There are too many NMAs performing health assessments to allow for adequate initial training, maintenance of skills, and quality control. Performing enough assessments to maintain skills is a potential problem with so many listed NMAs.
- There is inadequate formal initial and continuing training for NMAs regarding purpose of the scheme and the criteria used to diagnose CMDLD.
- EMOs have no formal recognition under the current scheme but they often perform health assessments, nominally under the supervision of an NMA. This results in an even larger pool of medical providers and further impacts quality control.

Recommendation 7

There should be a much smaller pool of approved doctors undertaking the respiratory component of health assessments under the scheme, taking into account geographical considerations and other workforce needs.

Recommendation 8

Doctors should undergo a formal training program, including visits to mine sites, prior to being approved by the DNRM, to ensure they reach a suitable standard of competence and have the necessary experience to undertake respiratory health assessments under the scheme.

8.1 The minimum qualifications and experience for doctors who are to undertake respiratory health assessments under the scheme should be established.

8.2 While doctors seeking to be appointed to perform respiratory health assessments should have already reached a certain level of competence in the necessary knowledge and skills set out below, a formal induction and ongoing training and audit program for these doctors should be developed to ensure initial and ongoing competence for the specific requirements of the early detection of CMDLD:

- 8.2.1 Information about the primary purpose of the respiratory component of the scheme, in particular health protection, prevention and early detection of CMDLD and the importance of undertaking such assessments in an independent way.
- 8.2.2 Information about the spectrum of diseases included in CMDLD.
- 8.2.3 Information about coal and silica dust exposure, and other respiratory hazards associated with the Queensland coal mining industry.
- 8.2.4 A visit to a coal mine(s), with a focus on inspecting jobs deemed "at risk from dust exposure".
- 8.2.5 Conduct and interpretation of quality spirometry.
- 8.2.6 Instruction in how to consider coal dust exposure for the purposes of deciding which miners require a CXR.
- 8.2.7 Instruction in the ILO CXR classification of pneumoconiosis to enable them to interpret such reports from the radiologists.
- 8.2.8 Instructions about how to complete each section of the respiratory component of the modified health assessment form.
- 8.2.9 Clinical guidelines for follow-up and appropriate referral of CMDLD cases or other respiratory abnormalities.
- 8.2.10 Instructions to explain the outcome of health assessments, including follow-up with treating doctors and specialists and workplace restrictions on dust exposure for those with indications of CMDLD.

8.3 An experienced Medical Officer should be responsible for the ongoing training and audit of doctors approved to undertake respiratory health assessments under the scheme.

Recommendation 9

The approval of doctors to undertake the respiratory health assessments for the early detection of CMDLD under the scheme should become the sole responsibility of the DNRM.

Recommendation 10

Doctors approved to undertake respiratory health assessments should have a different designation from 'NMA', which should reflect their specific responsibility for respiratory health assessments under the new scheme.

Chapter 10: Chest x-ray review

A sample of 258 digital CXRs from coal miners with at least 10 years of experience in coal mine work was assessed independently by two B-Readers.

- Twenty percent of the CXRs had quality issues, which could affect the accurate detection of the small opacities characteristic of pneumoconiosis.
- The quality issues include poor positioning cutting off portions of the chest, covering up the chest with the scapula or shoulder blades, poor contrast and excessive edge enhancement.

- The quality issues noted above may result in false positive classifications for pneumoconiosis.
- Of the 248 classifiable CXRs reviewed, 18 were considered to have opacities consistent with simple pneumoconiosis.
- Review of the original radiology reports for the 18 positive cases found only two which identified abnormalities consistent with pneumoconiosis, 13 were reported as no abnormalities, and three reports were missing.
- Follow up by the NMA was not done in the two cases where the original radiologist had identified changes on the CXR.

Recommendation 11

Chest x-rays should be performed by appropriately trained staff to a suitable standard of quality and performed and interpreted according to the current ILO classification by radiologists and other medical specialists classifying CXRs for the scheme.

11.1 Require additional training in the use of the ILO classification for radiologists or respiratory physicians classifying CXRs for the Coal Mine Workers' Health Scheme.

11.2 Develop a program to evaluate those radiologists or respiratory physicians who seek to classify CXRs for pneumoconiosis to demonstrate adequate performance. Examples of programs that provide such an evaluation are the US NIOSH B-Reader and the Asian Air Pneumo programs.

11.3 In order to maintain the highest quality, ILO classifications of CXRs for the DNRM should be performed by a selected group of medical practitioners, separate from the clinical interpretation provided by the local radiologist.

11.4 Due to variability in reading CXRs, utilise a protocol involving at least two independent classifications to confirm agreement about the presence or absence of radiological features of pneumoconiosis, similar to the protocol used in this study.

11.5 Provide guidelines to radiology clinics performing CXRs for the Coal Mine Workers' Health Scheme detailing the appropriate qualification of personnel, imaging equipment and software, image acquisition, documentation, image display, and quality control systems. An example of such a guideline to be found at http://www.cdc.gov/niosh/docs/2011-198/

11.6 Develop ongoing clinical audit of CXRs and classifications to ensure quality.

11.7 Provide appropriate feedback to coal mine workers so that they have access to the information in the radiologist and NMA reports.

11.8 Improve the acquisition and archiving of digital CXRs by Queensland DNRM to facilitate disease surveillance efforts.

Chapter 11: Spirometry review

We audited spirometry equipment and training using an online survey which was completed by around one-third (74) of NMAs on the current Health Surveillance Unit (HSU) list. We also assessed the quality and reading of a sample of 256 spirometry tests completed under the current scheme.

a. Spirometry equipment and training:
   - Less than 50% of spirometry currently performed is undertaken by sufficiently trained and experienced staff.
   - Overall, quality control and quality assurance of spirometry testing is inadequate for more than 50% of sites.

b. Spirometry quality and interpretation:
   - Forty percent of spirograms reviewed could not be interpreted as they were not performed to American Thoracic Society/European Respiratory Society (ATS/ERS) standards.
   - Only 43% (110/256) of the spirometry results evaluated had been accurately interpreted and reported by NMAs.
   - Of the 30 spirograms assessed as abnormal by the reviewers, only two had been accurately identified in the NMA reports.

Recommendation 12

Spirometry should be conducted by appropriately trained staff and performed and interpreted according to current ATS/ERS standards.

12.1 Spirometry should be conducted at respiratory laboratories accredited by Thoracic Society of Australia and New Zealand (TSANZ) or similar bodies and for other medical facilities seeking to undertake spirograms under the scheme, accreditation specific to spirometry should be required.

12.2 Spirometry scientists or technicians who conduct tests for the new scheme should undergo initial training and participate in periodic refresher courses provided by an approved organisation.

12.3 Spirometry testing must take part in a quality control program consistent with current ATS/ERS standards and the quality of spirometry tests should be audited regularly as part of the overall auditing within the scheme.

Chapter 12: Health assessment form data handling and storage

We reviewed DNRM's data handling and storage procedures, including accessibility of previous health assessments.

- The transfer of health assessments between the DNRM and NMAs by ordinary mail is inefficient, and the use of hard copy forms and test results is outmoded compared with modern electronic data entry and storage methods.
- The HSU performs an administrative check of the health assessment forms for missing information, but there is no medical review or audit of the collected health data.
- The storage of health records as both scanned and hard copy across a number of sites hampers access to previous records by DNRM staff and NMAs.
- There is a large backlog of about 100,000 health assessments still awaiting entry into the DNRM database, which further hampers accessibility of these records. However, steps are in place to process health assessments for underground coal mine workers by the end of 2016, and to clear the remaining backlog by the following year.

Recommendation 13

DNRM should transition to an electronic system of data entry and storage, whereby doctors undertaking these respiratory assessments enter the data for their assessment and can access previously collected data for the mine worker and to facilitate auditing.

13.1 DNRM should institute electronic data entry and data storage, with suitable consent and security arrangements and the facility to link all records for individual mine workers, and enable access to previous records by doctors undertaking the respiratory health assessments.

13.2 A regular audit function of the collected medical information should be introduced to monitor quality with regular feedback to the doctors performing respiratory health assessments under the scheme.

Recommendation 14

All coal mine workers, including contractors, subcontractors and labour hire employees, who meet the revised criteria for being "at risk from dust exposure" should be registered in the DNRM database on entry into the industry for the purposes of ongoing medical surveillance.

Recommendation 15

DNRM should conduct ongoing individual and group surveillance of health data collected under the scheme, to detect early CMDLD and analyse trends to disseminate to employers, unions and coal mine workers.

Recommendation 16

Coal mine workers should have exit respiratory health assessments regardless of whether they leave the industry due to ill-health, retirement or other reasons.

16.1 Due to the latent period for developing CMDLD, health surveillance under the scheme should include current and former coal mine workers, including retirees, as this would provide a more accurate depiction of industry-wide disease trends.

Recommendation 17

An implementation group, including representatives of stakeholders and relevant medical bodies, should be established to ensure that the necessary changes to correct the identified deficiencies with the respiratory component of the current scheme are implemented in a timely manner.

Recommendation 18

There should be a further review of the revised respiratory component of the scheme within 3 years to ensure that it is designed and performing according to best practice.

Chapter 13: Interstate and overseas health surveillance schemes for miners

We reviewed health surveillance systems for mine workers in other Australian states and overseas, to determine components which could be incorporated to improve Queensland's current scheme. The following points were common to the surveillance programs:

- The objectives and purpose of the scheme, in particular identification and monitoring of respiratory disease, are explicit.
- There are designated high dust exposure jobs and a clearly stated frequency of health assessments and CXRs for workers in these (and other lower risk) job categories.
- Health assessments, including spirometry and CXR interpretation and reporting are administered by trained medical and nursing staff.
- Data collection is electronic to facilitate data collation, analysis and reporting of group surveillance data.
- Medical staff are required to explain the outcome of (adverse) health assessments to workers, with suggested referral pathways to treating doctors and specialists.

Chapter 14: Queensland medical capacity

We identified the specialist medical expertise and resources currently available in Queensland to contribute to the performance of high quality health assessments for the early detection of CMDLD.

- There are three relevant Australian specialist medical organisations (Royal Australian and New Zealand College of Radiologists, Thoracic Society of Australia and New Zealand and the Australasian Faculty of Occupational and Environmental Medicine of the Royal Australasian College of Physicians) with the interest and capacity to assist with health assessments under an improved scheme, however this expertise has not been adequately harnessed.
- While some training and up-skilling is needed due to limited recent experience with CMDLD, these organisations can contribute to training, accreditation of CXR and spirometry testing and clinical audit, development of clinical guidelines, and nominating members to provide specialist opinion to miners with suspected CMDLD.

Chapter 15: Other sources of data about the extent of CWP

We identified routinely collected health data to gauge the extent of CWP among Queensland coal miners, from Queensland hospital records and workers' national and state-based compensation data.

- Four probable and seven possible CWP cases in older, probably retired coal mine workers were identified by Queensland Health after cross-checking public hospital records from the last 20 years with Queensland Coal Mine Workers' Health Scheme records.
- Six accepted workers' compensation (WC) claims for CWP were found through a search of the Queensland compensation database from 2005/06 to current, including four accepted claims in 2015/16. There are also a further 6 cases pending.
- These data sources have limitations and do not provide accurate information about the prevalence of CWP or other CMDLD.

Chapter 16: Research framework for a survey of CMDLD prevalence among coal miners

The current review was not intended to provide an estimate of CWP or other CMDLD among Queensland coal miner workers and the information from existing data sources are also incomplete. Therefore, the extent of CMDLD in current and retired Queensland coal miners remains unknown. As a result, the review team designed a research framework which could better estimate the prevalence of CMDLD in Queensland coal miners.

Overall conclusions

This review of the respiratory component of the Coal Mine Workers' Health Scheme has revealed major system failures at virtually all levels of the design and operation of the respiratory component of the current health assessment scheme, but has also identified ways to modify the current scheme to make it more effective in undertaking medical screening for CMDLD in the future.

The measures identified in the review to address the system failures include:

- A more clearly articulated purpose of the scheme.
- A smaller number of doctors approved by the DNRM to undertake respiratory health assessments under the scheme.
- A greater focus on the credentials and experience of these doctors.
- Introducing initial and ongoing training about CMDLD for doctors seeking approval to undertake respiratory health assessments under the scheme.
- Developing clinical guidelines to inform diagnosis and management of CMDLD identified through the scheme.
- More standardised and consistently applied criteria to determine workers "at risk from dust exposure" for deciding which coal mine workers require a CXR.
- A more complete and better designed respiratory component of the health assessment form with data collected online and better access to the findings from the worker's previous health assessments.
- Better standard of CXR referral, interpretation and reporting using the ILO criteria.
- Better standards of spirometry testing and interpretation.
- A process of clinical audit of collected health data, including spirometry and CXR.
- Greater accessibility of previous job history and health assessment records to inform subsequent assessments of coal mine workers, resulting in a greater ability to monitor changes in respiratory health at an individual level over time.
- Inclusion of former mine workers, including retired mine workers, in whom CMDLD is most likely to be seen.
- The development of robust industry-wide health surveillance data to assist in informing coal mine dust exposure control measures, including review of occupational exposure levels.
- A research framework to provide more robust estimates of the prevalence of CMDLD in Queensland coal mine workers.

These (and other) deficiencies with the respiratory component of the current scheme itself have been confounded by the widespread belief that CWP had been eliminated in Queensland and is of historical interest only leading to complacency about the risks of CMDLD. Where there is a lack of belief that CMDLD can occur among coal mine workers, then it is no surprise that there is a lack of rigour applied to detect such diseases.

Therefore, a major overhaul of the design and operation of the respiratory component of the current Coal Mine Workers' Health Scheme is necessary. As previous attempts by the DNRM to improve aspects of the respiratory component of the scheme did not result in required changes, it will be important for an oversight group to be formed to drive the implementation of the recommendations of this review and in a timely manner.

It is also important to acknowledge the loss of confidence among coal mine workers (and their families) in the scheme's ability to effectively monitor their respiratory health, especially since the recently diagnosed CWP cases have been identified. Understandably, this has resulted in uncertainty about the validity of clearances received about their respiratory health after previous respiratory health assessments. The review team encourages all workers who are concerned about their respiratory health to consult their local doctor in the first instance. Where a CXR or spirogram examined in this report suggests the possible presence of CMDLD, the authors will inform DNRM of the finding so that the appropriate medical practitioner(s) can be informed.

More broadly, the findings of this review, the failures identified and the recommendations to improve the scheme have implications beyond the coal mining industry in Queensland. The coal mining industry in other Australian states, and other industries where (hazardous) respirable dust exposure, such as silica, occurs should also take note of our findings. Respiratory surveillance for their workers should be assessed and, where existing health assessment schemes are in place, these should be reviewed to ensure that their design, implementation and audit are best practice.

The review team would like to conclude by restating that medical screening and surveillance is not a substitute for effective dust control, which should be the first line of action in protecting coal mine workers from CMDLD. This is particularly important since this group of diseases can progress even after dust exposure has ceased. Regular respiratory health assessments are an adjunct to dust control and can inform preventive programs, but only if such medical screening is effectively designed, implemented and monitored.

1. Introduction

1.1 Background

Coal Mine Dust Lung Disease[1] (CMDLD) comprises a group of occupational lung diseases that result from the cumulative inhalation of respirable coal mine dust. Coal mine dust includes: carbon, quartz and silicates, and it is thought that interactions between these dusts leads to a range of pathological changes in the lungs which result in CMDLD.[2]

Coal miners are at risk of developing these diseases, which include the classic fibrotic lung diseases of CWP, mixed dust pneumoconiosis and silicosis, as well as chronic bronchitis, emphysema and diffuse dust-related fibrosis. Progressive massive fibrosis (PMF) is also on the spectrum CMDLD, and is the most severe form of CWP. Early detection of each of these diseases is based on different diagnostic criteria and testing. For example, CXRs primarily detect the small opacities of early CWP, while spirometry can identify early declines in lung function and better assists in the early diagnosis of chronic obstructive pulmonary disease (specifically emphysema), than CXR.

Detection of small opacities, especially those indicative of early lung disease requires careful examination of a high quality CXR. There are established guidelines to read CXRs for changes indicative of CWP, published by the International Labour Organization (ILO). The use of the ILO guidelines results in systematic and reproducible CXR reading so that screening and surveillance can be carried out.[3]

All Queensland coal mine workers are required under the *Coal Mining Safety and Health Act 1999* (Queensland), and Part 6 of Division 2 of the *Coal Mining Safety and Health Regulation 2001*, to undergo a Coal Mine Workers' Health Scheme (the scheme) medical assessment prior to the start of their employment at a coal mine, and then at least once every five years during their employment. The scheme commenced in 1983 when all current coal miners were required to participate in a one-off CXR survey, although participation was voluntary for retired miners. This study revealed cases of pneumoconiosis and other respiratory abnormalities,[4] and prompted the second Health Order.

Under the second of the Health Orders issued, all new entrants to the coal mining industry were required to undergo CXR and lung function tests to satisfy a pre-employment medical standard. A further Order was issued by the Queensland Coal Board in 1993 that provided for both pre-employment and ongoing health surveillance periodically every five years. In addition, a CXR was required only when the employer advised that the coal mine worker was "at risk from dust exposure".

The focus on respiratory diseases continued after the Queensland Coal Board was abolished in 1997, and at least until the Coal Mining Safety and Health Regulation (2001) came into force. Although the current Regulations stipulate periodic monitoring of workers' level of risk, this relates broadly to the variety of hazards encountered in coal mines.

The parts of the current health assessment relevant to the early detection of CMDLD include a medical history, physical examination, spirometry to assess lung function and a posterior-anterior CXR.

Health assessment under the scheme is the responsibility of NMAs, who are required to complete a "Report on Health Assessment" (the report) at the completion of the assessment. The actual health assessment may be performed by the NMA or an EMO, however only the NMA may complete and sign off on the report. The report is provided to the coal mine worker and the employer, and the full health assessment form, CXR films and CXR reports are also forwarded to HSU at DNRM.

As of December 2015, when this review was proposed, six confirmed cases of CWP had been identified within seven months among coal miners in Queensland, and an additional case was notified in May 2016. An 8th case was reported on 28 June 2016, but this case was identified too late for further details to be included in this review. Prior to this, no new cases had been identified despite the ongoing coal miners' health assessment scheme, and CWP was thought to have been eradicated decades ago. A review of the design and operation of the respiratory component of the scheme was therefore commissioned.

1.2 Coal mining in Queensland

There were 54 coal mines in Queensland in 2013-2014, including 41 open-cut and 13 underground mines.[5] In addition there were 31 coal handling and preparation plants (CHPPs), some of which serve multiple mines. According to data from the DNRM, there were approximately 5,000 underground coal miners in Queensland at the end of 2015. Table 1 presents the number of miners in each mine, and which mines are regarded as "gassy". Gassy mines are dewatered to expedite gas extraction, for example of methane, leading to drier and more friable coal, and hence likely higher dust levels.

Table 1: Estimated number of mine workers in Queensland underground mines, in 2015 (Data source: DNRM)

Mine	No. of miners	Gassy Mine?	Operational Status
Aquila	0	No	Non-operational (care and maintenance)
Broadmeadow	683	Yes	Operating Long Wall
Carborough	314	Yes	Operating Long Wall
Cook	362	No	Redevelopment - Long Wall not yet operating
Crinum	223	No	Non-operational (care and maintenance)
Eagle Downs	5	No	New development (care and maintenance)
Ensham	209	No	Operating Place Change
Grasstree	639	Yes	Operating Long Wall
Grosvenor	249	Yes	New development - Long Wall not yet operating
Kestrel	536	No	Operating Long Wall
Moranbah North	649	Yes	Operating Long Wall
Newlands	109	No	Operating Long Wall
North Goonyella	275	Yes	Operating Long Wall
Oaky No 1	248	Yes	Operating Long Wall
Oaky North	386	Yes	Operating Long Wall
Total	**4,887**		

The vast majority of Queensland coal is coking coal or thermal coal. These are classified as bituminous coals and typically contain between 76–90% fixed carbon, that is, high rank coal types. All of the underground mines in Queensland are bituminous coal mines mines.[6] Currently, there are no anthracite coal mines in Queensland, though three are considered semi-anthracite, one of which is currently on 'care and maintenance. All three of these mines are/were operated as open-cut mines. There is also an anthracite deposit in Nebo West, but the DNRM advised that there are no current plans to mine it.

In general, Queensland underground coal mines are thought to contain less than 5% silica, provided the mining horizon is within the seam, which can vary. On the other hand high silica exposure can occur with mining processes that involve driving drifts through stone, mining through rock intrusions, drilling or bolting into a stone roof during development and secondary support activities. Open cut mines remove overburden (overlying soil and rock) before reaching the coal seams, and there is a potential for silica exposure during this process.

Most Queensland underground coal mines are operating longwall mining. Longwall mining is thought to give rise to four times as much dust as continuous mining,[7] particularly when production rates (machine speeds) are high.[7, 8] In addition, bi-directional cutting can result in increased exposure to coal mine dust.[7]

1.3 Trends in coal workers' pneumoconiosis

The rates of fatalities and injuries among coal miners have diminished markedly in the USA[1] and UK[9] since the 1970s, however workers in the coal mining industry are more likely to suffer chronic lung disease than comparable non-mining heavy industry.[10] Using the USA as an example, data on occupational illnesses are substantially underreported in coal mining[11] (and other industries[12]), and hinders a targeted public health and industrial hygiene response.

CWP re-emerged in the USA in the late 1990s, though the occurrence of the disease was expected to continue to decline after the institution of modern dust control Regulations. The USA National Institute for Occupational Safety and Health (NIOSH) had reported a decline in prevalence of CWP from 6.5% in the 1970s to a low of 2.1% in the 1990s. However, CWP prevalence subsequently increased to 3.2% in the first decade of the 21st century. The rate of progressive massive fibrosis (PMF) in certain coal mining states in the USA has also recently increased to levels observed prior to the introduction of modern dust controls.[13] In addition, exposure to silica and silicates, e.g. from cutting rock beyond the coal seam and roof-bolting, has been implicated as a factor in rapidly progressive disease.[14]

High rates of CWP have been measured elsewhere. For example, coal miners in Chinese state-owned coal mines who commenced work in the 1970s had cumulative rates of CWP of between 4 to 17%.[2] In Colombia, the prevalence of CWP was recently reported as 36%.[2] A 1984 prevalence survey of CMDLD in Queensland identified 75 cases of pneumoconiosis or suspected pneumoconiosis among 7,784 current and 123 retired employees. [15]

Since the 1990s, Australia has had very few reported cases of CWP.[16] A 24-year mortality surveillance study[17] revealed that out of over 1,000 pneumoconiosis-related fatalities in Australia between 1979 and 2002, CWP accounted for fewer than 100 fatalities, with the largest decline occurring between 1988 and 1996. There were fewer than 5 WC claims per million employees for pneumoconioses (excluding asbestosis) from 2000-01 to 2007-08 and no claims from 2008-09 to 2010-11.[18]

This contrasts with the situation in the USA, where there has been little change since the late 1970s (See Figure 1). Joy et al[19] compared the differences observed between USA and Australian mines and miners, although most of the data were from New South Wales, not Queensland. They concluded that the much lower prevalence of CWP (defined as an ILO category of 1/0 or greater) among Australian miners was due to less exposure to quartz, and perhaps the thicker coal seams, larger numbers of employees (implying bigger operations with more investment for environmental monitoring and dust control), and more effective use of respiratory protection. This was despite occupational exposure limits for coal dust in Australia not keeping pace with reductions in such limits overseas (see section 1.4).

The recent cases of CWP identified in Queensland indicate that more recent information on prevalence and/or incidence of CWP is required and a research framework for this is included in chapter 16 of this report.

