Report preface

The University of Illinois (Chicago) was selected through an open tender process by the NSW Government to independently conduct a review of the health surveillance scheme for NSW coal workers.

The review, recommended and overseen by the NSW Mine Safety Advisory Council, examined the current approach to the health surveillance of workers in the coal industry, including the detection of occupational dust lung disease.

This report outlines 16 recommendations and identifies areas for continued improvement to ensure robust health surveillance.

Review of the New South Wales Health Surveillance Scheme for Coal Mine Workers

Final Report

School of Public Health
University of Illinois Chicago

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UIC SCHOOL OF PUBLIC HEALTH
UNIVERSITY OF ILLINOIS AT CHICAGO

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Executive Summary

The University of Illinois School of Public Health was engaged by the NSW Government (Department of Regional NSW) to undertake an independent quality assurance review of the NSW Health Surveillance Scheme for Coal Mine Workers. The independent review was a recommendation of, and overseen by, the NSW Mine Safety Advisory Council.

The New South Wales (NSW) health surveillance scheme for coal mine workers is designed to support secondary prevention of coal mine dust lung disease (CMDLD) by identifying early abnormalities on screening tests. Coal mine dust lung disease was re-identified in Australia beginning in 2015, in Queensland. As of March 2021, when this review was proposed, 10 cases of CMDLD had been reported to the NSW Resources Regulator, as specified in schedule 1 of the *Workers' Compensation (Dust Diseases) Act 1942*. The review team was tasked with determining whether the health assessment performed under the Coal Services Health (CS Health) surveillance scheme for coal workers is adequately designed and implemented to most effectively detect health conditions among NSW coal workers, with a particular focus on occupational dust lung disease.

Main recommendations

In this report, the review team provide a total of 16 recommendations. The following are, in the opinion of the review team, of primary importance:

- **Recommendation 2:** CS Health should develop clear formal guidelines for the management of abnormal findings on spirometry and chest x-rays, or workers with significant symptoms. This documentation should include clearly stated criteria for determining which workers are to be evaluated further for dust diseases, as opposed to non-occupational diseases by the worker's own treating medical providers.
- **Recommendation 3:** All cases of CMDLD, including emphysema and chronic bronchitis, should be made reportable to the relevant regulatory bodies, in the same manner as coal workers' pneumoconiosis (CWP) or silicosis. This will accurately reflect the spectrum of lung disease attributable to coal mine dust exposure, and allow the regulator to have an accurate understanding of the prevalence and morbidity resulting from CMDLD in NSW and would improve oversight of the health surveillance scheme.
- **Recommendation 4:** CS Health should record occupational exposure data in a more detailed and structured format, with data including years of coal mine employment, work setting, and other measures of exposure.
- **Recommendation 5:** CS Health should require that all chest x-rays taken as part of health surveillance are classified by certified B Readers given the now large number of radiologists holding this certification in Australia.
- **Recommendation 6:** The review team recommend the use of the dual read protocol for the classification of chest x-rays taken as part of health surveillance.

- **Recommendation 9:** Given the large number of cases with abnormal spirometry and few cases of lung disease attributed at least in part to coal mine dust exposure, a detailed external review of these cases is strongly recommended. It is the recommendation of the review team that such a review include all cases in which the forced expiratory volume in one second (FEV_1) was less than 70% predicted and include detailed work history with assessment of level of coal mine dust exposure, history of tobacco smoking and other exposures, and other lung disease.
- **Recommendation 11:** An external review should be commissioned of cases referred for respiratory physician evaluation, given the evidence that some respiratory physicians who provide consultations for CS Health appear unaware of the relationship between coal mine dust exposure and obstructive lung disease and lung function decline.
- **Recommendation 13:** CS Health should have access to all records and studies resulting from investigations initiated by CS Health, including those ordered by respiratory physicians, to the extent permissible by law.
- **Recommendation 14:** Establish formal criteria to return workers with early CMDLD or other non-occupational lung diseases to work, or removal from exposure for those with more advanced disease.

Overall conclusions

CS Health has a robust system of medical surveillance of coal mine workers. They have made considerable improvements since the re-identification of black lung in Australia in 2015. There is, however, room for significant improvements in their protocols for data collection, chest imaging, and spirometry. In addition, clear training on the spectrum of CMDLD should be provided to CS Health, External Doctor Network, and respiratory specialist providers.

Introduction

Background

The University of Illinois School of Public Health was engaged by the NSW Government (Department of Regional NSW) to undertake an independent quality assurance review of the NSW Health Surveillance Scheme for Coal Mine Workers. The independent review was a recommendation of, and overseen by, the NSW Mine Safety Advisory Council.

Coal mine workers are exposed to a range of respiratory hazards in the mine atmosphere, including not only coal dust, but also silica, silicates such mica and kaolin, volatile compounds, and diesel exhaust particulate. In some workers, these exposures, collectively comprising coal mine dust, may cause coal mine dust lung disease (CMDLD), a spectrum of chronic lung diseases resulting from cumulative exposure to these respiratory hazards. CMDLD includes not only the "classic" pneumoconioses of coal workers' pneumoconiosis (CWP), mixed-dust pneumoconiosis, and silicosis, but also obstructive lung diseases including emphysema and chronic bronchitis; lung function decline; and pulmonary fibrosis, known as dust-related diffuse fibrosis.

Medical surveillance for CMDLD, part of secondary prevention programs, is essential to detect early disease and provide the opportunity to mitigate exposures or remove more severely affected workers from the mine atmosphere. It also provides essential feedback to industry to identify where primary prevention is failing. Tests used in medical surveillance are directed at the varied manifestations of the disease. For example, chest imaging is most useful for detecting the opacities that represent the scars of CWP, while spirometry is better suited for detecting abnormalities of lung function that occur with emphysema or chronic bronchitis. Coal mine workers have differing susceptibility to coal mine dust and may present with varied severity and patterns of disease.[1] For example, a worker may present with CWP and normal spirometry, or another worker with severe coal mine dust-related emphysema and no radiographic evidence of CWP. Therefore, a health surveillance scheme must have excellent chest imaging and lung function testing to adequately detect the early changes of CMDLD.