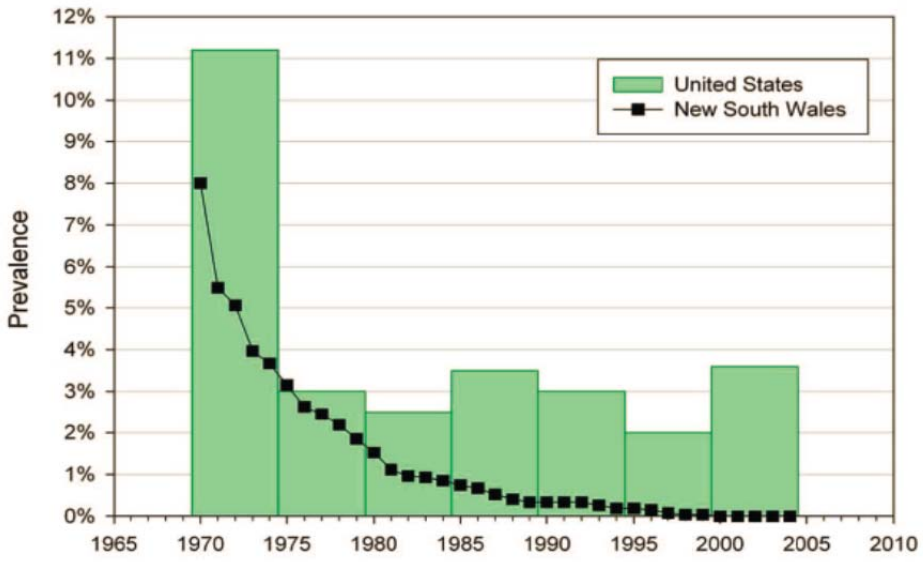


Figure 1: Prevalence of pneumoconiosis, ILO category 1/0 or greater among US underground coal miners and New South Wales[1] coal industry employees, by year [19]

[1]. Equivalent data from Queensland were not provided in this paper but CWP rates in Queensland were thought to be similar to those in NSW

1.4 Exposure limits and risk of pneumoconiosis

The current Australian workplace exposure standard for coal dust is 3 mg/m^3, and for crystalline silica which may also cause silicosis, another type of pulmonary fibrosis, the exposure limit is 0.1 mg/m^3.[20] Other countries have lower occupational exposure limits (OELs) for coal dust than does Australia.

Exposure limits for coal dust are measured as mean air concentrations over 8 hours (i.e. an 8-hour time weighted average (TWA)). If the shift is normally 12 hours for 5 days (i.e. longer than 40 hour per week) the mean exposure must be compared to a proportionally reduced limit (e.g. 8/12). This is because for coal dust and silica, increased risk is associated with cumulative exposure rather than exposure intensity. Consideration of extended shifts is discussed in Appendix C of a Queensland Government report 2010.[6]

The USA Mine Safety and Health Administration (MSHA) requires mine operators "to use the continuous personal dust monitor to monitor the exposures of underground coal miners in occupations exposed to the highest respirable coal mine dust concentrations".[21] Samples must be taken over the whole of a shift during normal production.

Number of samples is a critical issue to demonstrate compliance with exposure limits. This is also discussed in the above Appendix.[6] Exposure measurements typically show lognormal distribution with a tail at the high end of the exposure distribution. This means that if few samples are taken, they are likely to fall at the lower end of the distribution.[22]

More information on exposure limits and risk including a list of the available international exposure limits for coal dust and silica are provided in Appendix 1.

2. Aims of the review

A. To determine whether the respiratory component of the health assessment performed under the Queensland Coal Mine Workers' Health Scheme, is adequately designed and implemented to most effectively detect the early stages of coal mine dust lung diseases in Queensland coal mine workers, estimating the extent and providing feedback and, if not,

B. To recommend necessary changes to correct deficiencies identified under Aim A, recommend measures to follow up cases that may have been missed as a result of these deficiencies, and identify what additional capacity is needed in Queensland to improve this scheme.

The full scope of the review is included in Appendix 2.

3. Ethics approval and data security

Ethics approval for the review was granted by Monash University Human Research Ethics Committee, and the Institutional Review Board of the University of Illinois at Chicago.

The DNRM accessed and extracted data for the review from their Coal Mine Workers' Health Scheme records. Data were de-identified, copied and provided in electronic format, except for analogue CXR films which were provided in hard copy. De-identification included removal of the name, address, telephone number, day and month of birth (but not year of birth) for each worker.

The de-identified data were sent to Monash University via secure file transfer, and stored on a password-protected server. Access was limited to the review team. CXR data were sent to Professor Cohen by secure file transfer and courier, from Monash University and the DNRM.

4. Purpose of the respiratory component of the current scheme

The original coal mine workers' medical assessment scheme was put in place in response to a concern about pneumoconiosis and other respiratory abnormalities (see chapter 1.1). The current NMA information kit does not however clearly state that the purpose of the scheme includes early detection of CMDLD.

A 2010 report of a dust self-assessment survey of coal mines[6] acknowledged the "general confusion around the requirements for, and the content of health surveillance for Queensland coal mine workers." There was a lack of awareness about the purpose of the respiratory component of the scheme, in particular when spirometry and CXRs were required.

While historically, early detection of CWP and other CMDLD in individual miners has been a focus of the respiratory component of the scheme, the current emphasis is on fitness for work. Different parts of the respiratory component of the current scheme are embedded within the assessments of other body systems, and so there is potential for the integration of all of the respiratory health information and important patterns of early lung changes to be overlooked.

CMDLD may develop after some years of exposure to coal dust even if exposure stops. The dust remains in the lungs and CMDLD may only become apparent some years later.[9] The scheme is designed to assess current coal mine workers, so once workers retire or move to another industry, they are lost to the scheme. Cases of CMDLD that develop among former mine workers are unlikely to be identified. This omission further reduces the effectiveness of the scheme as a group surveillance program.

The main purposes of the respiratory component of the scheme, with respect to CMDLD, should be more clearly stated as being to:

1. Provide respiratory health screening to detect early CMDLD in coal mine workers.
2. Ensure appropriate referral for follow-up, diagnosis and management, including appropriate reductions in further exposure to dust, for coal mine workers with respiratory abnormalities.
3. Collect, analyse and report group surveillance data to monitor trends in CMDLD, and to inform Government, industry and trade union reviews of dust exposure levels and occupational exposure limits for coal mines.

The review team would like to emphasise that medical surveillance of CMDLD is only useful for secondary prevention and identifying where there may have been previous excessive exposure. Because of the long latency in the development of CMDLD, it is not a substitute for primary prevention, which should be in the form of coal mine dust monitoring and control.

5. Overall process of the current scheme

Having considered the purpose of the respiratory component and identified the lack of a focus on the early detection of CMDLD, the review team assessed the scheme's processes.

The information in this chapter is summarized from the Coal Mine Workers' Health Scheme – Information for Newly Appointed Nominated Medical Advisers (version 8, 24/02/15), which includes relevant sections of the Coal Mining Safety and Health Regulation (2001) (CMSHR). The flow chart in figure 2 depicts the overall process of the current scheme.

Current situation

The process and procedures of the Coal Mine Workers' Health Scheme begin when a potential, current or previous coal miner applies for work with an employer, which could be a coal mine operator or a contractor (step 1).

As specified under section 46 of the CMSHR, employers must ensure prospective coal mine workers undergo health assessments with their NMA prior to employment. Employers are expected to complete section 1 of the coal mine workers' health assessment form before workers attend NMA appointments (step 2). Section 1 is meant to inform the NMA about the potential hazards of the coal miner's proposed job and importantly should specify whether the worker is "at risk from dust exposure" and therefore requires a CXR.

In some instances however, companies advertise for workers, especially contractors and subcontractors with a current fit for work health assessment. As the miner's job category and location(s) will be unclear, section 1 about the relevant SEG and other potential hazards associated with the job cannot be completed.

The coal mine worker is required to complete section 2 of the health assessment form, to provide details about work history and past and current medical history (including respiratory symptoms) prior to attending their NMA appointment (step 3).

Section 3 of the form consists of the clinical findings, including the spirometry and CXR results (if a CXR was performed), and is completed by either the NMA or an EMO after s/he has reviewed sections 1 and 2 (step 4). Under section 46 of the CMSHR, health assessments can be carried out by an EMO other than the NMA, although assessments must be undertaken under the supervision of an NMA.

EMOs are not authorized to complete section 4 of the report. Instead, partially completed health assessments should be forwarded by the EMO to the NMA, who is meant to review sections 1 to 3 prior to completing section 4 and issuing the report to the employer and coal mine worker (step 5). The report essentially summarizes the health assessment and outlines a worker's fitness for work, including any restrictions. NMAs are expected to provide an explanation of the outcome of the medical examination to the worker and "where practical" secure the worker's signature on the report. It is also the NMA's role to specify the nature and duration of restrictions imposed on a worker's fitness and any required review. However, the instructions do not relate explicitly to CMDLD or other respiratory abnormalities.

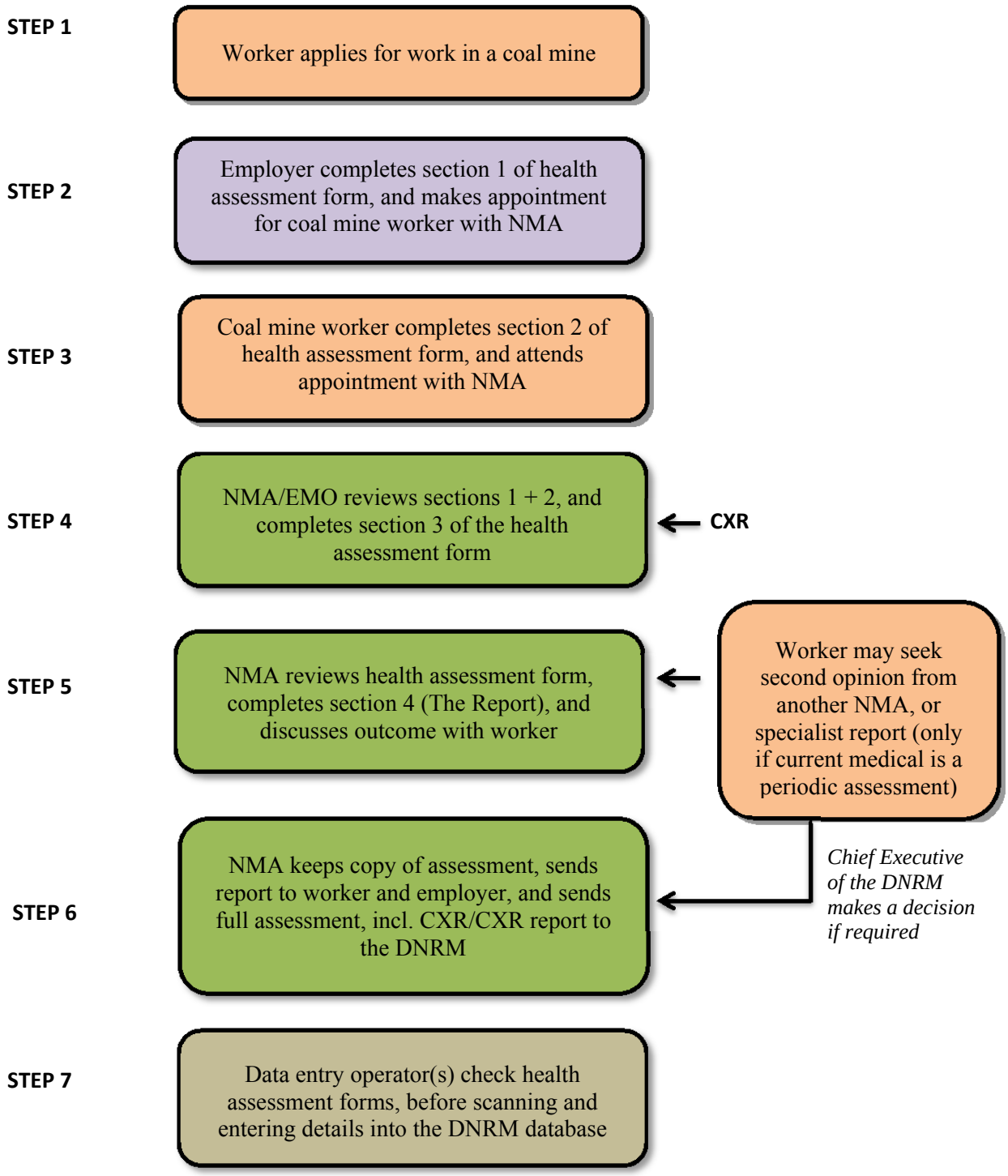


Figure 2: Flow chart of the process of the current Coal Mine Workers' Health Scheme

If the report indicates that a coal mine worker is unable to perform in their usual role without creating an unacceptable level of risk, the worker has a right under section 48 of the CMSHR to request an opportunity for a second opinion from another NMA or relevant specialist, although only if the medical is a periodic health assessment (step 5a). The original NMA is then expected to review their initial report in light of the findings in the second doctor's report and issue another report. Where differences between the reports are unresolved, the worker or employer notifies the chief executive of the DNRM, who will appoint a medical specialist to make a final decision based on a review of the conflicting reports and, if necessary, arrange a further assessment of the worker.

The health assessment records collected under the scheme are the property of the DNRM. NMAs are required to keep a copy of the health assessment data and completed forms and to send a copy of the full assessment, including original CXR films and reports (or copies of CD/DVD) and spirograms to HSU at DNRM (step 6).

Data entry operators in the HSU check health assessments for completeness, before entering the data into the DNRM database (step 7).

Section 46 of the CMSHR states that employers must ensure coal mine workers undergo health assessments periodically as decided by the NMA, but at least every 5 years.

Limitations

As found in our review of the purpose of the scheme in the previous section, the overall assessment process, including the respiratory component, is also aimed at establishing current fitness for work rather than the early detection and management of CMDLD.

There is no clear referral pathway for follow up of respiratory abnormalities detected during the health assessments, nor criteria for further investigation, diagnosis or management of CMDLD in instances where abnormal lung function (spirometry), CXR or other respiratory abnormalities are identified. Clinical guidelines for follow-up of respiratory abnormalities are needed, including involvement of a respiratory physician and/or other specialist with expertise in occupational lung disease, and determination of appropriate workplace restrictions aimed at preventing or reducing dust exposure. It is also important that the results of health assessments are explained to the workers, especially where abnormalities suggestive of CMDLD are detected.

A diagnosis of CMDLD may be made by a respiratory physician or other medical specialist after referral from the NMA, but this may require further investigations, such as a CT scan. However, there are currently no agreed standardised diagnostic criteria within the scheme for the various diseases within CMDLD and no established process in the Regulations by which coal mine workers found to have such disease is formally reported to the DNRM when identified under the scheme.

The SEG approach in section 1 of the form, which is currently required to determine whether a miner needs a CXR, does not account for contractors, subcontractors or labour-hire workers who may not be based at a specified mine or employed for a specific role. CXRs are not being undertaken by all coal mine workers who work underground,[6] but there is also the potential for duplication of health assessments and CXRs. In addition to the scheme assessments, we understand from stakeholders that many employers arrange their own pre-employment and periodic health assessments.

Under the current process, information from previous assessments is not promptly available to NMAs. Miners may have very small opacities and acceptable lung function at any one

assessment and be viewed as fit for work. However, comparison across serial medical assessments is more likely to show the development of small, preclinical changes and declines in lung function. The current scheme also has no requirement for any follow-up health assessments focusing on the respiratory health of coal miners previously in a position "at risk from dust exposure" once they leave such a position. In addition, there is no mention of exit health assessments or on-going follow-up of coal mine workers who retire or leave the industry.

The current process does not prevent the submission of incomplete health assessments, as this is performed manually. An electronic system of data entry to a centralised secure database would reduce workload for HSU by removing step 7. Lack of completion of steps e.g. step 2 could be programed to prevent the submission of incomplete forms. Such a system would also enable the findings from previous health assessments to be accessed by NMAs directly from the DNRM data and compared with the current assessment, including in instances where a worker's previous health assessments have been completed by different NMAs.

The review of the health assessments at DNRM is purely administrative and involves no medical review or audit, and the DNRM database is currently not being utilised for group surveillance.

There is also no explicit process by which DNRM can ensure that the scheme as implemented remains fit for purpose as the industry changes, i.e. that it continues to meet its intended aims.

In order to utilise data from the respiratory component of the scheme for evaluation and monitoring of industry-wide trends, the necessary data fields should be identified and the database interrogated regularly for overall reporting purposes. If a case of CMDLD is identified, the DNRM Occupational Physician should be able to contact the employer's NMA to discuss and implement action to reduce exposure and try to prevent other cases occurring. However, under the current regulations, these discussions can only proceed with the consent of the individual worker.

6. Confirmed CWP cases

Having reviewed the purpose and processes of the scheme, we examined health records for the confirmed CWP cases to identify where the scheme had failed to identify and/or act on early respiratory abnormalities indicative of CMDLD. We received de-identified data of the seven individuals with confirmed CWP (as of May 2016), including a majority of completed health assessment forms and CXR reports, from the DNRM. The spirometry printouts performed under the scheme were not available, however lung function results were reported in the records.

The respiratory component of the health assessment forms was reviewed and the overall deficiencies are summarised below. The details of the individual cases are not included, to preserve confidentiality.

The review team was not provided with additional medical information gathered outside the scheme, so we were not always able to assess what prompted the (re-)assessments or investigations that led to the diagnosis of CWP in these cases.

Limitations

For most cases, there were abnormalities identified (respiratory symptoms, spirometry or CXR) during one or more of their health assessments. However, there was a lack of documentation and inconsistent processes about follow-up or referral when abnormal results were found. Furthermore, there were cases where workers were still reported as being fit to work underground with no recommendation for restrictions for respiratory conditions, e.g. to avoid exposure to dust.

Health assessments are required to be completed periodically at least every five years. Some earlier review appointments were organised to re-assess previously identified respiratory problems, but these were sometimes scheduled less frequently than the NMA indicated. In some cases, health assessments were conducted more frequently, but the reasons for this were not always made clear on the health assessment forms. This may be explained, in part, by the worker changing employer and requiring a new health assessment. This can result in more frequent CXRs than desirable.

The majority of the abnormal spirometry results found that the health assessments were considered to be suggestive of chronic obstructive airways disease, but these were often attributed to tobacco smoking rather than coal dust exposure. In addition, decline in lung function tests over serial health assessments were not taken into account by NMAs.

CXRs were not reported according to the ILO classification (see chapter 1.1), although for two cases where abnormalities on CXR were noted, the terminology used by the radiologist was consistent with this classification.

In some cases, diagnosis of CWP was made many years after retirement, this highlights another limitation of the current scheme, which is its exclusion of retired (and former) coal miners and lack of ongoing health surveillance for these groups.

7. Health assessment form

We reviewed the content and design of the respiratory component of the health assessment form (Appendix 3), which includes information about the worker's medical history, respiratory symptoms, job history and information provided by the employer about "at risk from dust exposure". We also assessed the completeness of a convenience sample of 91 forms, and explored possible reasons for incompleteness and/or poor quality.

7.1 Content and design

Current situation

The scheme's health assessment form is a seven page paper-based document. It is divided into four sections for completion by the employer, worker, EMO and NMA, respectively.

The employer's section consists of free text boxes to record the employer and mine name, the coal worker's position (including generic and company SEG) and six "yes/no" questions about exposure to various hazards.

The coal mine worker's section consists of over 40 questions grouped under five separate headings, including "yes/no" tick box options for a range of medical conditions and free text entry for the work history.

The EMO's section consists of over 50 questions grouped under eighteen separate headings, including "yes/no", "abnormal/normal", "absent/present" tick box options for medical history and clinical findings for the respiratory and other major body systems, and space for additional comments.

The NMA's section (section 4 – the report), consists of similar fields as the employer's section, the EMO's examination details and five tick box options to record the coal mine worker's fitness for duty and restrictions.

Limitations

The current structure of the health assessment form has the respiratory component scattered among the numerous questions and physical findings related to other body systems, which reduces the focus on the respiratory system.

The form is also lengthy, and could be shortened by the use of tick boxes, e.g. for previous occupational history provide a list of jobs (such as in Table 2), and duration of employment. This would allow rapid identification of jobs associated with development of CMDLD.

There are insufficient questions about previous respiratory conditions such as asthma, bronchitis, emphysema, tuberculosis, pneumoconiosis, lung surgery, lung infections, and allergies. The form does not have a complete respiratory symptom questionnaire, which should be a standard for health surveillance of workers exposed to hazardous substances that affect the lungs.

The 1995 National Occupational Health and Safety Commission (now Safe Work Australia) guidelines include a respiratory questionnaire and both the NSW and (previous) WA health assessment forms for mining employees include expanded respiratory sections, compared

with the Queensland form. The six-page health assessment form used in the WA scheme focussed almost entirely on work history, respiratory symptoms, spirometry and CXR results.

The current Coal Mine Workers' Health Scheme assessment form has several ambiguously-phrased questions, e.g. Question 2.4e "Abnormal shortness of breath or wheezing?" asks about two symptoms in one question. The smoking history is also poorly worded, e.g. "Do you currently smoke, or have you ever smoked?", and doesn't allow for the differentiation of current and former smokers.

There are also several duplicate questions: Question 1a, "Dust exposure (x-ray needed?)" corresponds with questions 3.12, and question 1b, "underground work" corresponds with a question in the report (section 4), "Is the assessment for underground work?"

The lack of "N/A" tick box options also increase the likelihood of errors, as well as inconsistent interpretation and responses during form completion.

There is also no specific reference in section 4 to the absence or presence of symptoms/signs, or to spirometry or CXR changes consistent with CMDLD, or to the follow-up required and frequency of subsequent health assessment in section 4.

Prior to 2001, the ILO classification of each CXR was provided on the form, so that the frequency with which categories other than 0/0 were reported could be used as an early warning of CXR changes, and which could also be used for health monitoring.

During the review, the DNRM advised that NMAs have been issued with an amended form (dated 01/05/16) that includes additional instructions about: the category of coal mine workers who require a CXR; qualifications for individuals conducting spirometry and CXRs; and the standards for interpreting/reporting these tests including the use of the ILO classification.

7.2 Completion and quality

Current situation

The respiratory component of the current health assessment form was compared with the fields included in a sample of 91 records extracted from the DNRM database.

In general, this sample from the DNRM database captured most of the respiratory component. However, a number of important questions were often omitted, including:

- Section 2.2 - work history;
- Section 2.3 - health-related history, in particular whether a previous medical had been completed under the scheme and date of the last examination;
- Section 2.4 - past medical history, in particular asthma, bronchitis or other lung diseases and abnormal shortness of breath or wheezing;
- Section 3.12 - quality of CXR film and whether it was attached to the report;
- Section 3.18 - fitness for duty in relation to working under various conditions such as underground, in dusty conditions and while wearing RPE;
- Section 4 - NMA explained restriction or additional assessment for the worker.

In addition, other past medical history from section 2, such as tightness of chest and allergic reaction or reaction to chemicals or dust, are relevant to the respiratory system and therefore should be included in the DNRM database.

The information contained in the sample of 91 health assessment forms was also assessed for completeness and quality. Completeness was ascertained by the proportion of dataset fields that required an entry that were provided, for example worker's date of birth. Quality was determined by the proportion of fields that were internally consistent, for example the consistency of entries for duplicate questions.

Full quantitative results from the review of completeness and quality are presented in Appendix 4.

We found that the medical information was largely complete. However, some fields were consistently incomplete or poorly completed.

Limitations

The employer's section of the form was poorly completed. This may in part be due to workers being required to complete a health assessment prior to being employed. This is problematic in that the job may be unknown, particularly where contractors are involved, and so the appropriate decision about whether a CXR is needed cannot be made.

The SEG to which the coal worker's position was allocated was a required field from November 2010. The generic SEG was only provided in a minority (4/21) of medicals and company SEGs were not completed in any of the health assessments. Some employers reported that section 1 is usually completed by a human resources staff member or their NMA, in which case they are provided with a list of SEGs. In other companies, this is the role of the line manager. This creates a potential for miscommunication, as NMAs (or labour hire companies) may not consider themselves as the "employer" for the purposes of completing section one.

Other important fields that were poorly completed were questions about dust exposure and whether the assessment was for working underground.

Some of these questions overlapped or were duplicated. Question 1a, "Dust exposure (x-ray needed?)" corresponded with questions 3.12 "CXR undertaken". Although "y" was entered for question 3.12 in all 91 medicals, over one-third (38%) of entries for question 1a did not correspond, and had either "N" entered or were left blank. Question 1b, "underground work" corresponded with a question in the report (section 4), "Is the assessment for underground work?" Almost one-third (27%) of the responses in section 4 did not correspond with the responses for question 1b.

Another field from section 1 that was poorly completed was the name of the mine. Although all 91 medicals had this field completed, approximately one-third (36%) had quality limitations, with either "Unknown" or "Various mines" entered for this field. It is possible that the term "Unknown" is because these were workers seeking employment and "Various" was used where the worker is a contractor or labour hire employee.

The remaining notable quality issues related to the EMO's details in section 4, for which surnames alone were entered for fifty-seven out of fifty-nine medicals, and details of restrictions on work activities in section 4, from which it was not apparent whether the restrictions were required for CMDLD, as it is the current practice not to include any medical information in section 4.

In some cases the free text boxes throughout the form had been completed in illegible handwriting.

Targeted auditing, which could be conducted in several ways, would reduce the poor completion of the forms. For example, an audit of the first batch of health assessment forms completed by new NMA, and a random sample of assessment forms completed by more experienced NMAs. For example, with the (recently ceased) WA system, approvals to undertake mining employees health surveillance was revoked if an unacceptable number of poor quality forms were submitted.

8. Risk from dust exposure requiring a surveillance CXR

Current situation

When a coal mine worker is sent for a health assessment under the current scheme, the employer must specify whether the worker is "at risk from dust exposure" in section 1 of the assessment form. This indicates that a CXR is required as part of the miner's health assessment.

In order to better understand the criteria used to determine coal mine workers "at risk from dust exposure", the review team visited an open-cut and an underground coal mine and a CHPP in Queensland. We had further discussions with health and safety representatives from 11 companies (including 3 labour-hire contractors), and with representatives from the CFMEU.

Who currently gets a CXR?

A recent survey[23] revealed that although all coal mines conduct health surveillance, only 83% of underground mines include CXRs as part of the periodic coal mine workers' health assessments. The majority of open-cut miners were considered not "at risk from dust exposure", however, from a convenience sample of 5,997 DNRM health assessment records, about half of the CXRs were performed for open-cut miners (though the majority, 41 of 54 mines in Queensland, are open-cut).

In discussions, some mine companies identified open-cut jobs such as drilling and blasting, overburden drilling, rock screening and exploration drilling as "at risk from dust exposure", mainly due to exposure from silica rather than coal dust.

Completion of SEGS on the health assessment form

In order to help with the decision about whether a miner is in a dust-exposed job, employers have been required, since November 2010, to specify the relevant SEG in Section 1. Employers may use the DNRM generic SEGs or company SEGs. It is important that the specified SEG accurately reflects the likely dust exposure. Otherwise those who require a CXR may not receive one and those who do not require a CXR may have one unnecessarily.

In the sample of 91 completed health assessment forms examined (discussed in chapter 7.2), 21 were completed after 2010, i.e. when the SEGs were introduced. For these 21, we found that:

1. Generic SEGs were poorly completed, having been provided in only four forms
2. Company SEGs were not completed in any of the forms, so the review team was unable to identify any company SEGs

There were also inconsistent entries for duplicate questions in the health assessment form relating to "at risk from dust exposure" criteria, e.g. dust exposure/CXR needed and working underground.

SEGs were defined recently by the DNRM as follows:[24] "SEGs are groups of workers who have the same general exposure to risk, for example:

- the similarity and frequency of the tasks they perform
- the materials and processes with which they work
- the similarity of the way they perform those tasks"

Table 2: Mines inspectorate SEG listing (from the DNRM information sheet)[6]

Underground Coal Mines SEGs	Task descriptions
Longwall production	Employees and contractors: • Operating shearer, maingate, chocks • Undertaking roof support, hanging/changing cables and hoses • Performing belt retraction, operating driftrunner and LHD
Development production	Employees and contractors: • Operating continuous miner, driftrunner, shuttle car, LHD, ram car • Undertaking roof and rib bolting • Hanging hoses, handling cables, hanging vent tubes, performing belt extensions, hanging brattice
Underground maintenance	Employees and contractors: • Performing mechanical maintenance services underground • Performing electrical maintenance underground • Undertaking mechanical repairs and vehicle servicing underground
Outbye supplies	Employees and contractors delivering supplies to underground locations on LHDs
Longwall moves	Employees and contractors operating dozers, LHDs, drift runners performing face retraction and installation. Any employees and contractors involved in the face retraction/ installation including fitters, electricians and mine technicians
Outbye construction/ infrastructure	Employees and contractors: • Operating grader, drift runner, LHD • Changing hoses, cables, tyres, lights and pipe work • Hanging hoses, pipes and cables • Undertaking roof and rib bolting, shovelling, secondary support, concreting underground
VCD installers	Employees and contractors spraying stoppings and using jackhammer
ERZ controllers	Employees and contractors performing inspections and statutory duties
Surface maintenance	Employees and contractors servicing/maintaining vehicles in surface workshop
Control room operator	Employees and contractors involved in control room operations
Belt splicers	Employees and contractors performing belt maintenance, splicing and commissioning
Boilermakers (surface)	Employees and contractors involved in steel fabricating, welding, oxy cutting, air gouging—surface workshop and CHPP workshop
Administration	Administration officers; stores; management
Resin Workers	Employees and contractors undertaking resin injection and void filling activities throughout the underground workings. This includes the use of polyurethane resins (PUR) and phenolic resins.
Stone Driveage	Employees and contractors involved in mining through stone, faults and intrusions. Generally this is for the purpose of mine expansion or drift construction. This does not include development or longwall workers who from time to time encounter small areas of faulted ground or stone banding.

Open-cut Coal Mines SEGs	**Task descriptions**
Pre-strip and overburden removal	Employees and contractors working in pre-strip areas of the mine and operating equipment (e.g. haul trucks, loaders, dozers, graders and excavators)
Coal removal	Employees and contractors involved in the removal of product coal (e.g. digger/shovel, dump trucks)
Open cut inspection services	Employees and contractors performing inspection and monitoring tasks in the mining and excavation areas (e.g. OCE and shift supervisors)
Road maintenance	Employees and contractors involved in road maintenance operations including grader and water truck
Boilermaker	Employees and contractors involved in steel fabricating, welding, oxy cutting, air gouging—surface workshop and CHPP workshop
Field Maintenance	Employees and contractors undertaking electrical and mechanical maintenance activities in the mining areas.
Blast crew	Employees and contractors undertaking blasting and shot firing duties
Tech services	Employees and contractors performing mine planning and design (includes surveyors, geotechnical engineers)
Exploration drillers	Employees and contractors undertaking exploration drilling operations
Blast hole drillers	Employees and contractors undertaking blast hole drilling operations
Belt splicers	Employers and contractors performing belt maintenance, splicing and commissioning
Warehousing	Employees and contractors undertaking warehousing activities including forklift operation
Administration	Administration officers; stores; management
Workshop	Employees and contractors undertaking electrical and mechanical maintenance and services in the workshop
Service crew	Employees and contractors supplying fuel, grease and oil to mobile plant throughout the mine.
Tyre fitters	Employees and contractors performing tyre handling, tyre fitting and tyre repair duties.
CHPP SEGs	**Task descriptions**
CHPP production	Employees and contractors involved in control room operations, hosing, clearing blockages, shovelling, bobcat ,general maintenance and train loading out
CHPP maintenance	Employees and contractors undertaking electrical and mechanical maintenance throughout the plant and in the workshop
CHPP laboratory	Employees and contractors taking samples and processing samples in CHPP laboratory
CHPP dozer	Employees and contractors operating CHPP stockpile dozer
Belt splicers	Employers and contractors performing belt maintenance, splicing and commissioning

The DNRM document lists generic SEGs in underground mines, open-cut mines and in CHPPs [24] (see Table 2). These SEG categories were devised by the Safety in Mines Testing and Research Station (SIMTARS), based on measurements of coal mine dust. A 2010 Queensland Government report contains the results of a survey, conducted on behalf of the DNRM, which revealed that only 39% of mines had implemented dust monitoring programs, characterised dust exposure and established SEGs.

The 2010 report also indicated that 11% of mines did not carry out monitoring, a further 26% monitored annually or less frequently, 31% only monitored on the day shift and only 25% adjusted the TWA for extended shifts.[6]

The Queensland Government dust self-assessment feedback report (2010)[6] stated that 76% of coal mines identified respirable silica as a hazardous dust at their site, and 29% identified that respirable coal dust might be a problem. Some company representatives reported that exposure monitoring for these dusts (performed outside respiratory protective equipment) are used to define SEGs.

SEGs are clearly useful to guide decisions about dust exposure monitoring and where dust control measures should be applied and to track exposure changes over time or when new processes or equipment are introduced. Therefore, conclusions about the use of SEGs for the purposes of deciding on requirement for CXR should not impact on the use of SEGs for these other important dust monitoring and control functions.

Limitations

The criteria to determine jobs "at risk from dust exposure" are not explicit in the regulations. The DNRM also do not specify which generic SEG categories fulfil these conditions. All underground workers (probably 13 of 15 underground SEGs) are likely to experience dust exposure, but some above-ground workers at underground sites, some open-cut miners and some workers at CHPPs may also be at risk.

It is unclear who decides which SEGs qualify as "at risk from dust exposure". This may depend on measured exposure data, but the companies varied in their approach. For example, several mine companies had a formal trigger, where recorded dust exposure exceeded the OEL or half the shift adjusted OEL (see Table 3).

Table 3: Company XXX corporate standard control categories (SIMTARS report)

Category	Personal exposure level	Control Zone
A	Exposure exceeds the OEL	**Intervention**
B	Exposure between 50% and 100% of the OEL	**Control**
C	Exposure between 10% and 50% of the OEL	**Supervisory**

In addition, dust generation at the mine may depend on the strata and whether the mine has been degassed. The use of a variety of dust control technologies also leads to situations where dust exposure for similar job categories may vary from mine to mine and between different coalfaces within a mine.

NMAs rely on the information completed by employers (including completion of the SEG information) in section 1 of the form to guide the decision about whether a coal miner requires a CXR, but there is generally no guidance for NMAs about the application or implication of SEGs. Several company health and safety representatives agreed that the decision about who required a CXRs and how frequently, should be the NMA's rather than the employer's decision. They also agreed that NMAs should be supported with training about SEGs and job categories with potential for high dust exposure.

Furthermore, workers' complete employment history, not just the job at the current health assessment, should also be taken into account when deciding about the CXR, because the likelihood of developing CMDLD is determined by cumulative exposure to dust over the whole working lifetime. This is particularly relevant to contractors (such as general labourers), who are more likely to have been employed in a range of jobs across various mines, and therefore deployed to different SEGs. In other words, the occupational history should identify the duties and tasks that have been performed.

The use of SEGs to categorise dust exposure has some merit, but is complex to operationalise. Even after taking into account workers' transition between different SEGs, SEGs themselves may change due to changes in dust levels when production or control measures change, and contractors would not necessarily have access to a company's dust monitoring data.

The SEGs should take into account silica as well as coal dust, as the exposure limit for silica is much lower than that for coal dust, so is more easily breached.

Lastly, if SEGs are used to define "at risk from dust exposure" they should be revisited and updated regularly if there are changes in the mine anticipated to change the dust exposure of jobs in the SEGs, e.g. strata, production methods or rates, and dust control measures.

9. Nominated Medical Advisers

We reviewed the list of NMA currently registered with the HSU. We examined their qualifications and their geographical coverage, and the information kit provided to newly-registered NMAs. We also had discussions with mine company health and safety and CFMEU representatives about their NMA appointment process, and how coal mine workers are referred to NMAs.

Current situation

Nominated Medical Advisers – Total number, clinic type and qualifications

In total, there are 237 NMAs registered to conduct the coal workers' health assessments. The NMAs practise in over 140 clinics and are based in five different States (see Appendix 5 for further details). Some NMAs practice in more than one clinic. The number of NMAs expanded during the mining boom (after 2005), but prior to this there were approximately 40 NMAs.

General Practitioners (GPs) accounted for 62% of NMAs, while specialist Occupational Physicians constituted the smallest proportion at 12%. Non-specialists or medical practitioners with general registration accounted for the remaining 26% of NMAs.

There were two main types of clinics in which the coal mine workers' health assessments were conducted, GP clinics and Occupational Health Service clinics. However, there were more than twice as many GP clinics as Occupational Health Service clinics (97 vs. 43).

The majority (about 90%) of NMAs and clinics are in Queensland. Although the coal workers' health assessments are undertaken in 28 different Queensland regions, these activities were concentrated in five main regions: Brisbane/Brisbane City, Mackay, Sunshine Coast, Rockhampton and the Gold Coast (Table 4 and Figure 3). The majority of these sites are a considerable distance from the mines and likely to cater for fly-in fly-out (FIFO) workers.

Table 4: Main locations of NMAs in Queensland, in 2015

Region	Occupational Physicians	General Practitioners
Mackay	2	28
Rockhampton	2	14
Sunshine Coast	0	14
Brisbane/Brisbane City	10	33
Gold Coast	1	8
Total	**15**	**97**

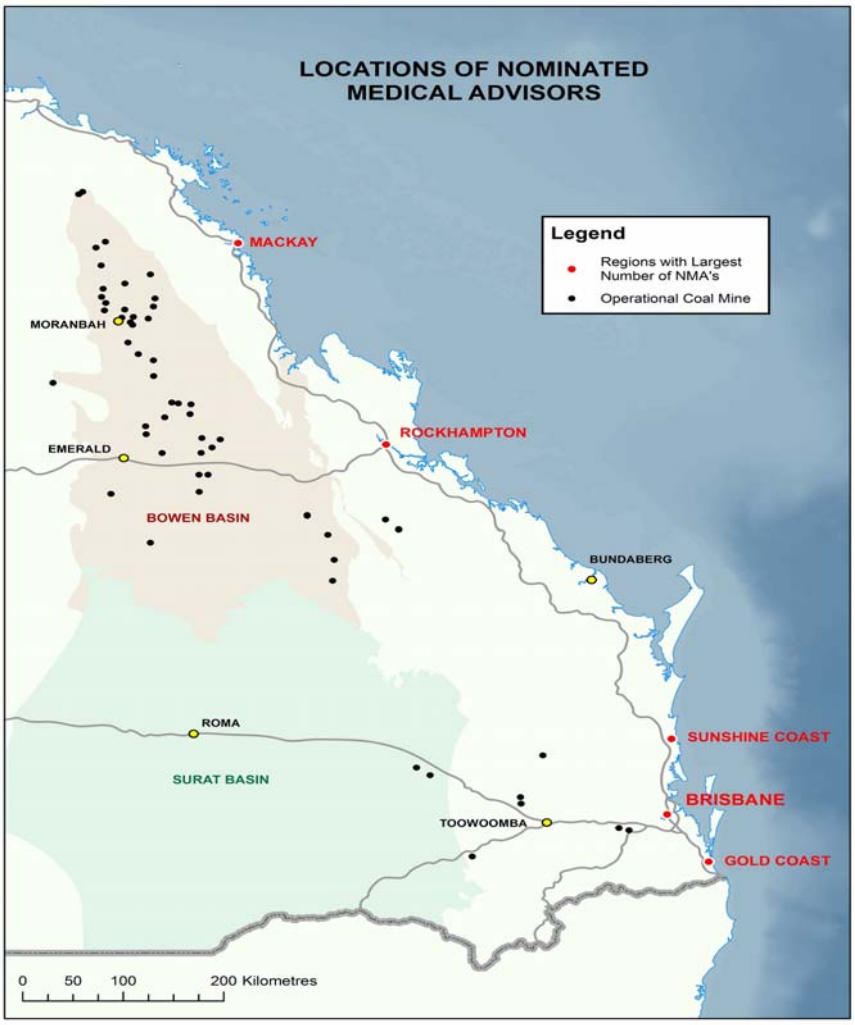


Figure 3: Underground mine and main locations of NMAs in Queensland (Figure courtesy of DNRM)

Nominated Medical Advisors - registration and training

There is no formal system for vetting the addition of NMAs to the list held by the DNRM, and selection of NMAs is at the discretion of the mine companies, contractors and labour hire firms. However, new doctors selected to become NMAs must be notified to the HSU.

The company and CFMEU representatives reported that though companies may have corporate medical advisors, NMAs are appointed by the specific mine sites, and in most cases are the local GPs. There may be up to two NMAs employed by companies per mine site, however labour-hire organisations tend to employ larger numbers of NMAs to cater for the geographical spread of their employees. For example, one company reported a pool of 20 to 30 medical advisers.

EMOs often perform the actual health assessments and complete section 3 of the form, but this is then forwarded to the company NMA to complete section 4. In this situation, the NMA has not collected the health information him/herself and so relies on the accuracy and quality of the information collected by the EMO or other health practitioners.

There is currently no formal training of NMAs prior to being registered to undertake coal mine workers' health assessments. However, regular meetings with NMAs were previously conducted by DNRM prior to the expansion of the number of NMAs during the mining boom. In addition, NMAs are not required to hold any specific qualifications apart from being a registered medical practitioner. Instead, the DNRM furnishes newly registered NMAs with an information kit. The current version (dated 24/2/15) is an 18-page document which outlines the process of the coal mine workers' health scheme, and an enclosed appendix illustrates examples of work restrictions relevant to nominated medical conditions, such as manual handling weight restrictions for musculoskeletal injury and diminished cardiovascular fitness. With respect to respiratory conditions, the information kit advises that individuals with chronic obstructive airways disease and pneumoconiosis are to avoid exposure to irritant airborne contaminants (including dusts) and should not work underground. However, there are no instructions or clinical standards to guide further evaluation and follow-up of abnormal clinical findings or newly diagnosed medical conditions, so the focus is mainly on fitness for work. NMAs are also advised not to disclose medical conditions on section 4.

Some companies reported a preference for NMAs with occupational medicine qualifications, but reiterated that local knowledge and mine proximity was important. In addition, most companies stated that they offered site visits for NMAs, particularly to their underground mines.

Limitations

There are currently too many NMAs on the HSU list who are eligible to perform health assessments under the current scheme. The inclusion of EMOs makes the pool of medical providers even larger. This situation has created challenges for the HSU in maintaining an accurate and up-to-date register of NMAs, especially as companies may not inform the DNRM of changes in appointments. Due to the large number of NMAs and the diverse geographical spread, it became more difficult to co-ordinate (previously held) NMA meetings and training and these are no longer held.

NMAs are advised to visit the mine sites for which they will be providing health assessment services under the scheme, but this is not mandated. Experienced medical providers working near the mines and/or those with specialist training in occupational medicine are likely to be familiar with hazards and risks specific to the coal mining industry. However, for many of the NMAs without a good knowledge of a coal mine worker's particular work environment, there are likely to be limitations in the conduct and quality of respiratory health assessments.

A large group of medical providers (NMAs and EMOs) with diverse qualifications and experience practising in a variety of clinic settings is likely to have further negative impact on quality assurance.

The lack of initial or ongoing training for NMAs is particularly concerning. There is currently no means of assessing NMAs' understanding of the content of the NMA information kit or its appropriate application, and no ongoing audit of NMAs' performance, apart from an administrative review at HSU. The main purpose of the information kit is to provide administrative procedures for conducting health assessments, rather than information about CMDLD or medical guidelines. There is no information in the kit about the primary purpose of the Coal Mine Workers' Health Scheme and no explicit instructions about the early signs of CMDLD, nor about procedures for clinical management/referral for suspected CMDLD cases.

Under the Regulations, the role and qualifications of the EMOs are undefined in the scheme, and EMOs are not required to be notified to the HSU. Given that more training and selection processes should be required for NMAs undertaking respiratory health assessments, allowing comparatively less trained EMOs to carry out the respiratory examination would continue to be a major weakness. Several companies highlighted the lack of quality control introduced by reliance on EMOs, especially where they are unfamiliar with mining work environments and the principles of health surveillance. However, they acknowledged that mine workers especially FIFO mine workers prefer to go to their local GPs, who may be an NMA or EMO, to conduct their health assessments.

10. Chest x-ray review

The purpose of this review was to identify deficiencies in the chest imaging component of the Coal Mine Workers' Health Scheme which may have contributed to the failure to identify early changes of CWP.

Sample size

The sample size of the number of coal miner CXRs required for the x-ray review was calculated[2] based on an estimated 3% prevalence of CWP (≥ 1/0 category by the ILO CXR classification system) among Queensland coal mine workers currently employed at a Queensland mine with more than 10 years of coal mine employment.

This estimate for prevalence is comparable to that reported by Blackley and colleagues [25] among underground coal miners in Kentucky, Virginia, and West Virginia, who participated in the USA Coal Workers' Health Surveillance Program between September 2005 and December 2012. A related study[26] found a 2.7% prevalence of at least ILO category 1 small opacities among coal workers who participated in the NIOSH surveillance program between 2000 and 2008. Based on these estimates, a sample size of 452 CXRs was determined to have enough power to detect a 3% prevalence of pneumoconiosis defined as ILO category 1/0 or greater.

The review team considered it important to include CXRs from as many mines as possible for this review. As some of the mines are small, the calculated number of CXRs needed was small and may not be representative. We therefore chose to request a minimum of 25 CXRs from each mine. The total requested was 478 CXRs. In addition, there are mine workers who are employed by contractors and work across different mines. We received 50 additional CXRs of miners for whom no mine was specified. It is likely that these CXRs were from miners who worked at a number of different mines. Ultimately, the total number of CXRs requested from DNRM was 528. The number of requested CXRs for coal miners from each mine is shown in Table 5.

[2] The formula used for this calculation is $\mathbf{n = (Z^2 \times P(1 - P))/e^2}$, where Z = value from standard normal distribution corresponding to desired CI (Z=1.96 for 95% CI), P is expected true proportion, and e is desired precision (half of the desired CI width).

Table 5: Number of CXRs by mine (numbers supplied by DNRM)

Mine	Number of mine workers[a]	Sample size	Number received	Number missing
Aquila – N/A	0	-	2	0
Broadmeadow	**683**	63	13	50
Carborough	314	27	14	13
Cook	362	32	25	7
Crinum – *closed*	223	25	13	12
Ensham	209	25	10	15
Grasstree	639	59	18	41
Grosvenor[b]	249	25	2	23
Kestrel	536	50	39	11
Moranbah North	649	59	15	44
Newlands	109	25	10	15
North Goonyella	275	27	6	21
Oaky No. 1	248	25	7	18
Oaky North	386	36	29	7
Mine Not Specified	N/A	50	50	0
Total	**4,887**	**528**	**253**	**277**

[a] Number of employees reported at the mine as of November, 2015.

[b] Mine with new development and therefore very few miners with 10 years of exposure.

Protocol for CXR review

1) ILO Classification

Small scars caused by the body's reaction to coal mine dust inhalation may manifest as small opacities seen on CXR. CXRs were classified according to the ILO Classification of Radiographs for Pneumoconiosis.[3] Briefly, this classification system is used to characterize opacities consistent with pneumoconiosis through the comparison of the chest radiograph of interest with standard radiographs issued by the ILO. Small opacities are described by their profusion (the number of opacities); affected zones of the lung; and their size and shape (rounded or irregular). Of these characteristics, the key item for the purpose of deciding whether pneumoconiosis is present is the profusion, which is rated on a 12-point scale. Digital radiographs from the worker are classified by comparison to the appropriate digital image from the ILO 2011D standards; analogue films are classified by comparison to the ILO 2000 analogue standards. A copy of the NIOSH reporting form can be found at: http://www.cdc.gov/niosh/topics/surveillance/ords/pdfs/CWHSP-ReadingForm-2.8.pdf.

2) Use of multiple certified B-readers

All images were classified by two NIOSH certified B-readers[3] in a protocol detailed below. An additional three B-readers were available for additional readings when the primary readers did not agree.

The following is a list of B-Readers who participated in this review.

1. Robert Cohen, MD, FCCP – Respiratory physician, B-Reader. NIOSH Project Officer, American College of Radiology Pneumoconiosis Task Force
2. Kathleen DePonte, MD – Radiologist, B-Reader. Member of NIOSH Coal Worker's Health Surveillance Panel, Member of American College of Radiology Pneumoconiosis Task Force
3. Edward Lee Petsonk, MD – Respiratory physician, B-Reader. Professor of Medicine, West Virginia University, Member of NIOSH Coal Worker's Health Surveillance Panel, NIOSH Project Officer for American College of Radiology Pneumoconiosis Task Force
4. David Lynch, MD – Radiologist, B-Reader. Professor of Radiology, National Jewish Health, University of Colorado School of Medicine, Denver Colorado. Member of NIOSH Coal Worker's Health Surveillance Panel, Member of American College of Radiology Pneumoconiosis Task Force
5. Jack Parker, MD – Respiratory physician, B-Reader. Chairman, Division of Pulmonary and Critical Care Medicine, West Virginia University. Member of NIOSH Coal Worker's Health Surveillance Panel

3) Classification of CXR quality

1. Good.
2. Acceptable, with no technical defect likely to impair classification of the radiograph for pneumoconiosis.
3. Acceptable, with some technical defect but still adequate for classification purposes.
4. Unacceptable for classification purposes.

4) Classification of small and large opacity (presence and profusion) and reaching a final determination

1. Two classifications were considered to be in agreement if one of the following occurred:
    a. Both found one or more large opacities of 1 cm in size or greater consistent with complicated pneumoconiosis (category A, B, or C);
    b. Both found small opacities of less than 1 cm in size consistent with simple pneumoconiosis in the same major category (category 1, 2, or 3);
    c. Both classifications with finding of small opacities were within one minor category of each other, in this instance the higher minor category is selected (see ILO Classification 12-point scale, Table 6) except if there was a reading sequence of 0/1, 1/0, or 1/0, 0/1, which was not considered agreement; or,

[3] Note: B-readers are licensed medical practitioners who have been trained to classify images according to the ILO system and who have successfully passed an exam offered by the US NIOSH every 4 years.

d. Both classifications were negative (i.e., 0/-, 0/0, or 0/1) for opacities consistent with pneumoconiosis.

2. If there was agreement between the two classifications, as described above, the result was considered a final determination and reported.
3. When agreement was lacking, a third classification was obtained. If any two of the three classifications demonstrated agreement, the majority result was considered the final determination.
4. If agreement was lacking among the three classifications, independent classifications were obtained from two additional B-Readers and the final determination was the median category derived from the total of five classifications.

Table 6: ILO scale for classifying CXRs for pneumoconiosis

Opacity Size[a]	ILO Category	Classification of Pneumoconiosis
None	0/- 0/0 0/1	Negative
Small (<10 mm)	1/0 1/1 1/2 2/1 2/2 2/3 3/2 3/3 3/+	Simple
Large (≥10 mm)	A B C	Complicated

[a] As measured by the short-axis diameter.

5) Comparison of the final determination with the original reports on the x-rays to determine if there was a qualitative agreement

a. The original radiologist reports were reviewed by at least one qualified occupational pulmonologist. The vast majority of these reports did not use the ILO classification. For this reason, the reports were reviewed to determine if the radiologist recognized features consistent with pneumoconiosis and indicated this on the report.

b. The radiologist reports were categorised as:
(0) No report available
(1) Normal
(2) Abnormal with small opacities suggestive of simple pneumoconiosis
(3) Abnormal with large opacities suggestive of complicated pneumoconiosis
(4) Other abnormality reported, not suggestive of pneumoconiosis

c. The Coal Mine Workers' Health Scheme radiology report was considered to be in agreement with the final ILO reading by the CXR reviewers as follows:

(1) Normal – ILO categories 0/-, 0/0, or 0/1
(2) Suggestive of simple pneumoconiosis – ILO categories 1/0 through 3/+
(3) Suggestive of complicated pneumoconiosis – ILO category A, B, or C
(4) Other abnormality not suggestive of pneumoconiosis – ILO categories 0/-, 0/0, or 0/1

d. The NMA's final report was reviewed to determine if the NMA had reviewed the radiology report and made the appropriate recommendation with regard to fitness for work.

6) Report back to the DNRM

The DNRM are to receive the results, and have advised they will make arrangements to notify the relevant NMA, physician or individual, where there has been a finding through this review process.

Results

Originally, the DNRM provided 268 film prints of digital CXRs, which could not be used for the review because film prints of digital images are unreliable in the accurate assessment of the presence of pneumoconiotic opacities. The DNRM also provided 50 digital images in a time frame that was too late to be included for this report, but which will be evaluated later.

The results described here are of digital CXR images from 257 miners provided by the DNRM in time for this report. These images were selected for miners who met the eligibility criteria of 10 years of coal mining experience. CXRs received were taken between June 2009 and January 2016. Table 5 indicates the mines from which these CXRs were sourced. As shown in the table, while CXRs were sourced from every mine, several of these mines were represented by fewer than 10 CXRs (mainly the smaller mines). Also, less than 50% of requested CXRs from the following mines were able to be accessed by the time this report was issued: Broadmeadow, Ensham, Grasstree, Grosvenor, Moranbah North, Newlands, and Oaky Creek No. 1.

1) Quality Review

a. ILO Image Quality

Review of the ILO image quality scores showed that only 25% of CXRs were Quality 1, 55% were Quality 2, 19% were Quality 3, and 1% were Quality 4. The CXRs that were rated Quality 3 had technical defects that to some extent affected the ability to classify the images, although it was felt that classification was still possible. Images of Quality 3 should represent a much smaller proportion of CXR images in a surveillance program. Observed technical problems with the CXRs included images with poor positioning, (such as exclusion of portions of the lungs in the image or overlap of the lung fields by the shoulder blades), poor contrast, and excessive edge enhancement. These issues can make it difficult to accurately detect the small opacities of pneumoconiosis. Unfortunately, these technical problems cannot be resolved by manipulation of the digital images after image acquisition and processing has taken place.

b. Image Processing

Fifteen percent of the images that were reviewed had quality issues related to processing. Digital radiographic images undergo processing after acquisition. This "post processing" is performed at the radiographic unit in accordance with pre-programmed parameters set by the manufacturer, some of which are able to be modified by the user, according to user preferences. Typically, once these parameters are set at the radiographic unit for a specific type of examination, they are not changed on an individual patient basis. A digital receptor (which may be either a computerized radiography cassette or digital radiography detector) captures the image, and then the image is processed and sent to the Picture Archiving and Communication System (PACS) to be viewed and interpreted by the radiologist. While the radiologist can adjust some viewing settings, such as window and level (contrast and brightness) and magnification, he/she cannot undo or change the other elements of image processing at the PACS workstation.

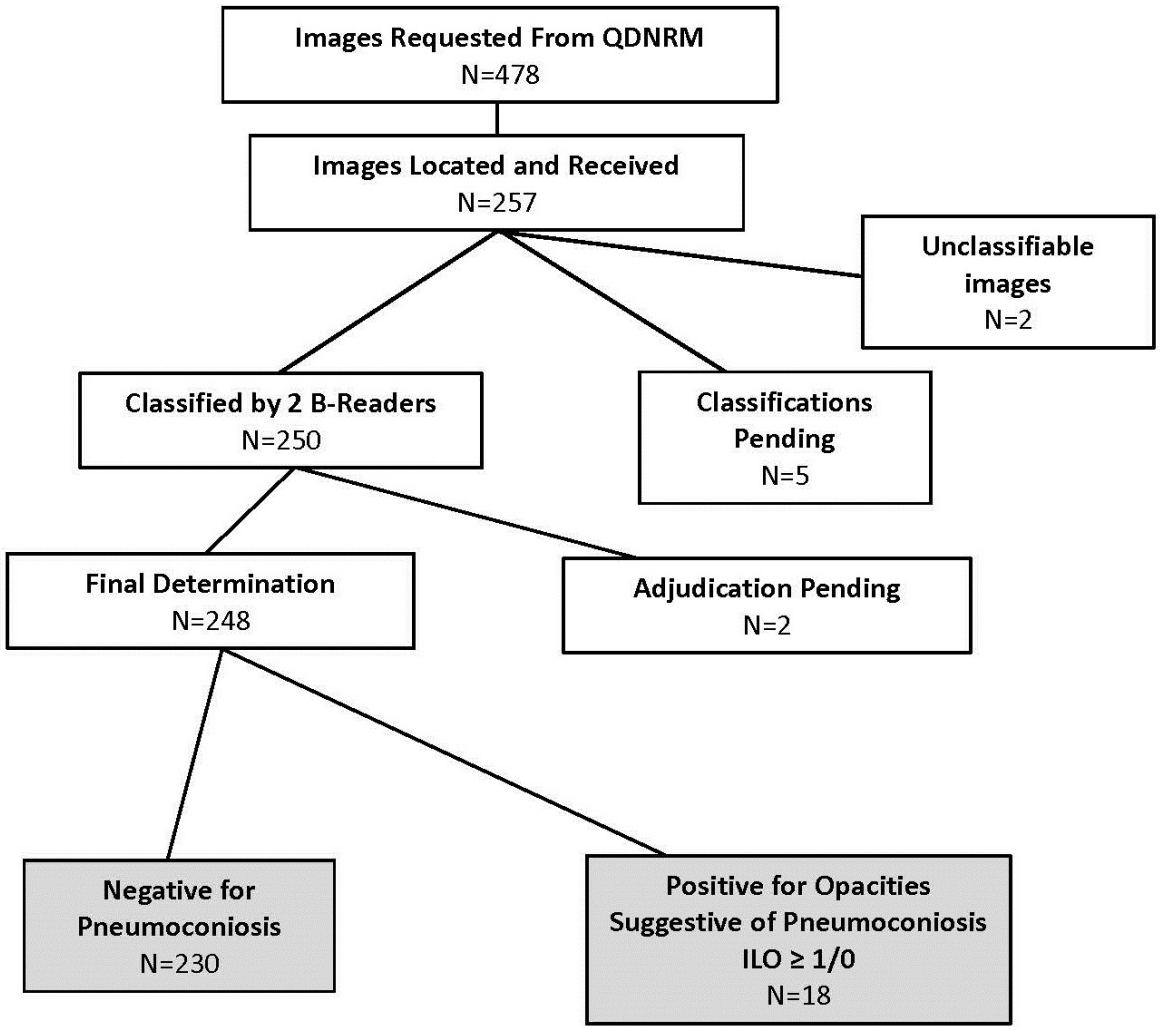
Post processing has evolved and improved over the years. The post processing modifications were developed with the primary purpose of improving the visibility of pathological changes. Initially these were primarily edge enhancement (unsharp masking) and noise reduction. More complex image-processing algorithms have been developed over the years to allow for optimal display of the wide dynamic range in radiographic images, particularly in chest films. Today's algorithms are more complex, but fundamentally have the same objective − to allow for better visualization of subtle pathology. While the image is enhanced to better display pathology, the same parameters also display normal structures more prominently and the reader must be able to recognize the subtle effects of image processing to separate anatomy from artefact. In the case of chest films, some image processing protocols will result in a "grainy" appearance to the lungs simulating certain types of small opacities. The radiologist who has set the image processing parameters to his/her preference and is used to this appearance as normal will recognize this appearance as normal. However, the same study, when sent to a different reader, may be interpreted as interstitial disease consistent with pneumoconiosis.

2) Presence or Absence of Pneumoconiosis

The CXRs were transmitted electronically to reviewers. All images were read according to the protocol described above. Given difficulties in receiving images in a timely fashion, only 250 images were classified by the time of this report (see Figure 4). Final determinations were obtained on 248 miners. Two CXRs were classified as unreadable (Quality 4).

Major Findings: No miner was found to have large opacities suggestive of complicated pneumoconiosis or progressive massive fibrosis. No miner was found to have small opacities consistent with of advanced or high-category (i.e., $\geq$ 2/1) simple pneumoconiosis. There were 18 miners, of the 248 (7.3%) with final determinations, whose CXRs were classified as having opacities at a profusion consistent with category 1 simple pneumoconiosis i.e. ILO classifications of 1/0, 1/1, or 1/2. Given the quality issues identified above and the possibility of emphysema resulting in irregular small opacities, it is recommended that these individuals undergo high resolution CT scanning prior to making a final diagnosis.

Figure 4: Flow chart of CXR review results



3) Comparison with Radiology Reports and NMA Reports

The radiology and NMA reports were analysed to determine whether or not the changes of pneumoconiosis were recognized and to determine if further action was taken. The results are shown in Table 7.

Three radiologist reports were not available for our review, leaving 15 reports. This comparison showed that only 2 out of these 15 (13%) CXRs identified by the reviewers as having features consistent with simple pneumoconiosis by chest radiograph were identified by the original radiologists as having interstitial abnormalities that could possibly be interpreted as evidence of pneumoconiosis. A number of these CXRs had irregular opacities. Irregular opacities have been well described in CWP,[27] although they may also occur with emphysema. The remainder (n=13) were classified as normal by the original radiologist. In neither case where possible pneumoconiosis was identified by the original radiologist did the NMA record a finding about possible CWP, nor was any recommendation made regarding fitness to work from a respiratory point of view.

Table 7: Comparison of findings of radiology reports and NMA assessment of the reports for those cases identified by the reviewers as having a final determination ≥ ILO category 1/0.

Case	Small Opacity Profusion	Radiologist Report	NMA Assessment of Report	NMA Action
1	1/0	Normal	Normal	Fit
2	1/0	Not available for review	None	Fit
3	1/0	Normal	Normal	Fit
4	1/0	Normal	Normal	Fit
5	1/0	Normal	Normal	Fit
6	1/0	Normal	Normal	Fit
7	1/0	Not available for review	None	Fit
8	1/0	Abnormal (Consistent with pneumoconiosis)	None	Fit
9	1/0	Normal	Normal	Not fit (right knee injury)
10	1/0	Normal	Normal	Fit
11	1/0	Not available for review	None	Fit
12	1/0	Normal	Normal	Fit
13	1/1	Abnormal (Consistent with pneumoconiosis)	None	Not fit (hearing, vision)
14	1/1	Normal	None	Fit
15	1/1	Normal	Normal	Fit
16	1/1	Normal	Normal	Fit
17	1/1	Normal	Normal	Fit
18	1/2	Normal	Normal	Fit

4) Findings from an additional Queensland radiology review

One coal mining company previously commissioned a review of all CXRs of its active miners, which was performed in 2015 and early 2016. Nearly 200 CXRs were reviewed using the same protocol we used in this study. Significant quality issues similar to those observed in the current review were identified. Although CT scans are generally **not** needed to make a radiographic diagnosis of pneumoconiosis, given the quality issues of those CXRs, miners with final determinations of simple pneumoconiosis were offered high-resolution CT (HRCT) scans to confirm the presence or absence of pneumoconiosis. While some of the CXRs had opacities that were verified by HRCT, the majority of these miners had negative HRCTs, so the quality issues of the CXRs led to over-reporting of simple pneumoconiosis. This is an important finding to assist in interpreting the findings in the current review.

11. Spirometry review

Spirometry is a standard investigative technique to assess lung function and is required for respiratory health assessments performed under the scheme. The aims of the review of spirometry procedures and testing were to:

1. Audit the spirometry equipment, quality control procedures and training and qualification of the spirometry technicians performing spirometry under the scheme.
2. Assess the quality of spirometry conducted as part of the current scheme for a sample of 258 coal mine workers.

The spirometry review therefore consisted of two components, which are discussed separately below.

11.1 Survey of spirometry equipment and training

We developed an online questionnaire to obtain information about spirometry testing, including the equipment used and their calibration procedures, and the qualifications and training of testers. A link to this online survey was distributed by the DNRM to all currently listed NMAs. The questionnaire is attached as Appendix 6 and participants' responses are summarised in Appendix 7.

Approximately one-third (74) of currently listed NMAs completed the online survey by the due date.

Results

Based on the responses, spirometry is mainly performed in GP (62%) or Occupational Medicine clinics (38%). Testing is primarily administered by registered nurses (77%) and medical practitioners (9%), but the qualifications of other staff performing spirometry include science graduate, GP and administration staff.

Forty percent of testers had over 10 years' experience in performing spirometry, however they conducted these tests infrequently. Only about a quarter performed more than 20 spirometry tests per month as part of the Coal Mine Workers' Health Scheme and more than 20 additional tests per week. Of the registered nurses performing spirometry, about a third had up to 5 years' experience, and approximately 20% performed 20 spirometry tests for the Coal Mine Workers' Health Scheme per month and more than 20 additional tests per week. In comparison, an accredited respiratory laboratory performs 15-20 spirometry tests per day (Professor Bruce Thompson, personal communication).

Spirometry training was limited. Approximately two-thirds of testers had attended a training course, but one-third were unable to specify the year this training was completed. Furthermore, 23% had completed their training more than three years ago. The National Asthma Council was the most frequently mentioned training course provider (35%), however just over one-fifth of responders could not nominate their training course organisation. Of

the registered nurses performing spirometry, only 42% had undertaken a spirometry training course and could recall the name of the course.

The limited training may contribute to the poor knowledge of the spirometry equipment, including quality control measures. One quarter of respondents did not know whether their spirometer had automated quality control, 10% were unsure how many manoeuvres were stored for each person tested and almost half did not know the reference values used by their equipment. On the other hand, every NMA reported their spirometers produced flow-volume graphical display and approximately 84% reported their spirometers stored 3 or more manoeuvres for each person tested.

Overall, the reported quality control and assurance of spirometry testing needs to be improved. For example, although 79% of spirometers were reported to have had a calibration check, most (66%) had not been calibrated in 2016. This is a significant inadequacy considering devices used in the study require daily calibration checks. Furthermore, only about one-third of spirometry sites participate in ongoing quality assurance programs.

Fourteen percent of sites do not have a post-bronchodilator spirometry routine, 10% did not use a weight measurement device and one respondent did not use a height measurement device during spirometry.

It is concerning that there were a number of other questions that high proportions of responders were unable to answer, for example, a third of respondents did not know the date of purchase of the spirometer. However, we were not certain that the survey was completed by the actual spirometry tester or technician; if more junior staff were involved, they may not know the answers to some of the more technical questions.

In summary, these data indicate that a majority of the spirometry performed under the scheme is likely to be of poor quality and more ongoing training and quality assurance is needed to reach accepted standards.

11.2 Spirometry quality and reading

The review team developed a protocol to examine the quality and accuracy of a sample of 260 spirograms performed under the current scheme. These were received from the DNRM and were for workers from a large number of mines. The protocol is included in Appendix 8**:** . Quality and accuracy of spirometry was assessed by two reviewers, Professor Bruce Thompson and Dr Ryan Hoy, who are both very experienced in interpreting lung function data according to the accepted standards of the ATS/ERS.

Results

In total, 256 spirometry results were evaluated, four others were illegible. Of the 256 spirograms, 102 were deemed to be of poor technical quality, i.e. the spirometry was poorly executed and did not allow meaningful interpretation. If these results are produced in an accredited respiratory laboratory they would be rejected and the tests, repeated.

154 spirometry results were included as they had sufficient demographic data for interpretation. In accordance with ATS/ERS standards, the lower limit of normal (LLN) was determined by the 5th percentile of a healthy, non-smoking population. The NHANES

reference values were used for the analysis. This most likely differed from NMAs' interpretation where pre-defined cut-off values are used to identify abnormality, such as $FEV_1/FVC < 0.70$ indicating airflow obstruction. FEV_1, forced expiratory volume in one second, is a measure of airflow limitation; FVC, forced vital capacity, is a measure of the total lung volume; and the ratio, FEV_1/FVC, is a measure of airway obstruction, i.e. where the airway is closed down and pushing air out of the lungs is impaired. Cut-off values are inaccurate and cause misclassification, specifically under-diagnosis of abnormalities in younger, taller individuals and over-diagnosis in those older or shorter.

Thirty spirometry results were assessed as abnormal, while the majority [n = 124 (81%)] were considered to be within normal limits by the reviewers.

Of the 30 spirograms with abnormalities, six showed mild obstructive disease patterns, and 24 showed "possible restriction" (21 with mild severity, and 3 with moderate severity). The NMA reports accurately identified only two of the abnormal spirometry results, the remaining 29 were reported as normal. These 29 abnormal results were from workers employed at a number of coal mines, however the largest proportion (10) were not registered with a particular mine.

Obstruction implies narrowing of the airways, and is usually the most common pattern identified with spirometry. Restriction implies reduction of lung capacity or volume, though this can only be confirmed with more specific and advanced lung function tests, including static (plethysmographic) lung volumes. Importantly, CMDLD includes both obstructive and restrictive respiratory diseases.

All 124 spirograms assessed as normal by the reviewers were also reported as normal by the NMAs. However, the actual data (FEV_1, FVC, and FEV_1/FVC) extracted from the spirogram by the reviewers and NMAs were consistent for 110 (89%) results. The main reason for lack of agreement was because the NMA did not select the most appropriate values, for example, the best results produced during the spirometry tests.

In summary, less than half of the spirometry results evaluated for this review had been accurately interpreted and reported by NMAs. The results of 130 are essentially unknown, though for different reasons: 4 were illegible photocopies; 102 were poor quality; and 24 showed "possible restriction". The review team recommends follow-up of these results, especially the three coal mine workers with moderate possible restrictive disease. In addition, although the six results that showed obstructive pattern were deemed mild, it is important that these individuals have had recent (and regular) spirometry, as obstructive respiratory disease can progress without appropriate treatment and management.

The DNRM have received the spirometry findings and have advised they will make arrangements to notify the relevant NMA, physician or individual, where there has been a finding through this review process.

Detailed measures to improve the quality of spirometry are provided in Appendix 9.

In addition, the Queensland Health Spirometry Guideline follows ATS requirements and is available at:

https://www.health.qld.gov.au/qhpolicy/docs/gdl/qh-gdl-386.pdf .

12. Health assessment form data handling and storage

We reviewed the system for data handling and storage used by DNRM, including accessibility by the NMAs of previous health assessments, through discussions with DNRM staff members. We also visited the data storage centre at Stafford to inspect and discuss the DNRM database and security arrangements.

Current situation

Data handling

The HSU receives full health assessments, including CXR reports and films from the NMAs by ordinary mail. The hard copy forms are initially checked by the data entry operators for completeness, for example to check that: individual health assessments consist of all seven pages; the worker's date of birth has been recorded consistently; spirometry results have been transcribed onto the appropriate section of the form; and the EMO examination date in section 3 corresponds with the EMO date in section 4. Incomplete and inaccurately completed health assessment forms are returned to the relevant NMAs for amendments. Although original CXR films (or CDs) and spirograms are supposed to be sent with their corresponding health assessments to the HSU, NMAs may not always comply with this requirement. In the case of spirometry printouts, there may be some uncertainty among NMAs about the requirement for these to be sent to DNRM.

Data storage

Prior to the mid-1990s all data from all health assessment forms were manually entered into a database. Since approximately the late 2000s, the forms have been scanned, and more recently only selected variables manually entered into the DNRM database at SIMTARS. The health assessments that are scanned are saved into the data entry operators' files on the SIMTARS hard drive, which is password protected. Individual health assessments files are renamed with the worker's surname and date of birth to aid search and retrieval upon request.

Hard copies of health assessments and CXR films are currently stored in boxes and shelves in storage facilities at three locations: Stafford, Geebung and Eagle Farm.

The storage facility at Stafford was acquired at the end of 2015. Health assessment files are segregated according to the first letter of surnames and each box is also given a numerical ID. The health assessment files are a mixture of records that have been entered but not scanned, those that are scanned but not entered and those that are entered and scanned. The warehouse is secured by a gate which requires a security code and a door which requires an access swipe card.

The storage facility at Geebung is based in a Government department in a privately-owned company, and has been in use from approximately 2011. All health assessment files at this facility have been scanned and entered into the DNRM database. The storage boxes have a barcode and an HSU registration number, and contain up to fifty files (a list of which is enclosed within the box). The health assessments can only be accessed by DNRM staff based at the facility.

The facility at Eagle Farm is used to store archived files, that is, health assessments that were completed between 1983 to the early 1990s. Most health assessments have been entered, but

no health assessments at this facility have been scanned. The files can only be accessed by Eagle Farm staff members. The DNRM database is only accessible by authorised HSU staff members.

CXR films are arranged alphabetically and some are stored separately from their corresponding health assessment files. X-ray wallets with unique registration numbers were previously used to store health assessment records for each worker, however this system ceased when scanning was introduced in the late 2000s. Therefore, the sequential health assessment records for a particular worker are often stored separately.

According to the 2015 Queensland Mines and Quarries annual report,[28] of 16,463 total health assessments received from NMAs in 2014/15 just under 3,000 assessments (<18%) had been entered into the database. A backlog of approximately 150,000 health assessments awaiting database entry had grown to almost 170,000 whilst this review was underway.

The DNRM has advised that steps are in place to clear this backlog, for example, by scanning and only entering key variables into the database. Furthermore, the health assessments for underground coal mine workers (which account for <10% of the 170,000) have been prioritised. As of 23 June 2016, 70,000 health assessments had been processed including 10,000 underground coal miners' assessments. The remaining assessments for underground workers are expected to be cleared by the end of 2016, and the backlog of the other health assessments by mid-2017.

Limitations

The process of sending and receiving health assessments by ordinary mail is not consistent with contemporary methods of transfer and receipt of medical records, which are predominantly electronic. NMAs are required to send the entire assessments but do not always submit CXR films or spirograms, so reliance on this means of communication is ineffective. Manual checking of documents for completeness and accuracy and manual database entry is slow, cumbersome and prone to quality issues as a result of human error. The DNRM review is purely administrative and involves no medical review or audit.

Scanning capability was introduced by the DNRM, in part to assist data storage, as well as searching and retrieval of files. However, with approximately 100,000 health assessments awaiting scanning, this process has not been maximally utilised. A mixture of scanned and/or entered health records is currently stored at three different locations and, although the files have been sorted alphabetically and numerically, access to records for a particular worker could be hampered by separate storage of the files. The sequential health assessments for individual workers have not been consistently linked and this contributes to inefficiencies of the data storage system and difficulties in accessing previous health assessment records.

Resources to enter data into the database did not increase when the number of health assessments increased during the mining boom, resulting in a large backlog of forms awaiting entry into the DNRM database. This further hampers access of previous records.

Electronic data entry by the NMA at the time of the health assessment would reduce workload for the HSU as scanning and manual entry would no longer be needed and facilitate completeness of data entry and medical review by HSU. Electronic data storage would also allow much easier access to previous health assessment forms by NMAs, though would have to comply with current privacy constraints. Importantly, it would facilitate collation and analysis of group surveillance data to assess trends in CMDLD.

13. Interstate and overseas health surveillance schemes for miners

We reviewed health surveillance systems for mine workers in Australia, and overseas including the USA (NIOSH), UK, South Africa and Japan. The purpose was to determine which components of these programs could be incorporated to improve the Queensland scheme. In Australia, only two other states have had a health assessment scheme for mine workers, and one of these, Western Australia (WA), has recently ceased its surveillance program.

New South Wales

This section is summarised from the NSW Coal Services (CS) website, and from discussions with Coal Services Health (CSH) representatives.

CS is a corporation owned equally by the NSW Mineral Council and the Trade Union (CFMEU) and was set up in 2002.[29] Among other functions, CS provide:

- occupational health and rehabilitation services for workers engaged in the coal industry, including providing preventative medical services, monitoring workers' health and investigating related health matters;
- collection, collation and dissemination of statistics relating to the health of workers engaged in the coal industry;
- promotion of the welfare of workers and former workers in the coal industry in the state;
- monitoring, promotion and specification of adequate training standards relating to health for workers engaged in the coal industry; and
- monitoring of dust levels in coal mines.

Business units within CS provide services to the coal industry. Health surveillance under Order 41[30] is provided by CSH, and dust exposure monitoring under Order 42[31] by Coal Mines Technical Services.

Services are provided by CS to CHPPs, underground and open-cut mines. Labour hire companies are included, so contractors must also have regular medicals. Any former coal miner, including retired mine workers within NSW can attend a CSH office for a medical assessment, and CXR, if clinically indicated. Retired miners are contacted through the relevant NSW Retired Miners Association and the mining union. Some retired miners choose to attend, while others may attend their own GP.

Pre-employment and periodic medicals (usually every 3 years) are carried out by CSH on workers at coal mines. CSH employs 8-9 doctors (usually occupational health specialists who are in training or who have completed their training) and other staff, e.g. nurses, at 5 clinics.

All periodic medicals are carried out by CSH, though some companies arrange their own pre-employment medicals they are required to send the data to CSH for quality checking and data entry.

Staff directly enter data from the medicals to an electronic system as it is collected. A miner's previous data, including the occupational history, is visible to medical staff who can

examine previous symptomatology, spirometry, CXR etc. CSH thus have a complete occupational and health history of each coal miner in electronic form.

The respiratory component of the medical includes a symptom questionnaire (based on the standard British Medical Research Council questionnaire), spirometry and a CXR. Spirometry is carried out in-house by nurses trained by the Asthma Foundation, and who undergo regular in-house training and annual competency testing.

A CXR is normally recommended every 6 years for mine site workers. The decision about CXR frequency is made by the CSH doctor after examination of the whole work history and is based on knowledge of the 'at risk' jobs, rather than relying on SEGs which vary from site to site and over time. For some workers, depending on the history, symptoms and signs, a CXR may be recommended more frequently. For individuals not thought to be dust-exposed e.g. administrative staff, the CXR interval might be up to 12 years.

Most of the CXRs are taken at two CSH sites, but may also be taken at other facilities. A CXR is read by one of a small pool of CSH radiologists across the state. The radiologists are aware that the CXRs are from miners. They are familiar with the ILO classification but do not undergo any specific or extra training in respect of this classification. The radiologists report the films using the usual radiology form, rather than the ILO form.

Any adverse medical findings are discussed at weekly review meetings by medical staff and, where necessary, the worker and their GP are contacted. Respiratory specialists may then become involved and their findings would be fed back to the GP and to CSH. Where necessary, with the individual's permission, the findings are fed back to the company so that appropriate restrictions can be placed on work practices/exposures.

An information sheet on respiratory diseases related to coal dust exposure has been developed for workers.

Western Australia

Western Australia's MineHealth system ceased in January 2013 after the outcome of epidemiological studies of the surveillance system database showed that health assessments neither prevented nor detected ill-health at an early stage.

The requirements for undertaking health assessments are stipulated in *The Mines Safety and Inspection Regulations 1995*, and health surveillance for mining employees in WA was administered by the Department of Mines and Petroleum Resources Safety. Details of the surveillance scheme have been summarised from the publication 'Guide to health surveillance system for mining employees',[32] and thus was not specifically for coal mine workers.

Objectives of the scheme were clearly stated from the outset, which were to: assess health status on a regular basis; analyse collected data to detect adverse health effects at the earliest opportunity; and provide data for future epidemiological studies. As well as setting out the responsibility of employers, employees and responsible medical practitioner or approved persons, the guide also included detailed instructions about how to complete all components of the health assessment form.

The health surveillance scheme was applicable to all miners except those who fulfilled the exemption criteria, such as workers not exposed to significant levels of hazardous agents, and employees who work for a cumulative period of less than three months in a 12-month period. Employees were issued with a health surveillance card (with a unique number and expiration

date) by the Department of Mines and Petroleum. Initial health assessments were to be completed within 3 months of commencing a job, and periodically at least every five years thereafter.

The approved medical assessment form was concise, included a formal respiratory questionnaire and had an entire page dedicated to spirometry which was to be conducted accorded to ATS standards. A doctor or "approved person" could undertake the assessments, however medical practitioners were required to complete a one-day approved persons course before performing lung function tests, and to attend refresher courses every 2 years unless exempted. Completed forms were submitted to the Mines Occupational Physician. Although there was no formal auditing of these forms, approvals to conduct the medicals were revoked if an "unacceptable" number of poor quality forms was submitted to Resources Safety.

CXRs were only required by employees who had worked in "designated work categories" in surface, underground and non-mining (such as tunnelling) environments for a specified duration, in WA or other states. A list of the "designated work categories" is provided in an appendix of the guide. CXRs were reviewed and reported by radiologists, but were no longer required to be reviewed by a CXR reader for coding purposes. Regulations required CXR reports to be recorded and, the employee notified of the results and given an explanation if follow-up was required. Medical practitioners were also required to specify remedial actions that were taken for abnormalities detected in other components of the health assessment.

All components of the health assessment, including the CXR film and radiology report, were forwarded to Resources Safety and transferred to the MINEHEALTH database.

NIOSH (USA)

The Respiratory Health Division of NIOSH, (within The Centers for Disease Control and Prevention) operates the Coal Workers' Health Surveillance Program (CWHSP) in the United States. The CWHSP was established by the Federal Coal Mine Health and Safety Act of 1969 and has been in continuous operation since 1970. The program is mandated by law, enforced by MSHA, part of the US Department of Labor and is administered by NIOSH. The CWHSP has operated four different programs since it began. These programs require that the operators participate by offering these services to all coal miners, however the miners are not obligated to participate. Participation rates have varied between 25% and 50% over the years.

1. Coal Workers' X-Ray Surveillance Program (CWXSP) 1970-2016

CWXSP operated from 1970 until February of 2016 when it was replaced by the newly legislated expanded program. This program collected demographic information and work histories in addition to performing CXR surveillance. Operators of underground coal mines were required to post a NIOSH-approved health examination plan providing health surveillance to their underground miners every five years. The operators chose the CXR facility and offered the miners the opportunity to go to those sites free of charge and obtain a CXR. The CXR was interpreted by on site physicians known as A-readers, and then sent to NIOSH for formal ILO classification by a panel of carefully selected B-readers for final determinations.

2. Miners Choice Program – 1999-2002

In addition to this program NIOSH and MSHA expanded participation to surface miners and also allowed miners to choose the site for their CXR rather than being required to go to the site selected by the coal operator. This program also consisted only of CXR screening and occupational histories.

3. Expanded Coal Workers' Health Surveillance Program (ECWHSP) – 2005 to present

The ECWHSP was developed in response to findings of increasing rates of pneumoconiosis and rapidly progressive pneumoconiosis detected by the CWXSP in certain areas of the country known as "hot spots". This program continues to this day. This program consists of a mobile van operated by NIOSH, which travels throughout the country for several months of the year. The program offers CXRs which are transmitted directly to NIOSH for B-reader interpretation. The ECWHSP also collects information on respiratory symptoms, occupational histories, smoking status, blood pressure measurements, and spirometry testing.

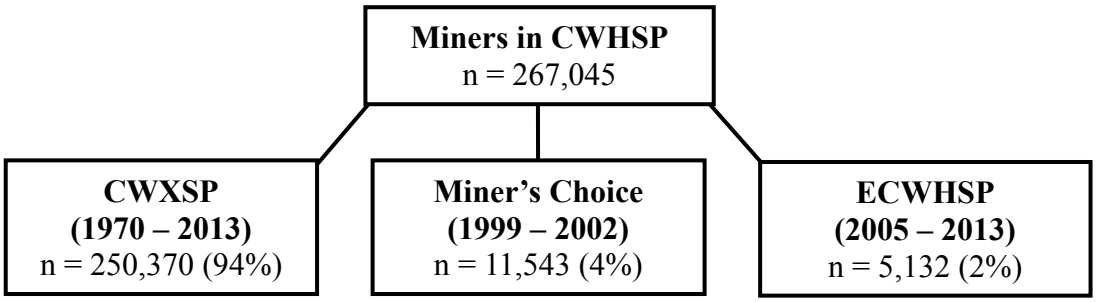


Figure 5: Distribution of coal miners in NIOSH's Coal Workers' Health Surveillance Program across different phases of the surveillance program, 1970 – 2013.

As noted in Figure 5, participation in the CWHSP is voluntary and as such, there is no set frequency of medical testing for participating miners, however operators have been required to offer testing every 5 years. Miners may appear in the program multiple times throughout their mining career, but participation is not required. It is not advised to receive more than one CXR within a 5 year time period, therefore while a miner may participate on a more frequent basis, they would be advised to undertake a CXR only once within a 5 year period. Miners are notified of their medical results after participation in the CWHSP. If evidence of disease or impairment is found, the miner in encouraged to follow up with their personal doctor. Employers are not notified of an employee's health status.

NIOSH reviews information on facilities which provide CXR screening and certifies those clinics before they may participate. NIOSH requires separate certification for x-ray and spirometry facilities which are based on the equipment used, the technician certifications, and a sample of CXRs or lung function tests for quality review by NIOSH experts. Facilities may be approved for x-rays only, spirometry only, or both see: http://www.cdc.gov/niosh/topics/surveillance /ords /pdfs/CWHSP-Facility-2.11.pdf.

Facilities that are NIOSH-approved for spirometry can provide the respiratory assessment as well as lung function test to the CWHSP. All persons administering spirometry exams must have successfully completed a NIOSH-approved Spirometry Training Course. This certification must be maintained through periodic refresher courses. Spirometry test results must be interpreted by physician or other health professional with appropriate state licenses for this service, in accordance with ATS guidelines for spirometry interpretation.

All CXRs taken as part of the CWHSP are read and interpreted by NIOSH-certified B-Readers. B-Readers are physicians who have demonstrated proficiency in interpreting and

classifying CXRs specifically for pneumoconioses. B-Readers classify CXRs according to the ILO classification system see: (http://www.cdc.gov/niosh/topics/ surveillance/ords/pdfs/CWHSP-ReadingForm-2.8.pdf). These physicians are tested every four years in order for their B-Reader certification to remain valid. The CWHSP data is collected, managed, and maintained by NIOSH staff. NIOSH uses the CWHSP data to estimate disease prevalence and identify geographic areas of resurgent disease.

Detailed work histories for up to 13 previous mining positions are collected as part of the CWHSP. Work histories include the names of prior mines, which can be linked to geographic location, mine characteristics, and job titles. See: (http://www.cdc.gov/niosh/topics/surveillance /ords/pdfs/CWHSP-ReadingForm-2.8.pdf). The CWHSP also contains data on CXRs with a standardized ILO classification by independent NIOSH B-Readers. Spirometry with age, height, FEV_1, FVC, FEV_1/FVC ratio; smoking status (former/current/never); and data from respiratory symptom questionnaires are available starting in 2005. The CWHSP also contains demographic information such as sex and race/ethnicity, as well as the body weight of the participating miners.

NIOSH produces de-identified publicly available aggregate data sets from the CWHSP for research purposes in addition to the data sets maintained for internal research use.

United Kingdom

The last underground coal mine in the UK ceased operation in 2015, although many open cut coal mines remain in operation and silicosis remains an important occupational lung disease. The Health and Safety Executive has published guides for health surveillance for workers exposed to respirable crystalline silica (RCS), [33, 34] and these are summarised below. Although health monitoring is not mandatory, information contained in the publication will assist employers to comply with the *Control of Substances Hazardous to Health Regulations 2002* to control exposure and protect workers' health.

The guides begin by stating the purpose of health surveillance, and reiterate that it is never an alternative to proper exposure control. The categories of RCS-exposed workers for inclusion in surveillance are clearly outlined, and include individuals working in underground and open-cut environments in high-risk industries and occupational groups, as well as retirees. Health monitoring is also advised in situations where there have been previous work-related cases, where there is reliance on RPE as an exposure control measure; or where there is evidence of work-related ill-health in the industry.

Questionnaires and lung function tests are recommended at baseline, and annually thereafter, and sample proformas are enclosed in the guides. Posterior Anterior CXRs are advised at baseline (to enable comparisons with subsequent CXRs, after 15 years work history), and every three years thereafter unless advised otherwise by a health professional. The ILO classification is not explicitly recommended for CXR reading, though the grade of silicosis (if present) is to be recorded. Radiographs should be read by a suitably qualified radiologist. Spirometry is to be conducted and interpreted according to the ATS criteria, and both spirometry and CXRs should be assessed relative to previous results.

The results of the health surveillance should be explained to the workers by the health professionals, who could be a doctor or nurse, especially if silicosis is diagnosed. Although there are no prescribed clinical guidelines for management of abnormal findings, there are suggestions about what constitutes "abnormal" and the frequency of subsequent health assessments. For example, an abnormal lung function result includes an average drop in

FEV_1 of 100mls per year, and spirometry should be repeated early if FEV_1 declines by 200mls or more. The Health and Safety Executive also recommend seeking the opinion of an appropriate occupational health professional for abnormal results, and to determine fitness for work and any action required to slow disease progression.

Health professionals are also required to collate, interpret and report the result trends across groups and individuals, in particular to identify the need for an employer to review and/or revise exposure risk assessments. Health results and records must be stored for 40 years.

Japan

Coal mine workers in Japan do not participate in a mandatory health surveillance scheme. However, it is one of six countries that participates in the Asian Intensive Reader of Pneumoconiosis project (AIR Pneumo). This is a non-government initiative to promote quality assurance of medical screening and surveillance for pneumoconioses. It was established in 2003 with an aim to upgrade skills of medical specialists in developing countries on the application of the ILO International Classification of Radiographs of Pneumoconioses, and to contribute to the implementation of the ILO/WHO Global Program for Elimination of Silicosis.

AIR Pneumo consists of three educational tools: attendance at an interactive 2.5 day-course, including a CXR view-box reading seminar and practice; provision of CXR teaching materials; and examination and certification of proficiency to read chest radiographs of pneumoconioses. The target audience includes chest physicians, radiologists, occupational physicians and GPs with an interest in occupational lung diseases [35]

South Africa

A number of minerals are mined and/or occur in South African mines, including gold, platinum and silica. Although mines are required by law to establish and maintain disease surveillance programs, there is no formal national or provincial health screening for mine workers in South Africa. [36] However, under the *Occupational Diseases in Mines and Works Act*, the pathology division of South Africa's National Institute of Occupational Health (NIOH) provides an autopsy service for deceased mine workers and former mine workers for the diagnosis of compensable disease, regardless of the clinical cause of death. The information is recorded in the Pathology Automation System database, and is currently the only source and resource for disease surveillance of occupational lung disease.

Mine medical officers, other doctors conducting medical examinations for former miners, and panel members who certify cases for compensation do not require specific qualifications to read CXRs. However, South Africa NIOH has recognised the utility of standardised reading and assessment of disease progression and will be presenting an ILO training program in November 2016. Importantly, the program will be tailored to local conditions, especially the high rates of pulmonary tuberculosis (David Rees, NIOH, personal communication).

14. Queensland medical capacity

We identified the specialist medical expertise and resources currently available in Queensland to contribute to the performance of high quality medical assessments for the early detection of CMDLD, including performance and interpretation of high quality CXR and spirometry. Based on the findings of aspects of this review outlined earlier in this report, specialist input will be needed for the following:

1. The development of clinical guidelines for NMAs to assist them in undertaking the respiratory health assessment, assessing coal dust exposure, identifying what signs/symptoms require follow up and further investigation, including specialist opinion when respiratory abnormalities are detected
2. High quality expertise in CMDLD among specialist respiratory physicians for referral and subsequent clinical management, including advice on reducing coal dust exposure of coal miners suspected of having CMDLD
3. A robust system for the reporting of CXRs by radiologists in line with the ILO classification, including relevant training and auditing
4. A robust system for the performance and reporting of spirometry to acceptable standards, including relevant training and auditing
5. Assistance in the development and delivery of training materials for NMAs and specialists involved in the health assessment scheme

Three relevant Australian specialist medical organisations are:

- The Royal Australian and New Zealand College of Radiologists (RANZCR)
- The Thoracic Society of Australia and New Zealand (TSANZ)
- The Australasian Faculty of occupational and Environmental Medicine (AFOEM) of the Royal Australasian College of Physicians (RACP)

These organisations have been contacted by the review team and all have indicated a strong willingness to assist in building improved capability in the health assessment scheme in Queensland in the areas indicated above. During the review, the RANZCR and TSANZ have each identified members in Queensland who are willing to provide relevant expertise to the scheme.

The Royal Australian College of General Practitioners is another Australian body relevant to building medical capacity within the scheme, as GPs are often the first point of contact for coal miners who develop respiratory symptoms. To start the process of increasing awareness among GPs, the review team has developed a CMDLD Fact Sheet for GPs, which was provided to the DNRM and distributed to Queensland GPs through Queensland Health (see Appendix 10).

Specific activities which would increase the quality and robustness of the respiratory component of the health assessment scheme for CMDLD in the future include:

- Introducing a training program for doctors, which they must successfully complete before being approved by the DNRM to perform respiratory health assessments for CMDLD.
- RANZCR, TSANZ and AFOEM will need to be involved in the design and running of this training program.

- Developing clinical guidelines to ensure consistency in identifying what respiratory abnormalities found at the health assessment require follow up and further investigation, establishing consistent criteria in the diagnosis of CMDLD and appropriate management, including measures necessary to reduce or eliminate further coal dust exposure.
- Establishing an accreditation system for spirometry to TSANZ standards, this will require input from TSANZ, especially respiratory scientists.
- Establishing a centralised system of independent dual reporting of digital CXRs performed for the scheme, involving a small group radiologists adequately trained in interpreting and reporting these films using the ILO classification and who are reporting on such films regularly enough to maintain skills. The dual reporting is important due to known high degree of variability among radiologists in detecting early opacities. Such a system would also involve ongoing clinical audit of a sample of CXRs and the radiologist reports to ensure that reporting standards among the radiologists are maintained. This model has been implemented successfully for mammographic screening.
- Conducting workshops at the annual conferences of the RANZCR, TSANZ and AFOEM, as is done in similar US medical bodies, to update involved members of these bodies in those aspects of CMDLD relevant to their specialty.
- Establishing a system of clinical grand round, which is a well-established medical system whereby relevant specialists meet to discuss cases requiring multidisciplinary expertise. For cases of CMDLD, such grand rounds would need to involve at least one radiologist, thoracic physician and occupational physician to fully assess workers found to have respiratory abnormalities suggestive of CMDLD at their respiratory health assessment.
- Establishing a system of health surveillance, involving the analysis and reporting of grouped results from the health assessment scheme to monitor trends across the industry and over time. This will require epidemiological input in the design of the surveillance system and analysis and reporting of the data. There are very few models for comprehensive surveillance of occupational disease in Australia, despite there being a strong need,[37] one being the Australian Mesothelioma Registry.[38] Such a surveillance system should include retired workers and those who have moved to another industry, given the long latency of the development of CMDLD after first exposure, which may only develop some years after ceasing work as a coal miner.
- One way that more accurate numbers and rates of CMDLD would be identified by the surveillance scheme would be to make CMDLD reportable diseases, as is the case with other diseases, such as cancer and communicable diseases. While cancer can usually be accurately diagnosed by pathology slides and communicable diseases can usually be accurately diagnosed by laboratory tests, the accurate diagnosis of respiratory diseases included in CMDLD do not rely on a single pathology or laboratory test, but require integrated consideration of the worker's cumulative exposure, respiratory symptomatology and physical signs, serial spirometry results, CXR findings and for specific conditions, other special investigations. Making all of the conditions included in CMDLD notifiable would require very specific diagnostic criteria to be set then consideration of establishing a medical panel to review possible cases, in line with the system used by the Dust Diseases Board in NSW or the Medical Panels in Victoria.

15. Other sources of data about the extent of CWP

As limited information was available to the review team about the extent of CWP among Queensland coal mine workers, we identified and examined routinely collected health data to help estimate the prevalence of CWP, from Queensland hospital records and workers' national and state-based compensation data. All of these data sources have their limitations, which are discussed below.

Queensland hospital data

To assist the review, Queensland Health undertook a preliminary search of its public hospital data to identify patients who had been hospitalised with CWP within the last five years.[39] The search was conducted using ICD-10 code J60: Coal Workers Pneumoconiosis. However, as this code includes CWP and other lung diseases associated with carbon exposure, a significant number of patients were identified who had not been Queensland coal miners, or coal miners at all. Relying solely on the J60 code for hospital inpatients overestimates the prevalence of CWP among Queensland mine workers as it includes:

- Non-miners with lung disease from exposure to carbon dust (the other major categories are anthracosis, and anthracosilicosis, but could have been coded using the silicosis code)
- The majority of the patients with a J60 code were found to have carbon pigment in lymph glands which were biopsied as part of a staging process for patients diagnosed with cancer
- Miners who worked overseas and/or interstate

To refine the search, the DNRM provided a list of over 100,000 people who had had a Queensland coal mine workers' medical since the inception of the scheme (in 1983), and this was cross-checked with Queensland public hospital records from the last 20 years. Twenty one individuals assigned a J60 code and who had been hospitalised between July 1995 and November 2015 were identified. The available hospital charts of these 21 individuals were reviewed by Queensland Health, and four were categorised as "probable" and seven as "possible" CWP cases.

De-identified data on ten of the possible and probable CWP cases were provided in the Queensland Health report.[39] (The other case details were not provided to avoid identification of the individual.) The mean age at hospitalisation for the ten cases was 69 years, though three individuals were under the age of 65. The majority were thus likely to have been retired at hospitalisation, but retired miners are not included in the current Coal Mine Workers' Health Scheme.

These findings could indicate that CWP is more prevalent among Queensland miners or former miners than otherwise known, and would be reinforced by the following factors:

- Queensland Health only has access to J60 codes and case history data from public hospitals, so cases only diagnosed or treated in private hospitals will not be identified and cannot be investigated.

- CWP may have been present in a miner or former miner, but may not have been diagnosed and therefore not coded. CWP with an ILO classification of 1/0 would be asymptomatic.
- Not all mine workers with CWP would have required hospitalisation.

However, as previously mentioned, a case being assigned a J60 code is not definitive identification of CWP, even after cross-referencing with the DNRM records and these cases would still need to be independently verified.

In summary, Queensland Health data indicate that more cases of CWP than those reported to DNRM have probably occurred in the past 20 years. However, limitations in the various data sources being compared make it difficult to reach firm conclusions on the incidence of CWP. It should also be noted that this review of cases by Queensland Health only looked at CWP and did not investigate other respiratory diseases among coal miners which are included in CMDLD.

Queensland compensation data

Q-COMP in Queensland is the authority responsible for the administration of WC claims. At the request of the review team, Q-COMP searched their claims database for compensation claims for CWP over the past 10 years. Because of the small numbers in each year, we have not provided yearly breakdowns, to preserve confidentiality. Instead we present summary findings. Over the past 10 years, there have been six accepted cases, with four being accepted in the 2015/16 year to date, while two were accepted in the late 2000s. There are also 6 pending cases, with five of these submitted in the current financial year, one rejected case and two withdrawn cases.

It should be noted that compensation claims have their limitations, especially for claims for disease as opposed to acute trauma, as the link between exposure and disease can easily be missed. Workers' compensation is only available for current workers, so retired workers are not eligible for wage replacement. Compensation payments usually require evidence of impairment or inability to work. However, the early stages of CWP are asymptomatic so a coal mine worker may not meet the requirements for compensation. Given the long latency of coal dust exposure until the onset of disease, compensation data are not an accurate indicator of the extent of CWP, nor other forms of CMDLD.

Safe Work Australia data

Safe Work Australia (SWA) collects national WC data. At the request of the review team, SWA extracted data for pneumoconiosis claims from 2000-01 to 2013-14. They found 237 accepted WC claims for respiratory diseases such as silicosis and pneumoconiosis (due to coal dust, asbestos, silica or other causes). (SWA website accessed 7/3/2016)

This included 162 WC claims for silicosis, 72 WC claims for pneumoconiosis (excluding asbestosis, CWP and silicosis), and 3 WC claims for CWP. Of the CWP claims, two were from NSW and the other was from WA. Of the total number of claims for all types of pneumoconiosis over this recent 13-year period, 22 were from the mining sector, including 19 claims for silicosis, one claim for CWP and 2 claims for other respiratory diseases. (SWA data, personal communication)

It is important to note that SWA WC data, like the other data sources referred to above, also have several limitations. Notably, they do not capture all occurrences of disease as it only

covers employees who are eligible for WC, and thus excludes self-employed and retired workers, as well as those who have been absent from work for less than five work days because of their condition.

There is some disparity between the SWA and Q-COMP WC data for CWP, which is mainly because SWA data lags state data collection, so it does not include recent cases. However, the two accepted WC claims for CWP in the late 2000s in the Q-COMP database were not identified in the SWA database. This highlights the limitations in any individual WC data source in identifying accurate data on disease prevalence or incidence.

16. Research framework to estimate CMDLD prevalence among coal miners

One part of the scope of the review was to outline a research framework to more accurately assess the prevalence of CMDLD among Queensland coal miners. This focus was thought important as little is known about the extent of CMDLD among Queensland coal miners and the other parts of the review were primarily aimed at assessing the quality and limitations of the scheme. In addition, the findings of previous chapter on other routine data sources cannot be relied upon to provide reliable estimates based on hospitalisations or WC claims. The CXR and spirometry review in this report examined CXRs from individuals who have worked for more than 10 years as a miner and accessible spirograms from DNRM. It is therefore not a random sample of miners and former miners and so it cannot be used to estimate the prevalence of CMDLD in Queensland.

As CMDLD can continue to develop after exposure has ceased, a survey to estimate the prevalence of CMDLD would need to include both current and former miners. Although the number of retired miners who participate is likely to be small, they are important as they are likely to have had the highest exposures. In addition, they may have left the industry due to development of respiratory problems, and a prevalence survey should capture this. The previous Rathus Abrahams CXR survey in 1984 included 7,784 employees, and though there were 123 retirees included, this was only a small proportion of retired miners.[15]

The proposed research framework is designed to estimate the current prevalence (number of existing cases) of CMDLD among Queensland coal mine workers, including those cases undetected by the current scheme.

Study design

The most appropriate research design to measure prevalence is a cross-sectional study, which involves measuring CMDLD in current and retired mine workers at one point in time. An advantage of this approach is that once participants are recruited they can be followed over time, longitudinally, to measure the incidence (new cases over time) of CMDLD. However, if a properly designed health surveillance program, based on the regular health assessments under a revised scheme was established, this could serve the same purpose as a longitudinal study.

Inclusion criteria

The most efficient approach would be to define the study group at risk of CMDLD with a minimum number of years of work in coal mines, such as 10 years. Setting this criterion will exclude those with minimal risk of having CMDLD at the time of the survey. This period is chosen as those with fewer years of exposure are at lower risk of developing disease and so would potentially dilute the recruitment efforts with no added benefit.

As referred to above, the study group should include current miners, retired miners andformer miners (i.e. those who are still working, but in jobs outside the coal mining industry) who meet the minimum work duration criterion. It is especially important to include retired and former miners, some of whom may have left the industry as a result of respiratory conditions

and are likely to have had longer exposure to coal mine dust, be older, and consequently more likely to have developed CMDLD.

Ideally, miners should be recruited from all mining sectors, that is, underground and open-cut mines, and CHPPs. This will increase the study size and the statistical power of the study, and result in a greater ability to detect excess risks of CMDLD, even if the excess risk is low. If the study was small, then low risks may not be detected. Miners may have moved from one sector to another, an open cut miner may previously have worked underground and *vice versa,* so inclusion of the likely lower-exposed open-cut miners is important. In addition, the likely differences in extent of exposure between these sectors would be informative as analyses could be undertaken to assess risks of CMDLD at different levels of exposure.

Assembly of the study group

Current miners can be identified through companies, including contractors and labour-hire firms. Identifying retired and former miners is likely to be more difficult as their contact details might be unavailable, however the following records could be used:

- Company records
- Trade Union records
- Existing DNRM medical records

It will be important to develop a complete list of current, retired and former miners to approach to take part in the survey, as voluntary participation is very likely to introduce bias into the findings. Including a large number of volunteers may result in an over or an underestimation of those with CMDLD, and thus skew the actual disease prevalence found in the survey.

Contact and recruitment process

The record holders will need to provide access to contact details for participants in the survey. It will be important to establish the completeness of these records and to ensure that contact details for prospective participants are up to date. If up to date contact details are not available for former miners, then other sources of contact information, such as the electoral roll could be used.

Some organisations may be reluctant to provide this contact information because of data privacy concern. However, the Australian Privacy Principles do allow the disclosure of such information for medical research, especially if the research is deemed to be of high public interest, which would be the case with this survey.

The study would need approval from a properly constituted Human Research Ethics Committee (HREC). An HREC is usually interested in reviewing the study design, contact procedures (including the explanatory statement and consent forms), data collection and storage, means of feedback to participants and overall study governance. The HREC will also want reassurance that the researchers are acting independently of the companies, government and other stakeholders, and that confidentiality of the data will be preserved.

Eligible current miners and retired/former miners would be contacted by email, telephone or by post, and asked to participate in the study. They would be provided with a plain language explanatory statement about why the study is being carried out, the research team, what the study would entail and how they will be advised of their results. At enrolment into the study,

participants must sign a consent form. The questionnaire part of the study survey could be designed to be completed online, by telephone or by mail.

There is a likelihood that some current miners or more probably former miners may not respond to the invitation. This may be because contact details were incorrect so the invitation was not received, the individual is unwell or deceased, or because they are healthy and so are not interested. It would be important to know the number of eligible and invited workers so that the response rate can be calculated. Higher response rates provide more confidence in study findings, as it is less likely to be prone to participation bias and will also ensure that there is sufficient statistical power for the survey.

Follow up invitation reminders would be needed, with two reminders normally considered acceptable by the HREC.

Data to be collected

The first stage of data collection would be through a questionnaire. This would include:

- Respiratory symptom questionnaire (standard questionnaires are available)
- Relevant medical history, e.g. asthma, and a smoking history
- Full occupational history including duration of employment as a coal miner, types of mines and jobs held at each, and other relevant (non-mining) jobs

CXR and spirometry, and perhaps other respiratory tests would also need to be included. These would need to be performed at clinic(s) with sufficient quality control procedures. The respiratory health outcomes of interest (CMDLDs) would be defined (based on a mix of history, spirometry abnormalities and CXR abnormalities), prior to the start of the survey and the individuals fitting these defined criteria would be identified from the collected data.

Pilot study

The contact, recruitment and survey procedures would need to be piloted on a small sample of potential participants prior to the start of the main survey. The clinical investigations would also have to be piloted to ensure that they have adequate quality control and do not impose too great a travel burden on participants, some of whom may be elderly and possibly ill.

Study governance

The study should have a stakeholder Advisory Committee, including representatives from the DNRM, mine operators, the CFMEU, current employees, as well as other researcher(s) independent of the study team undertaking the survey. The members of the Committee would advise the research group about various aspects of the study, promote it to their members and facilitate dissemination of the findings.

A Scientific Advisory Group made up of three or four independent researchers can be a further way of ensuring the scientific integrity of the survey and its findings. The researchers' role would include reading the study protocol and suggesting means of strengthening its conduct, including data analyses. They can also provide an independent evaluation of the scientific merit of the study, as well as the quality and robustness of the findings and report.

17. An ideal Queensland coal mine workers' respiratory health assessment scheme

This section draws together the proposed modifications to the respiratory component of the scheme to address the identified limitations, as outlined in the previous sections of this report, and to outline the key aspects of a best practice scheme.

The purpose of the revised respiratory component of the scheme should be to:

- Identify reduced/impaired respiratory health indicative of CMDLD
- Provide appropriate referral for follow-up, diagnosis and management, including appropriate reductions in further exposure to dust, for coal mine workers with respiratory abnormalities
- Collect, analyse and report group surveillance data to monitor trends in CMDLD, and to inform Government, industry and trade unions reviews of dust exposure levels and occupational exposure limits for coal mines
- Provide feedback to mine companies where reduced/impaired respiratory health is likely to be due to coal mine dust exposure, so that exposure levels can be reviewed

The revised respiratory component of the scheme should include the following components:

- Current and former workers in underground and open-cut mines and CHPPs would be included
- All coal mine workers should be registered under the scheme on entry into the industry, and up-to-date contact details would be maintained
- A complete occupational history would be obtained from the worker on entry into the industry, and updated at subsequent health assessments
- Employers and workers would be informed about an upcoming periodic health assessment as part of the surveillance component of the scheme
- A limited pool of trained doctors would be approved by the DNRM after review of their qualifications and experience
- The training for these doctors should include the objectives and purpose of the scheme, CMDLD and associated diagnostic criteria and knowledge of the coal mining industry
- Doctors should be available in the main mining regions of Moranbah and Emerald, with additional offices sited in Mackay, Rockhampton and Brisbane for the convenience of drive-in-drive-out and fly-in-fly-out coal mine workers
- Respiratory health assessments would be completed at 3-5 year intervals and should include:
    - a comprehensive medical history, including smoking history
    - a standard respiratory symptom questionnaire
    - a focused respiratory physical examination

  - spirometry
  - a CXR (if assessed by the doctor as being indicated)

- CXRs would be dual read and reported according to the ILO classification by trained radiologists in a limited pool to ensure they read enough CXRs under the scheme to maintain skills
- The CXR interval should be determined by the doctor undertaking the health assessments and should take into account past and current exposure. More frequent assessments including CXR may be required for those workers with longer periods of higher dust exposure
- Spirometry would be conducted by a trained technician to TSANZ standards and interpreted by trained doctors
- There would be a process of clinical audit of the spirometry and CXR data
- Clinical guidelines including referral pathways for further investigations and specialist opinion are also established for workers with spirometry, CXR or other respiratory abnormalities, and these results are to be discussed with individual miners and their local doctor
- Cases of CMDLD identified under the scheme would be reported to DNRM after diagnosis
- Electronic data entry (with appropriate data security) is implemented so that current health assessments can be reviewed in the light of previous medical records
- DNRM oversees regular review of the respiratory health data to audit quality
- The collected respiratory health data are analysed at least annually as part of a health surveillance program to examine trends in CMDLD
- An implementation group which could include representatives of stakeholders and relevant medical bodies would be established to ensure that the new respiratory scheme is implemented and in a timely manner
- DNRM provides regular reports on the function and findings of the new scheme to the Coal Mining Safety and Health Advisory Committee[4] so that appropriate industry-wide action can be taken where indicated, for example review/revision of dust exposure levels.
- A review of the new scheme after its first 3 years of operation to confirm that it is meeting its objectives and regularly thereafter to ensure that it remains 'fit for purpose'.

[4]The Coal Mining Safety and Health Advisory Committee is a tripartite body set up by DNRM. Its mission statement includes the following: To represent and influence the industry to improve safety and health and to review and recommend improvements to safety and health in coal mines.

Glossary

ACGIH	American Conference of Governmental Industrial Hygienists
AFOEM	Australasian Faculty of Occupational and Environmental Medicine
AIHW	Australian Institute of health and Welfare
ATS	American Thoracic Society
CD	Compact Disc
CFMEU	Construction Forestry Mining and Energy Union
CHPP	Coal Handling and Preparation Plants
CMDLD	Coal Mine Dust Lung Disease
CMSHR	Coal Mining Safety and Health Regulation (2001)
COPD	Chronic Obstructive Pulmonary Disease
CS	Coal Services (NSW)
CSH	Coal Services Health (NSW)
CT	Computed Tomography
CWHSP	Coal Workers' Health Surveillance Program (US)
CWP	Coal Workers' Pneumoconiosis
CWXSP	Coal Workers' X-Ray Surveillance Program (US)
CXR	Chest X-ray
DICOM	Digital Imaging and Communications in Medicine
DNRM	Department of Natural Resources and Mines
ECWHSP	Enhanced Coal Workers Health Surveillance Program (US)
EMO	Examining Medical Officer
ERS	European Respiratory Society
FEV_1	Forced Expiratory Volume (in one second)
FVC	Forced Vital Capacity
GP	General Practitioners
HRCT	high-resolution CT
HREC	Human Research Ethics Committee
HSU	Health Surveillance Unit
IARC	International Agency for Research on Cancer
ICD	International Classification of Diseases
ILO	International Labour Organization
J60	ICD code for CWP which includes anthracosilicosis, anthracosis and coal worker lung
LLN	Lower Limit of Normal
MSHA	Mine Safety and Health Administration (US)
NIOH	South Africa's National Institute of Occupational Health
NIOSH	National Institute for Occupational Safety and Health (US)
NMA	Nominated Medical Adviser
NSW	New South Wales
OEL	Occupational Exposure Limits

PACS	Picture Archiving and Communication System
PMF	Progressive Massive Fibrosis
PPE	Personal Protective Equipment
Q-COMP	Queensland Compensation
RACP	Royal Australasian College of Physicians
RANZCR	Royal Australian and New Zealand College of Radiologists
RCS	Respirable Crystalline Silica
RPE	Respiratory Protective Equipment
SEG	Similar Exposure Group
SIMTARS	Safety in Mines Testing and Research Station
SMR	Standardized Mortality Ratio
STEL	Short Term Exposure Limit
SWA	Safe Work Australia
TLV	Threshold Limit Values
TSANZ	Thoracic Society of Australia and New Zealand
TWA	Time Weighted Average
U/G	Underground
WA	Western Australia
WC	Workers' Compensation
WHO	World Health Organisation

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Appendices

Appendix 1: Occupational exposure limits for coal dust and silica

There are two types of OEL, those such as the American Conference of Governmental Industrial Hygienists (ACGIH) which are health-based, and those that are regulatory or pragmatic limits (usually higher) which take into account the feasibility and cost-effectiveness of control (and sometimes measurement feasibility) in relation to the risks.

Coal Dust Exposure Limits

The ACGIH set Threshold Limit Values (TLVs) for coal dust in 1988, replacing the 2 mg/m^3 that had been proposed in 1971 with 0.4 mg/m^3 respirable fraction for anthracite and 0.9 mg/m^3 respirable fraction for bituminous coal.[41] The TLVs are set to prevent the development of COPD and PMF. The TLV documentation states that a small risk of the latter disease will remain at this TLV, and that exposure should be reduced to those lowest achievable and that silica exposure should also be controlled.[41]

Anthracite coal dust would appear to be more fibrogenic then bituminous coal dust and the ACGIH recommends lower exposure limits for dust from anthracite than from bituminous coal[41] based on risk modelling (see Table 8).

Table 8: Predicated prevalence rates of CWP and PMF among US coal miners aged 58 following exposure 1 mg/m^3 respirable coal mine dust over a 40-year working life time (after ACGIH [41])

	% CWP Category 1 and greater	% CWP Category 2 and greater	% PMF
Anthracite	12.8	4.6	3.4
Bituminous	11.9	4.1	2.9

Table 9 lists the occupational exposure limits by country, mainly sourced from the German government website GESTIS in 2016.[42] The Australian and New Zealand limit of 3 mg/m^3 is the highest value listed for respirable dust. The UK Advisory Committee on Toxic Substances has expressed concern that the UK value of 2 mg/m^3 may not adequately protect health "because of doubts that the limit was not soundly-based". [42] The OEL of 2 mg/m^3 was included in the published UK 2002 list and its 2003 supplement, but was omitted from the published 2005 list.[42]

The ACGIH TLV for bituminous coal dust is less than a third of the current Australian exposure limit. Some of the OELs listed for the anthracite dust (0.4 mg/m$^{3)}$ are almost an order of magnitude lower than the Australian limit (Belgium, Ireland and Spain), but the GESTIS source[42] did not identify whether they applied as inhalable or respirable dust. Ontario uses the ACGIH TLVs values as respirable dust limits.

Table 9: Occupational exposure limits for coal mine dust [8, 21, 42-44]

Country	Coal Dust 8 Hour TWA mg/m^3			
	Anthracite	Bituminous	Inhalable fraction	Respirable fraction
Australia				**3**
NSW				**2.5**
ACGIH TLV	0.4 (1)	0.9 (1)		
Belgium	0.4	0.9		0.4
Canada - Ontario	0.4 (1)	0.9 (1)		
Denmark				2
Ireland	0.4	0.9		1.6
Latvia	4	4		
New Zealand				3 (3)
People's Republic of China			4 (2)	2.5 (2)
Singapore	2 (1)			
Spain	0.4	0.9		
South Korea				1
USA - OSHA PEL				2.4 (4)
USA - MSHA				1.5 (1)(4)
USA - NIOSH REL				1(1)
United Kingdom				2 (5)

(1) Respirable fraction or aerosol
(2) Free SiO2 < 10%
(3) 0.15 mg/m³ respirable quartz
(4) < 5% SiO_2 if >5% SiO_2, the standard is 10/% quartz
(5) No longer included in published lists

Silica Dust Exposure Limits

The international OELs for silica are listed in Table 10. The Australian workplace exposure limits for silica are similar to those of most countries, but higher than the TLV for respirable crystalline silica set by the ACGIH in 2006, and higher than the values set by many countries for cristobalite (the main form of crystalline silica). The ACGIH document states that the silica value was set to prevent lung cancer and the development of silicosis which had been identified in retirees.[45] Silica has been identified as a human carcinogen by the International Agency for Research on Cancer (IARC),[46] part of the World Health Organisation (WHO).

Table 10: 8 Hour TWA occupational exposure limits (OELs) and short-term exposure limits (STEL) listed for silica [42, 43, 47]

Country	Silica 8 Hour TWA mg/m^3				
	Quartz Cas 14808-60-7	Mineral Dust with Respirable Quartz	Respirable Crystalline Silica	Cristobalite, total Cas 14464-46-1	Tridymite Cas 15468-32-3
ACGIH			0.025	0.025	
Australia	0.1 (1)		0.1	0.1 (1)	0.1 (1)
Austria	0.15 (1)		0.15		0.15 (1)
Belgium	0.1		0.1	0.05	0.05
Canada - Ontario	0.1 (1)			0.05 (1)	
Canada - Québec	0.1		0.05		0.05
Denmark	0.3 (0.6 STEL)(2) 0.1 (0.2 STEL)(1)	0.5	0.05 (0.1 STEL)	0.15 (0.3 STEL)	0.15 (2)
Japan		E=3.0/(1.19 Q+1)(7)			0.05 (1)
Finland	0.05 (1)		0.05		0.05 (1)
France	0.1 (1)(3)			0.05 (1)(3)	0.05 (1)(3)
Hungary	0.15 (1)			0.15 (1)	0.15 (1)
Ireland	0.1 (1)		0.1	0.1 (1)	0.1 (1)
New Zealand	0.2 (1)			0.1 (1)	0.1 (1)
People's Republic of China	1 (1)(4) 0.7 (1)(5) 0.5 (1)(6)		0.7 (3) 0.3 (4) 0.2 (5)		
Singapore	0.1 (1)		(8)	0.05 (1)	0.05 (1)
South Korea	0.05			0.05 (1)	0.05
Spain	0.1 (1)			0.05 (1)	
Sweden	0.1 (1)			0.05 (1)	0.05 (1)
Switzerland	0.15 (1)		0.15	0.15 (1)	0.15 (1)
The Netherlands	0.075 (1)		0.0758	0.075 (1)	0.075 (1)
USA - NIOSH REL	0.05		0.05	0.05	0.05
USA - OSHA PEL				0.05 (1)	0.05 (1)
United Kingdom			0.1		

(1) Respirable dust, fraction or aerosol;
(2) Inhalable or total dust
(3) Restrictive statutory limit values
(4) 10% <= free SiO2 <= 50%
(5) 50% < free SiO2 <= 80%
(6) free SiO2 < 80%
(7) E = administrative control level; Q = content of free silica (percent) Dust of sand and stones, rocks, ores (minerals), metallic or carbon.
(8) See cristobalite, quartz, tridymite, tripoli

Appendix 2: Scope of the review of the respiratory component of the Coal Mine Workers' Health Scheme

A. The adequacy of the scope, processes, quality and reporting of the respiratory component of the existing medical assessment program, including information provided by the employer on risk of dust exposure, medical history, physical examination, chest radiography and spirometry, in detecting the early stages of coal mine dust lung disease.

B. The expertise and resources required, firstly to undertake high quality medical assessments (respiratory component) under the scheme, secondly to have effective referral pathways for suspected of a CMDLD, thirdly to use the gathered data to effectively implement a high quality medical surveillance program for the early detection of coal mine dust lung disease in Queensland coal miners and fourthly to make the information available to relevant stakeholders for necessary action.

C. The expertise and resources currently available in Queensland to perform medical assessments, perform and interpret high quality CXR and perform and interpret high quality spirometry. This will include a review of expertise and training of the current list of Nominated Medical Advisers, the use of EMOs and the specialist respiratory physicians available for referral and subsequent patient care.

D. Where deficiencies are found, make recommendations to improve the current program for the medical assessment of coal mine dust lung disease to achieve a state of the art program for the reliable detection of early disease.

E. Recommendations to build capacity in Queensland to ensure that a list is available of sufficient numbers of suitably qualified practitioners to be NMAs, respiratory physicians, trained personnel to carry out and interpret chest x-rays (CXR) and spirometry, where the current level of expertise and/or resources are found to be inadequate.

F. Depending upon findings from A, B and C, make recommendations for an interim strategy to handle undetected cases and ensure that the current cohort of mine workers is effectively screened for coal mine dust lung disease until longer term recommendations can be implemented.

G. Develop a methodology for the review of past x-rays and spirometry to estimate the extent of coal mine dust lung disease that may have been undetected by the medical assessment scheme.

H. Develop a research plan to measure the current prevalence of CMDLD in Queensland coal mine workers.

Appendix 3: Coal Mine Workers' Health Scheme - Health Assessment Form[5]

[5] The DNRM advised that NMAs have been issued with an amended form (dated 01/05/16) that includes additional instructions about: the category of coal mine workers who require a CXR; qualifications for individuals conducting spirometry and CXRs; and the standards for interpreting/reporting these tests, including the use of the ILO classification.

Coal Mine Workers' Health Scheme - Health Assessment Form

Section 46 Coal Mining Safety and Health Regulation 2001 **Form Number CMSHR 1**
(*Form approved by Chief Inspector under section 281 of the *Coal Mining Safety and Health Act 1999)

Name (Full Given Name(s) and Family Name)	**Date of Birth**

Privacy Obligations

Health surveillance information is collected by the Department of Employment, Economic Development and Innovation for the purpose of identifying medical conditions or impacts on health resulting from exposure to chemical and physical agents in the coal mining industry. It is collected under the authority of Part 6 – Division 2 of the *Coal Mining Safety and Health Regulation 2001*.

The Department will not disclose this information to any person except in accordance with the Regulation. The Regulation requires that the identity of a coal mine worker is protected when information is disclosed for research purposes.

Guidance Notes for completion of Health Assessment

Employer

- ❑ Must arrange for the Health Assessment of Coal Mine Worker.
- ❑ Must complete Section 1 on page 2 which includes informing the Examining Medical Officer or Nominated Medical Adviser if: a colour vision test is required; the worker is, or may be, exposed to dust (and therefore a chest x-ray is required); and the SEG (similar exposure group) of the worker.
- ❑ Must meet the cost of the Health Assessment.

Coal Mine Worker

- ❑ Must bring photo identification to have identity checked by the Examining Medical Officer.
- ❑ Must complete Section 2 on pages 2 to 3.
- ❑ In relation to Section 2 - Work History:
  - ***if the coal mine worker is commencing work*** – full work history must be provided; or
  - ***if the coal mine worker is already employed in the industry*** – only work history since last Health Assessment is required.
- ❑ Should request the Nominated Medical Adviser provide a copy of the Health Assessment Report and an explanation.

Examining Medical Officer/ Nominated Medical Adviser

- ❑ Must check photo identification provided by the Employee.
- ❑ Must review Section 1 and Section 2 (pages 2 to 3 with the coal mine worker and comment on any abnormality).
- ❑ Must complete Section 3 on pages 4 to 6
- ❑ Must attach a separate statement if space on Form is insufficient.
- ❑ Must take advice from the employer on the requirements for a colour vision test and/or chest x-ray.
- ❑ Must **not** complete the "Section 4 Health Assessment Report" if not a Nominated Medical Adviser.
- ❑ Must, where appropriate, forward the completed Health Assessment Form (intact) to Nominated Medical Adviser.

Nominated Medical Adviser

- ❑ Must review Sections 1, 2 and 3.
- ❑ Must assess whether the Health Assessment provides adequate information to make a report on the fitness for duty of the coal mine worker.
- ❑ If the coal mine worker has an abnormal colour vision and/or hearing result affecting fitness for duty, a practical test should be arranged.
- ❑ Must complete "Section 4 Health Assessment Report".
- ❑ Must provide an explanation of "Section 4 Health Assessment Report" to the Coal Mine Worker and, where practical, secure the signature of the Coal Mine Worker on the Health Assessment Report:
- ❑ Must provide a copy of "Section 4 Health Assessment Report" to:
  - the Coal Mine Worker at the address shown on page 2; and
  - the employer.
- ❑ Must forward a copy of the complete "Health Assessment Form" (all 7 pages) to the Health Surveillance Unit of the Department of Employment, Economic Development and Innovation.
- ❑ Must maintain secure records of the Health Assessment and associated documentation.

Section 1 – Employer to complete

Name of Nominated Medical Adviser

Employer

Coal Worker's Position

Description:

Generic SEG*: | **Company SEG**:**

Mine (e.g. Southern Colliery)

SEGs are groups of workers with similar exposure
* Generic SEG is sourced from the list provided by Safety & Health ** Company SEG is the employer SEG

(a) Is the coal mine worker at risk from dust exposure (X-ray needed)?	❑ Yes	❑ No
(b) Will the coal mine worker be working underground?	❑ Yes	❑ No
(c) Does the coal mine worker require colour discrimination?	❑ Yes	❑ No
(d) Is the worker at risk from occupational noise?	❑ Yes	❑ No
(e) Is the worker at risk from hazardous chemicals? (comment)	❑ Yes	❑ No
(f) Are there hazardous duties requiring a specific fitness assessment? (comment)	❑ Yes	❑ No

Comment

Section 2 – Coal Mine Worker to complete

2.1 Coal Mine Worker

(a) Family Name | Given Name (s)

(b) Date of Birth | (d) ❑ Male ❑ Female | (e) Telephone:

(c) Address:

2.2 Work History (coal mine worker to refer to Guidance Notes on the coversheet)

Year		Job Title or Description	Employer
From	To		

2.3 Health-related History

		Yes	No
(a)	Have you previously had a medical examination under this scheme?	❑	❑
(b)	If Yes, when was the last examination?		
(c)	Have you been admitted to a hospital or undergone surgery or an operation?	❑	❑
(d)	Have you ever had an illness or operation that has prevented you from undertaking your normal duties for more than two weeks?	❑	❑
(e)	Have you ever had an injury that has prevented you from undertaking your normal duties for more than two weeks?	❑	❑
(f)	Are you taking any medication?	❑	❑
(g)	Do you use hearing protection whilst in noisy areas?	❑	❑
(h)	Do you currently smoke, or have you ever smoked?	❑	❑

(Supply details) START..... STOP ..... TYPE ... ... QUANTITY/ DAY .....

Examining Medical Officer's comments on Questions 2.1 to 2.3

Approved by the Chief Inspector of Coal Mines under s281 of the Coal Mining Safety and Health Act (1999))

2.4 Have you ever suffered from, or do you now suffer from, any of the following?

		Yes	No			Yes	No
(a)	Heart disease or heart surgery	❑	❑	(n)	Diabetes	❑	❑
(b)	Chest pain, angina or tightness in chest	❑	❑	(o)	Sciatica, lumbago, slipped disc	❑	❑
(c)	High blood pressure	❑	❑	(p)	Neck injury or whiplash	❑	❑
(d)	Asthma, bronchitis or other lung diseases	❑	❑	(q)	Back or neck pain which has prevented you from undertaking full duties	❑	❑
(e)	Abnormal shortness of breath or wheezing	❑	❑	(r)	Knee problems, cartilage injury	❑	❑
(f)	Deafness, loss of hearing or ear problems	❑	❑	(s)	Fractures or dislocations	❑	❑
(g)	Ringing noises in your ears	❑	❑	(t)	Shoulder, knee or any other joint injury	❑	❑
(h)	Other hearing difficulties	❑	❑	(u)	Hernia	❑	❑
(i)	Disease or disorder of the nervous system	❑	❑	(v)	Arthritis or rheumatism	❑	❑
(j)	Episodes of numbness or weakness	❑	❑	(w)	Dermatitis, eczema, or skin problems	❑	❑
(k)	Psychiatric illness	❑	❑	(x)	Allergies	❑	❑
(l)	Blackouts, fits or epilepsy	❑	❑	(y)	Allergic reaction or reaction to chemicals or dust	❑	❑
(m)	RSI, tenosynovitis, over-use syndrome or wrist strain	❑	❑				

2.5 Previous vaccinations and blood tests

(a) When were you last immunised against Tetanus? Year ☐

(b) When were you last immunised against Hepatitis A? Year ☐

(c) When were you last immunised against Hepatitis B? Year ☐

(d) When was your last cholesterol test? Year ☐

Examining Medical Officer's comments on Questions 2.4,and 2.5 .....

.....

.....

.....

.....

Coal Mine Worker's Declaration (to be witnessed by Examining Medical Officer)

I certify to the best of my knowledge that the above information supplied by me is true and correct.
I understand that if any of the information given is knowingly false, my employment may be terminated.

Signature …… Date / /

Witness …….. Date / /

Approved by the Chief Inspector of Coal Mines under s281 of the Coal Mining Safety and Health Act (1999))

Section 3 – Clinical Findings – Examining Medical Officer to complete

3.0 **ID Check** | Type |

3.1 **Height** | cm |

3.2 **Weight** | kg |

Comment

3.3 **Vision**

Visual acuity

		Uncorrected			Corrected	
		Right	Left		Right	Left
(a)-(b)	Distant	6/	6/	(e)-(f)	6/	6/
(c)-(d)	Near	N	N	(g)-(h)	N	N

3.4 **Visual fields** (by confrontation) Abnormal ❑ Normal ❑

Colour Vision Test (if indicated by employer)
Ishihara (if abnormal, the NMA to arrange practical test) Abnormal ❑ Normal ❑

3.5

3.6 Work-related colour vision practical test (if Ishihara test abnormal) Unsatisfactory ❑ Satisfactory ❑

3.7 **Hearing**

Audiogram		500 Hz	1000 Hz	1500 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz	8000 Hz
(a)-(h)	Left								
(i)-(p)	Right								

(q) Time since last high noise exposure? | hours |

(r) Audiogram result Abnormal ❑ Normal ❑

(s) Were hearing aids used Yes ❑ No ❑

(t) Auditory canals Abnormal ❑ Normal ❑

(u) Tympanic membranes Abnormal ❑ Normal ❑

The result is normal if hearing threshold is 40dB or less in the better ear at 500, 1000, 1500 and 2000 Hz. If an abnormal result impacts on a coal mine worker's "fitness for duty", the NMA should consider a practical test.

Examining Medical Officer's comments on Questions 3.1 to 3.7 (Note any abnormality, including past noise exposure, workers' compensation claims and tinnitus)

3.8 **Cardiovascular System**

		Systolic	Diastolic
(a)	Blood Pressure		
(b)	(Repeated if necessary		
(c)	Pulse rate	/min	

(d) Peripheral pulses Absent ❑ Present ❑

(e) Heart sounds Abnormal ❑ Normal ❑

(f) Evidence of cardiac failure or oedema Yes ❑ No ❑

(g) Varicose veins Yes ❑ No ❑

(h) E.C.G. (if indicated by some abnormality) Abnormal ❑ Normal ❑

Examining Medical Officer's comments on Questions 3.8

3.9 Respiratory system

Litres	Observed		Predicted		Observed/Predicted %	
Forced exp. Vol. 1 sec- FEV_1	(b)		(e)		(h)	
Forced vital capacity - FVC	(c)		(f)		(i)	
FEV_1/FVC%	(d)		(g)			

3.10 Spirometry *(abnormal includes FEV_1/FVC<70%)* Abnormal ❑ Normal ❑

3.11 Auscultation of chest Abnormal ❑ Normal ❑

3.12 (a) Was chest x-ray undertaken (as advised by employer) Yes ❑ No ❑

(b) Date x-ray was taken / / ❑ ❑

(c) Quality of film? Unsatisfactory ❑ Satisfactory ❑

(d) What was the result? (Also attach x-ray film to this Report) Abnormal ❑ Normal ❑

3.13 Musculo-skeletal system

	Abnormal	Normal
(a) **Lower back**		
(i) Range of movement	❑	❑
(ii) Posture and gait	❑	❑
(iii) Straight leg raising	❑	❑
(b) **Neck** – range of movement	❑	❑
(c) **Joint movements**		
(i) Upper Limbs	❑	❑
(ii) Lower Limbs	❑	❑
(iii) Reflexes	❑	❑

3.14 Urinalysis and Blood Sugar

	Present	Absent
(a) Sugar	❑	❑
(b) Protein/albumin	❑	❑
(c) Blood	❑	❑
(d) Blood sugar analysis (optional)	❑	❑

3.15 Abdomen

(a) Abdominal scars	❑	❑
(b) Abdominal mass	❑	❑
(c) Hernia	❑	❑

3.16 Skin

(a) Eczema, dermatitis or allergy	❑	❑
(b) Skin cancer or other abnormality	❑	❑

Examining Medical Officer's comments on Questions 3.9 to 3.16

3.17 Is the coal mine worker's fitness for duty is likely to be affected by any of the following?

		Yes	No
(a)	Dietary Habits	❑	❑
(b)	Exercise routine	❑	❑
(c)	Stress Level	❑	❑
(d)	Alcohol Consumption	❑	❑
(e)	Drugs or medication not prescribed by a doctor	❑	❑

3.18 Is there any reason why the coal mine worker may be not fit for duty in relation to work:

		Yes	No
(a)	As an operator of (or working around) around heavy vehicles	❑	❑
(b)	Underground (including use of self-rescue breathing devices and escape)	❑	❑
(c)	Shift work	❑	❑
(d)	Performing heavy manual handling	❑	❑
(e)	In wet or muddy conditions	❑	❑
(f)	In dusty conditions	❑	❑
(g)	At height or on ladders	❑	❑
(h)	In confined spaces	❑	❑
(i)	While wearing safety footwear or other personal protective equipment such as ear plugs, glasses and respirators	❑	❑
(j)	Another capacity – define ……..	❑	❑

Examining Medical Officer's comments on Questions 3.17 and 3.18 ----------

Examining Medical Officer's name and address **Please print or stamp**	**Signature** **Date** / /

Approved by the Chief Inspector of Coal Mines under s281 of the Coal Mining Safety and Health Act (1999))

Approved Form - Section 4 – Health Assessment Report

Coal Mine Worker's Details

Family Name	Given Name(s)	Date of birth
		...../...../.....

Employer	Mine(s) (if applicable)

Examination Details

Date of Examination by EMO	Position (e.g. job title (generic))	Is the assessment for underground work?
...../...../.....		Yes ❑ No ❑

As at the date of this examination, the coal mine worker:

❑ Is fit to undertake any position

❑ Is fit to undertake the proposed / current position

❑ Is suitable for and has no condition which precludes participation in mines rescue - See Mines Rescue Medical Guidelines
For Queensland Mines Rescue Service personnel / applicants only.

❑ Is fit to undertake the proposed / current position subject to the following restriction(s) (if necessary, outline a management program)

❑ Is not fit to undertake the proposed / current position because of the following restriction(s):

The duration of the restriction is:

Is a further review necessary? Yes ❑ Date / / No ❑

Specify full or type of review required:

Was a chest x-ray taken? Yes ❑ Date / / No ❑

As Nominated Medical Adviser I have explained the restriction / additional assessment to the worker Yes ❑ No ❑

As Nominated Medical Adviser I have provided a copy of Section 4 to the worker (refer Note a): Yes ❑

I have been advised of the outcome of this assessment. (Practical constraints prevent this from being a compulsory item)	Coal Mine Worker's Signature	Date / /
Nominated Medical Adviser's name and address: Practice stamp	NMA's Signature:	Date / /

Distribution:

(a) copy of Section 4 to coal mine worker at address shown on page 2; and

(b) copy of Section 4 to employer; or in the case of Mines Rescue membership a copy also to Queensland Mines Rescue Service, GPO Box 156, Dysart, Qld 4745; and

(c) copy of complete Health Assessment Form to Health Surveillance Unit, Simtars, Department of Natural Resources and Mines, PO Box 467, Goodna Qld 4300.

Approved by the Chief Inspector of Coal Mines under s281 of the Coal Mining Safety and Health Act (1999)

Appendix 4: Completion and quality assessment of a sample of 91 completed health assessment forms

	Section/Questions	Included in the DNRM dataset	If Y, degree of completeness	
Section 1	**Employer to complete**		Num.	Qual.
	Name of NMA	Yes	91/91	91/91
	Employer	Yes	82/91	79/82
	Coal workers' position - description	Yes	90/91	89/90
	Coal workers' position - generic SEG	Yes	4/91	-
	Coal workers' position – company SEG	Yes	0/91	0/0
	Mine	Yes	91/91	58/91
	(a) Dust exposure (X-ray needed?) - Y/N *(Duplicate Q – see section 3/3.12)*	Yes	60/91	56/91
	(b) Underground work - Y/N	Yes	66/91	66/66
Section 2	**Coal Mine Worker to complete**			
2.1	(a) Family Name, Given Names	N/A – De-identified data		
	(b) Date of Birth	Yes	91/91	91/91
	(c) Address	N/A – De-identified data		
	(d) Gender	Yes	91/91	91/91
	(e) Telephone	N/A – De-identified data		
2.2	**Work history**	No		
2.3	**Health-related history**			
	(a) Previous med./examination under scheme – Y/N	No		
	(b) If yes, date of last examination	No		
	(c) Current smoker, or ever smoked – Y/N Supply details – Start, Stop, Type, Quantity/day	Yes No	89/91	89/89
2.4	**Ever suffered from, or currently suffer from any of the following:**	No		
	(b) Chest pain, angina or tightness of chest – Y/N (?)	No		
	(d) Asthma, bronchitis or other lung diseases – Y/N	No		
	(e) Abnormal shortness of breath or wheezing – Y/N	No		
	(y) Allergic reaction or reaction to chemicals or dust – Y/N (?) – *irritant*	No		
	No detailed questions about respiratory symptoms			
Section 3	**Clinical Findings**			
3.1	Height	Yes	91/91	90/91
3.2	Weight	Yes	91/91	90/91
3.8	**Cardiovascular system**			
	(h) ECG - AbN/N (R-sided heart changes)	Yes	68	5/68
3.9	**Respiratory system**			
	(b) FEV_1 – observed	Yes	88/91	-

	Section/Questions	Included in the DNRM dataset	If Y, degree of completeness	
	(e) FEV_1 – predicted	Yes	88/91	-
	(h) FEV_1 – observed/predicted %	Yes	87/91	86/87
	(c) FVC – observed	Yes	88/91	-
	(f) FVC – predicted	Yes	88/91	-
	(i) FVC – observed/predicted %	Yes	87/91	84/87
	(d) FEV_1/FVC% - observed	Yes	88/91	85/88
	(g) FEV_1/FVC% - predicted	Yes	88/91	86/88
3.10	Spirometry – abnormal/normal	Yes	90/91	90/90
3.11	Auscultation of chest – abnormal/normal	Yes	90/91	90/90
3.12	CXR undertaken – Y/N	Yes	91/91	91/91
	Date CXR taken	Yes	85/91	83/85
	Quality of film – unsatisfactory/satisfactory	No		
	What was the result – AbN/N Attach film to report	Yes No	70/91	70/70
3.17	**Is coal mine worker's fitness for duty likely to be affected by any of the following**	No		
	No lifestyle question relating to respiratory system, e.g. smoking			
3.18	**Is there any reason why the coal mine worker may not be fit for duty in relation to work:**	No		
	(b) Underground (including use of self-rescue breathing devices & escape) – Y/N	No		
	(d) Performing heavy manual handling – Y/N	No		
	(f) In dusty conditions – Y/N	No		
	(h) In confined spaces – Y/N (?)			
	(i) While wearing safety footwear or other PPE such as ear plugs, glasses and respirators – Y/N	No		
Section 4	**Health Assessment Report**			
	Examination Details			
	Date of examination by EMO (Name of EMO – not on assessment form)	Yes Yes	91/91 59	0 2/59
	Is assessment for underground work – Y/N *(Duplicate Q – see Section 1)*	Yes	85	62/85
	Detail of restrictions	Yes		?4
	NMA explained restriction/additional assessment	No		
	1. Fit for duty – 5 options to select from with a tick 2. None of the options are specific for the respiratory system	Entered as "true" or "false"		
	NMA provided copy of Section 4 to worker - Y	No		
	Coal mine workers' signature/date	No		
	NMA's stamp & signature NMA date	Yes	91/91 91/91	91/91 91/91

Detailed explanation of the quality issues of completed health assessment forms

	Section/Questions	**No. of entries**	**Details**
Section 1	**Employer to complete**		
	Employer	3	"H", "Self", "Services"
	Coal workers' position - description	1	"U/G"
	Coal workers' position - generic SEG	-	
	Mine	33	12 "Unknown" BUT 11 with employer named; remainder no employer named 21 "Various mines" BUT 20 with employer named; remainder no employer named
	(a) Dust exposure (X-ray needed?) - Y/N (*Duplicate Q – see Section 3*)	35	4 "N", but CXR "Y" 31 blanks, but CXR "Y"
Section 3	**Clinical Findings**		
3.1	Height	1	"0" entered
3.2	Weight	1	"0" entered
3.8	**Cardiovascular system**		
	(h)ECG - AbN/N (R-sided heart changes)	63	"X" entered instead of "A" or "N"
3.9	**Respiratory system**		
3.9	FEV_1 – observed	-	
	FEV_1 – predicted	-	
	FEV_1 – observed/predicted %	1	FEV_1 observed & FEV_1 predicted but no %
	FVC – observed	-	
	FVC – predicted	-	
	FVC – observed/predicted %	3	FVC observed & FVC predicted but no % FVC observed > predicted but =100% FVC observed > predicted but <100%
	FEV_1/FVC% - observed	3	FEV_1 > FVC but <100%
	FEV_1/FVC% - predicted	2	FEV_1 > FVC but <100%
3.12	(b) Date CXR taken	2	Incomplete "11/10", "06/2001"

	Section/Questions	**No. of entries**	**Details**
Section 4	**Health Assessment Report** Examination Details		
	Date of examination by EMO (Name of EMO – not on assessment form, but in the DNRM database)	0 57	 55 with surnames only 2 with the names of the surgery
	59 medicals completed by an EMO (35 doctors in total, including 14 NMAs) 28 medicals completed by EMOs who are also NMAs		
	Is assessment for underground work – Y/N (*Duplicate question – see Section 1*)	23	Work U/G cf. U/G work Blank cf. "Y" (18) Blank cf. "N" (1) "N" cf. "Y" (3) "Y" cf. "N" (1)
	Detail of restrictions	4	Not clear from the details if these relate to a respiratory condition

Appendix 5: List of NMAs, by practice type and qualifications

In total, there were 237 Nominated Medical Advisers (NMAs) conducting the coal workers' health assessments, in over 140 surgeries and in five different States. The majority (146) of NMAs were General Practitioners who were mainly based in General Practice clinics, followed by Medical Practitioners (57) with General registration practising in both Occupational Health Service and General Practice clinics. There were only twenty-eight specialist Occupational Physicians participating in the coal workers' health scheme. The different surgeries included ninety-seven General Practice clinics and forty-three Occupational Health Service clinics.

Queensland

The majority (approximately 90%) of NMAs and surgeries where the coal workers' health assessments were conducted were in Queensland. The coal workers' health assessments were undertaken in twenty-eight Queensland regions and these activities were concentrated in six regions: Brisbane, Mackay, Sunshine Coast, Rockhampton, Gold Coast and Brisbane City.

In Brisbane there were forty-eight NMAs based in twenty-nine different surgeries, including nine Occupational Health Service clinics and sixteen General Practice clinics. Three specialist Occupational Physicians, three General Practitioners and seven non-specialists conducted the assessments in the Occupational Health Service clinics. There were an additional two specialist Occupational Physicians practising from private clinics. The General Practice clinics were comprised of twenty-six General Practitioners and five non-specialists.

In Mackay there were forty NMAs based in twenty different surgeries, including three Occupational Health Service clinics and seventeen General Practice clinics. Medical Practitioners in the Occupational Health Service clinics included one specialist Occupational Physician, five General Practitioners and one non-specialist. There were one specialist Occupational Physician, twenty-three General Practitioners and nine non-specialists in the General Practice clinics.

On the Sunshine Coast the coal workers' health assessments were conducted by nineteen NMAs, all of whom were based in General Practice clinics. The NMAs included fourteen General Practitioners, four non-specialists and no specialist Occupational Physicians.

In Rockhampton, the distribution of NMAs was similar to the Sunshine Coast, but there were two Occupational Health Service clinics.

On the Gold Coast there were 12 NMAs in eleven different surgeries, including two Occupational Health Service clinics and nine General Practices. Eight General Practitioners and two non-specialists were based in the General Practice clinics.

In Brisbane City there was a similar number of NMAs as the Gold Coast, but there were more Occupational Health Service clinics (5) than General Practice clinics (1). There were five Specialist Occupational Physicians, four General Practitioners and three non-specialists.

Other States

The coal workers' health assessment was conducted in four other States: New South Wales, Victoria, Western Australia and South Australia. There were twenty-seven NMAs, based in eleven different Occupational Health Centres and three General Practices. The Medical Practitioners included nine specialist Occupational Physicians, nine General Practitioners and nine non-specialists.

Appendix 6: Spirometry survey

Dear participants,

As part of our review of the operation of the Coal Mine Workers' Health Scheme, we are seeking further information about the conduct of spirometry during the health assessments.

This survey is being sent to all Medical Practitioners listed as Nominated Medical Advisers with the Queensland Department of Natural Resources and Mines.

The survey will take approximately 15 minutes to complete, however you may need the assistance of the technician, nurse or other individual(s) who actually perform the spirometry. It is important that you complete as many questions as possible before submitting the survey.

The data collected during this survey will be sent directly to Monash University for analysis. Only anonymised group data will be reported to the Queensland Department of Natural Resources and Mines.

Your assistance with our review is appreciated.

START OF SURVEY

1. Type of site where spirometry performed

☐ General Practice
☐ Occupational Health Clinic
☐ Hospital
☐ Other facility (please specify) _____

2. Manufacturer of spirometer

☐ Don't know
Please specify _____

3. Spirometer model

☐ Don't know
Please specify _____

4. Year spirometer acquired

☐ Don't know
Please specify year (XXXX) _____

5. Spirometer software version

☐ Don't know
Please specify _____

6. Does the spirometer have automated quality control?

☐ Yes
☐ No
☐ Don't know

7. Does the spirometer produce volume-time graphical displays?

☐ Yes
☐ No
☐ Don't know

8. Does the spirometer produce flow-volume graphical displays?

☐ Yes
☐ No
☐ Don't know

9. Does the spirometer store all manoeuvres performed for each individual tested?

☐ Yes
☐ No
☐ Don't know

10. How many manoeuvres does the spirometer store for each individual tested?

☐ 1
☐ 2
☐ 3
☐ More than 3
☐ Don't know

11. What is the electronic output format of the spirometer?

☐ 2005 American Thoracic Society/European Thoracic Society (ATS/ETS)
☐ Don't know
Other (please specify) _____

12. What software does the spirometer use for report generation?

☐ Don't know
Please specify _____

13. What reference values do the reports use? e.g. National Health and Nutrition Examination Survey (NHANES)

☐ Don't know
Please specify _____

14. How often is the spirometer calibrated?

☐ At least daily
☐ Weekly
☐ Monthly
☐ Less than monthly
☐ Don't know

15. Which year was it last calibrated?
Please specify year (XXXX) _____

16. Does the spirometer have a calibration check?

☐ Yes
☐ No
☐ Don't know

17. Do you take part in an on-going spirometry quality assurance program?

☐ Yes
☐ No
☐ Don't know

18. What year did you last participate in a quality assurance program (if applicable)?
Please specify year (XXXX) _____

19. Do you have a post-bronchodilator spirometry routine?

☐ Yes
☐ No
☐ Don't know

20. Is a spacer used to administer the bronchodilator?

☐ Yes
☐ No
☐ Don't know

21. Is a spirometry procedure manual available at the site where spirometry is performed?

☐ Yes
☐ No
☐ Don't know

22. Which year was the spirometry procedure manual last revised?
☐ Don't know
Please specify year (XXXX) _____

23. Is a height measurement device used during the spirometry?

☐ Yes
☐ No
☐ Don't know

24. Is a weight measurement device used during spirometry?
☐ Yes
☐ No
☐ Don't know

25. What are the qualifications of the person usually administering spirometry for the coal mine workers' health scheme?

☐ Medical practitioner
☐ Registered nurse
☐ Science graduate
☐ Don't know
Other (please specify) _____

26. How many spirometry tests, approximately, does he/she perform *per month* for the coal mine workers' health scheme?

☐ Fewer than 1 per month
☐ Between 1 and 5 per month
☐ Between 6 and 20 per month
☐ More than 20 per month

27. How many spirometry tests, approximately, does he/she perform *per week*, excluding tests performed for the coal mine workers' health scheme?

☐ Fewer than 1 per week
☐ Between 1 and 5 per week
☐ Between 6 and 20 per week
☐ More than 20 per week

28. How many years of experience at performing spirometry does he/she have?

☐ Fewer than 1 year
☐ Between 1 and 5 years
☐ Between 6 and 10 years
☐ More than 10 years

29. Has this person attended a spirometry training course?

☐ Yes
☐ No
☐ Don't know

30. If yes to question 29, which year did he/she attend the spirometry training course?

☐ Don't know
Please specify year (XXXX) _____

31. If yes to question 29, what was the name of the organisation that delivered the training?

☐ National Asthma Council
☐ Thoracic Society Australia and New Zealand (TSANZ)
☐ Don't know
Other (please specify) _____

Appendix 7: Summary of spirometry survey data

Question	Response	%	N	Total
1. Type of site where spirometry performed	General Practice	62.2	46	74
	Occupational Medicine Clinic	36.5	27	
	Hospital	0	0	
	Other (GP/Occ med clinic)	1.4	1	
2. Manufacturer of spirometer	MIR (variety)	21.1	15	71
	Vitalograph	19.7	14	
	QRS	9.9	7	
	Welch Allyn	7.0	5	
	Others (all fewer than 5 responses)	35.2	25	
	Don't know	7.0	5	
3. Spirometer model	MiniSpir	15.3	11	72
	Spiro	12.5	9	
	Alpha	8.3	6	
	Orbit	8.3	6	
	Other (all fewer than 5 responses)	43.1	31	
	Don't know	12.5	9	
4. Year spirometer acquired	Pre 2013	16.4	12	73
	2013	12.3	9	
	2014	9.6	7	
	2015	15.1	11	
	2016	12.3	9	
	Unclear	2.7	2	
	Don't know	31.5	23	
5. Spirometer software version	Winspiro	21.6	16	74
	Office medic	8.1	6	
	Other (all fewer than 5 responses)	50.0	37	
	Don't know	20.3	15	

Question	Response	%	N	Total
6. Does the spirometer have automated quality control?	Yes	63.8	44	69
	No	11.6	8	
	Don't know	24.6	17	
7. Does the spirometer produce volume-time graphical displays?	Yes	90.3	65	72
	No	4.2	3	
	Don't Know	5.6	4	
8. Does the spirometer produce flow-volume graphical displays?	Yes	100	74	74
	No	0	0	
	Don't Know	0	0	
9. Does the spirometer store all manoeuvres performed for each individual tested?	Yes	94.4	68	72
	No	1.4	1	
	Don't know	4.2	3	
10. How many manoeuvres does the spirometer store for each individual tested?	1	2.7	2	74
	2	4.1	3	
	3	33.8	25	
	More than 3	50.0	37	
	Don't know	9.5	7	
11. What is the electronic output format of the spirometer?	2005 American Thoracic Society/European Thoracic Society (ATS/ETS)	44.6	33	74
	Other (please specify) *European, CE or ERS (5) Other (3)*	10.8	8	
	Don't know	44.6	33	
12. What software does the spirometer use for report generation?	Winspiro	23.0	17	74
	Office medic	6.8	5	
	Medical director	6.8	5	
	Others (all fewer than 5 responses)	35.1	26	
	Don't know	28.4	21	
13. What reference values do the reports use? e.g. National Health and Nutrition Examination Survey (NHANES)	NHANES	21.9	16	73
	Knudsen	6.8	5	
	Other (all fewer than 5 responses)	24.7	18	
	Don't know	46.6	34	

Question	Response	%	N	Total
14. How often is the spirometer calibrated?	At least daily	19.4	14	72
	Weekly	5.6	4	
	Monthly	20.8	15	
	Less than monthly	41.7	30	
	Don't know	12.5	9	
15. Which year was it last calibrated?	Pre 2015	4.3	3	70
	2015	34.3	24	
	2016	50.0	35	
	Other e.g. unknown or self-calibrates	11.4	8	
16. Does the spirometer have a calibration check?	Yes	79.2	57	72
	No	6.9	5	
	Don't know	13.9	10	
17. Do you take part in an ongoing spirometry quality assurance program?	Yes	29.2	21	72
	No	59.7	43	
	Don't know	11.1	8	
18. What year did you last participate in a quality assurance program (if applicable)?	Pre 2015	16.2	6	38
	2015	29.7	11	
	2016	13.5	5	
	N/A	27.0	10	
	Other (all fewer than 5 responses)	13.5	6	
19. Do you have a post-bronchodilator spirometry routine?	Yes	79.7	59	74
	No	14.9	11	
	Don't know	5.4	4	
20. Is a spacer used to administer the bronchodilator?	Yes	78.1	57	73
	No	19.2	14	
	Don't know	2.7	2	
21. Is a spirometry procedure manual available at the site where spirometry is performed?	Yes	91.9	68	74
	No	6.8	5	
	Don't know	1.4	1	

Question	Response	%	N	Total
22. Which year was the spirometry procedure manual last revised?	Pre 2014	16.9	12	71
	2014	7.0	5	
	2015	19.7	14	
	2016	19.7	14	
	Other	4.2	3	
	Don't know	32.4	23	
23. Is a height measurement device used during the spirometry?	Yes	98.6	73	74
	No	1.4	1	
	Don't know	0	0	
24. Is a weight measurement device used during spirometry?	Yes	90.5	67	74
	No	9.5	7	
	Don't know	0	0	
25. What are the qualifications of the person usually administering spirometry for the coal mine workers' health scheme?	Medical practitioner	8.1	6	74
	Registered or enrolled nurse	81.1	60	
	Science graduate	1.4	1	
	Occ Med/Health screener	2.7	2	
	Clerical	2.7	2	
	Other	4.1	3	
	Don't know	0	0	
26. How many spirometry tests, approximately, does he/she perform per month for the coal mine workers' health scheme?	Fewer than 1 per month	4.1	3	74
	Between 1 and 5 per month	37.8	28	
	Between 6 and 20 per month	35.1	26	
	More than 20 per month	23.0	17	
27. How many spirometry tests, approximately, does he/she perform per week, excluding tests performed for the coal mine workers' health scheme?	Fewer than 1 per week	6.8	5	73
	Between 1 and 5 per week	37.0	27	
	Between 6 and 20 per week	30.1	22	
	More than 20 per week	26.0	19	

Question	Response	%	N	Total
28. How many years of experience at performing spirometry does he/she have?	Fewer than 1 year	0	0	74
	Between 1 and 5 years	33.8	25	
	Between 6 and 10 years	25.7	19	
	More than 10 years	40.5	30	
29. Has this person attended a spirometry training course?	Yes	62.2	46	74
	No	28.4	21	
	Don't know	9.5	7	
30. If yes to question 29, which year did he/she attend the spirometry training course?	Pre 2013	15.4	8	52
	2013	7.7	4	
	2014	11.5	6	
	2015	23.1	12	
	2016	3.8	2	
	Other	7.7	4	
	Don't know	30.8	16	
31. If yes to question 29, what was the name of the organisation that delivered the training?	National Asthma Council	35.4	17	48
	Thoracic Society Australia and New Zealand (TSANZ)	2.1	1	
	Don't know	22.9	11	
	Other (all fewer than 5 responses)	39.6	19	

Appendix 8: Spirometry review protocol

The quality and accuracy of a sample of approximately 300 spirograms and their corresponding Nominated Medical Adviser (NMA) reports were examined as part of the review. The sample of spirograms were selected to be representative of the various Queensland mines, and were restricted, where possible, to coal miners at a higher risk of developing changes in lung function, i.e. individuals with at least 10 years of underground work.

Dr Ryan Hoy and Professor Bruce Thompson are experienced in interpreting lung function data, and undertook the review.

The quality of spirometry was assessed according to the guidelines set out in the National Asthma Council handbook, *Spirometry – The measurement and interpretation of ventilatory function in clinical practice* and the 2005 American Thoracic Society/European Respiratory Society (ATS/ERS) Standardisation of Spirometry. In particular, there was specific evaluation of the presence of artefact (such as cough, leak and early termination), adequate start and satisfactory exhalation. Spirograms were deemed to be poor quality if one or more of the previously noted criteria are not acceptable. As well as the above criteria, the ATS/ERS Standards also requires three acceptable spirograms to be recorded and saved, and repeatability between tests to be present, that is, two largest values of forced vital capacity (FVC) must be within 0.150 L of each other and two largest values of forced expiratory volume in 1 second (FEV_1) must be within 0.150 L of each other. Spirograms were also evaluated for the presence of adequate documentation, repeatability of results and quality of spirometry.

The accuracy of spirometry results were interpreted in accordance with the 2005 ATS/ERS interpretive strategies. The lower limit of normal (LLN) is taken to be equal to the 5th percentile of a healthy, non-smoking population. Pattern and severity of abnormal results (or lung function impairment) were assessed according to the following ATS/ERS classification:

Obstruction
- FEV_1/VC < 5th percentile of predicted

Restriction
- Reduced VC does not prove a restrictive pulmonary defect, but may be suggestive of lung restriction when FEV_1/VC is normal or increased

Mixed defect
- FEV_1/VC and TLC < 5th percentile of predicted

Severity of Impairment
$FEV_1 \geq$ LLN (Normal)
70% reference $\leq FEV_1 <$ LLN (Mild)
60% reference $\leq FEV_1 <$ 70% reference (Moderate)
50% reference $\leq FEV_1 <$ 60% reference (Moderately Severe)
35% reference $\leq FEV_1 <$ 50% reference (Severe)
$FEV_1 <$ 35% reference (Very Severe)

Spirometry review procedure

1. The two reviewers independently examined the spirometry data according to the outlined criteria for acceptability and repeatability.
2. The following fields were extracted by a research assistant from the health assessment forms, and entered into an EXCEL spreadsheet (to facilitate data collation and analysis):
    - Study ID
    - Name of Mine
    - FEV_1 – observed, predicted, and observed/predicted %
    - FVC – observed, predicted, and observed/predicted %
    - FEV_1/FVC% – observed and predicted
    - Spirometry result – abnormal or normal
    - NMA/EMO comments
3. The following fields were assessed and extracted from the spirograms by the reviewers, where possible, and entered into an EXCEL spreadsheet:
    - Study ID
    - Reference values used
    - Data readable – Y/N (e.g. based on quality of photocopy)
    - ATS/ERS standards met – Y/N
    - Artefact free – Y/N
    - Good start – Y/N
    - Satisfactory exhalation – Y/N
    - 3 spirograms provided – Y/N
    - 2 largest FVC within 0.15l – Y/N
    - 2 largest FEV_1 within 0.15l – Y/N
    - Largest FVC, FVC % predicted
    - Largest FEV_1, FEV_1 % predicted
    - FEV_1/FVC, FEV_1/FVC % predicted
    - Interpretation – normal/abnormal
    - Obstructive – Y/N
    - Restrictive – Y/N
    - Severity
    - Other comments
4. The interpretation of the two reviewers was compared to determine whether there was agreement in evaluation of spirometry quality and the results.
    a) If there was agreement, the result was considered final and reported
    b) When agreement was lacking, reviewers met and discussed the results to reach agreement by consensus.
5. The final results were compared with the existing NMA reports (i.e. NMA/EMO results entered in Q3.9 and Q3.10 for agreement)
    a) Overall findings were reported, focusing on agreement between the existing reports and reviewers' interpretations.

   b) Where there was disagreement, any common features e.g. one particular mine will also be reported and/or investigated

6. Where a major discrepancy was found, the coal mine worker will be notified via DNRM and the appropriate medical practitioner(s) about results of the re-evaluation of their spirometry according to procedures within the Coal Mine Workers' Health Scheme.

Appendix 9: Detailed measures to improve quality of spirometry

1. Adoption of the 2013 American Thoracic Society (ATS) Technical Standards: Spirometry in the Occupational Setting, with development of consensus regarding each of the components (see ATS List below) specific to the task of underground coal mining in Queensland.
2. Spirometry must be performed at Thoracic Society of Australia and New Zealand (TSANZ) accredited respiratory laboratory. Currently, there are 10 TSANZ accredited respiratory laboratories in Queensland. A list of accredited laboratories and accreditation processes is available at:
   https://www.thoracic.org.au/respiratorylaboratoryaccreditation/australia
3. Spirometry testing facilities and staff require registration with the Coal Mine Health Surveillance Program. The testing facility and staff will be designated registration numbers, which need to be recorded on test results when performed and submitted to the Surveillance Program. Approval requires provision of documentation for review including:
   a. Documentation of current accreditation of the laboratory by TSANZ.
   b. Staff training certification: Each person administering spirometry must provide documentation of successful completion of an approved spirometry training program and refresher courses on a periodic basis as determined by TSANZ accreditation. The most recent TSANZ position paper regarding training courses recommends the duration of a spirometry training course is at least 10 hours, particularly if participants are spirometry naïve. A refresher course should be attended within the first 12 months of completion of the initial course, and thereafter every three years
4. Test performance and interpretation factors:
   a. Spirometry must be performed and recorded in accordance with current ATS/ERS Standardisation of Spirometry. Each session must have the goal of obtaining at least 3 acceptable spirograms with 2 repeatable forced expiratory manoeuvres.
   b. Spirometry tests should be interpreted by a physician or respiratory scientist with expertise in spirometry.
   c. Interpretation must follow the current ATS/ERS Interpretative strategies for lung function tests and use the fifth percentile lower limit of normal (LLN) to differentiate normality from abnormality, rather than a fixed value, such as 80% of predicted. In the workplace setting it has been noted that use of fixed values to detect abnormality will result in false negative results for younger workers and false-positive results in older workers.
   d. Data should be recorded and stored to allow interpretation of longitudinal changes to permit detection of greater than expected rate of decline.
   e. Detection of abnormal test results or greater than expected rates of decline must result in further evaluation of the worker. For example, if reduced a vital capacity is noted on spirometry the worker should be referred for more complex respiratory function tests including plethysmographic lung volumes and gas transfer.

5. Equipment factors:
    a. Spirometry system must be in a quality control program consistent with current ATS/ERS Standardisation of Spirometry and TSANZ accreditation manual.
    b. Use spirometers that can save and export all data and all flow–volume and volume–time curves and can display them on real-time graphical displays large enough for inspection of quality by scientists as tests are performed.
    c. Whenever possible, use the same type of spirometer for serial testing, and document the spirometer used.
    d. The spirometry software must automatically perform quality assurance checks on expiratory manoeuvers during the testing session.
6. Scientist/operator training:
    a. Provide scientists with initial training and periodic refresher courses by an approved spirometry training program, which should include hands-on practical experience.
    b. Use spirometers that can assess quality of tests and provide automated real-time feedback to technicians.
    c. Conduct ongoing review of the quality of spirometry tests that are performed and provide technicians timely, ongoing feedback about the quality of their tests and how to correct problems that are identified. This is also a requirement of TSANZ respiratory laboratory accreditation.
7. Spirometry results and other data to be specified must be submitted to the Coal Mine Health Surveillance Program with 14 days of completing the test. The Coal Mine Health Surveillance Program will undertake review of provided data by a respiratory physician for assessment of quality, validation of results and longitudinal change for individual workers. A database will be maintained of all spirometry results. Centralised review of all results will allow provision of recommendation for potential intervention for specific workers, testing sites and/or mine sites.

<u>Components of a workplace spirometry program from the 2013 Official American Thoracic Society (ATS) Technical Standards: Spirometry in the Occupational Setting</u>

1. Define purpose of the spirometry testing, such as:
    a. Medical surveillance (to detect effects of inhalational exposures/occupational lung diseases)
    b. Appropriate job placement (after hire, before job placement)
    c. Component of medical evaluation for respirator usage
    d. Component of an impairment or disability evaluation
2. Define parameters for the spirometry program, including:
    a. Inhalational exposures and lung diseases of concern
    b. Regulatory and workplace-mandated requirements
    c. Frequency of testing
    d. Workers to be tested (based on potential hazards or other concerns)
3. Clarify responsibility for evaluation of:
    a. The individual worker
    b. Aggregate analysis of the spirometry and other data collected on the group of workers
4. Clarify lines of communication of relevant information between the patient, employer, and medical provider.

5. Ensure that spirometers and technician training meet or exceed ATS recommendations.
6. Establish and maintain an effective quality assurance program.
7. Define appropriate spirometry reference values and interpretative strategies.
8. Establish triggers for further evaluation and initial action plan.

Standards incorporated in recommendations:

Pellegrino R, et al. ATS/ERS Task Force: Standardisation Of Lung Function Testing. Interpretative strategies for lung function tests. Eur Respir J 2005; 26: 948–968

Miller M.R, et al. ATS/ERS Task Force: Standardisation Of Lung Function Testing. Standardisation of spirometry. Eur Respir J 2005; 26: 319–338

Redlich C, et al. Official American Thoracic Society Technical Standards: Spirometry in the Occupational Setting. Am J Respir Crit Care Med 2014; 189 : 984–994

The National Institute for Occupational Safety and Health (NIOSH) Coal Mine Health Surveillance Program (CWHSP) Accessed 5/6/16.

http://www.cdc.gov/niosh/topics/surveillance/ords/coalminerhealth.html

Thoracic Society of Australia and New Zealand – Respiratory Function Laboratory Accreditation: Accessed 9/6/16

https://www.thoracic.org.au/respiratorylaboratoryaccreditation/respiratory-function-laboratory-accreditation

Appendix 10: Coal Miners Dust Lung Disease – Fact sheet for GPs

Coal Mine Dust Lung Disease – Fact sheet for GPs

Since May 2015, there have been six confirmed cases of coal workers' pneumoconiosis (CWP), one form of coal mine dust lung disease (CMDLD), reported among former and current Queensland coal mine workers, and the outcome of at least one suspected case is still pending. The Queensland Department of Natural Resources and Mines (DNRM) has commissioned an independent review of the respiratory component of the coal mine workers' health scheme, including an interim strategy to detect and manage further CMDLD cases. This fact sheet contains information for General Practitioners about CMDLD, to assist in the assessment and management of such cases. Due to the high media interest in this issue, many coal miners in Queensland are likely to be worried about their respiratory health and seek advice from their GP.

Summary

- Coal miners occupationally-exposed to respirable coal mine dust over several years are at risk of developing coal mine dust lung disease, which includes CWP, emphysema, chronic bronchitis, and lung function impairment.
- CMDLD should also be considered in former coal miners, such as retirees and ex-industry employees, who present with significant respiratory symptoms. These diseases develop gradually, usually after at least 10 years of exposure, however in sensitive miners or in cases of intense exposure symptoms may occur sooner.
- Typical symptoms of CMDLD include cough, sputum production, and shortness of breath, however individuals with early disease may be asymptomatic but may have detectable chest x-ray or spirometry findings.
- Early detection of CMDLD is based on chest imaging and lung function testing, usually with plain chest radiography and spirometry, along with careful evaluation of respiratory symptoms.
- Individuals who are or have been coal mine workers and are suspected of having CWP should be referred to a Respiratory and/or Occupational physician for further assessment. Links to lists of such physicians can be found at https://www.business.qld.gov.au/industry/mining/safety-health/mining-safety-health/medicals/coal-board-medical/pneumoconiosis-screening

About Coal Mine Dust Lung Disease

Coal mine dust lung disease is the broad term for diseases caused by coal mine dust exposure, and comprises a group of occupational lung diseases that result from the cumulative inhalation of respirable coal mine dust over several years. Coal miners are at risk of developing these diseases, which include pneumoconioses (coal workers' pneumoconiosis, silicosis, and mixed dust pneumoconiosis). Pneumoconiosis is a disease of the lung parenchyma caused by deposition of dust particles, and the reaction of lung tissue to the dust.

Emphysema, chronic bronchitis, lung function impairment, and diffuse dust-related fibrosis are other manifestations of the disease.

Coal workers' pneumoconiosis, the form of disease identified by chest imaging, can be further classified by severity: simple CWP which may be category 1, 2, or 3 reflecting increasing profusion of scars seen on chest imaging. The more severe stage of the disease known as complicated CWP or progressive massive fibrosis (PMF) is diagnosed when a scar is greater than one cm in diameter. The likelihood of CWP development is directly related to the intensity and duration of exposure to coal mine dust. The disease typically occurs after at least 10 years of exposure, and the risk of disease persists after exposure has ceased.

Under the current Queensland Coal Mine Workers' Health Scheme, all coal mine workers are required to undergo a medical assessment prior to the start of their employment at a coal mine, and then at least once every five years during their employment. Employees identified as at risk from dust exposure, in particular underground coal miners are also required to undertake chest x-rays as part of their health assessments. Given the long latency between exposure and disease occurrence, the population at risk extends to previous employees including retired coal miners and coal miners who have transferred to other industries. Coal workers' pneumoconiosis was thought to have been eradicated from Australia, with no new cases having been reported for many years. In light of the recent CWP cases increased vigilance is required among treating doctors, in particular GPs, to identify individuals with early stages of CWP.

Symptoms

Individuals with early-stage coal workers' pneumoconiosis are often asymptomatic, however typical symptoms of CWP (and other CMDLD) include cough, sputum production, wheezing, and shortness of breath. Progressive massive fibrosis is a debilitating and life-threatening condition, and individuals may present with more severe symptoms. Emphysema, chronic bronchitis and lung function impairment are well described adverse health outcomes of coal mine dust exposure and have the same presentation seen when caused by tobacco smoke exposure. The toxicity of tobacco smoke and coal mine dust are roughly equal in potency, and result in an additive effect.

Investigations

Detection of coal mine dust lung disease requires identification of relevant occupational exposure history and evaluation of respiratory symptoms, as well as chest imaging and lung function testing, which usually includes plain chest radiograph and spirometry. Chest imaging is interpreted using International Labour Office (ILO) criteria. Coal workers' pneumoconiosis is a more complex disease to diagnose, and suspected cases should be referred to specialist Respiratory or Occupational physicians for assessment and management. All confirmed cases of CWP should be reported to the Queensland Department of Natural Resources and Mines by treating specialists.

There is currently no effective treatment for coal workers' pneumoconiosis, and emphasis is therefore on early detection of asymptomatic or early-stage disease, and advice to avoid further exposure to coal mine dust and other respiratory hazards including smoking cessation.

Further information

The Queensland Department of Natural Resources and Mines has compiled a list of Respiratory physicians who can be contacted for further assessment of potential cases of CWP. A list of radiology clinics reporting chest x-rays to the ILO classification has also been compiled. These lists can be accessed on the Department's webpage, and will be regularly updated. See https://www.business.qld.gov.au/industry/mining/safety-health/mining-safety-health/medicals/coal-board-medical/pneumoconiosis-screening

Reference

Petsonk EL, Rose C, Cohen R. Coal Mine Dust Lung Disease – New Lessons from an Old Exposure. *Am J Respir Crit Care Med* 2013;187(11):1178-85.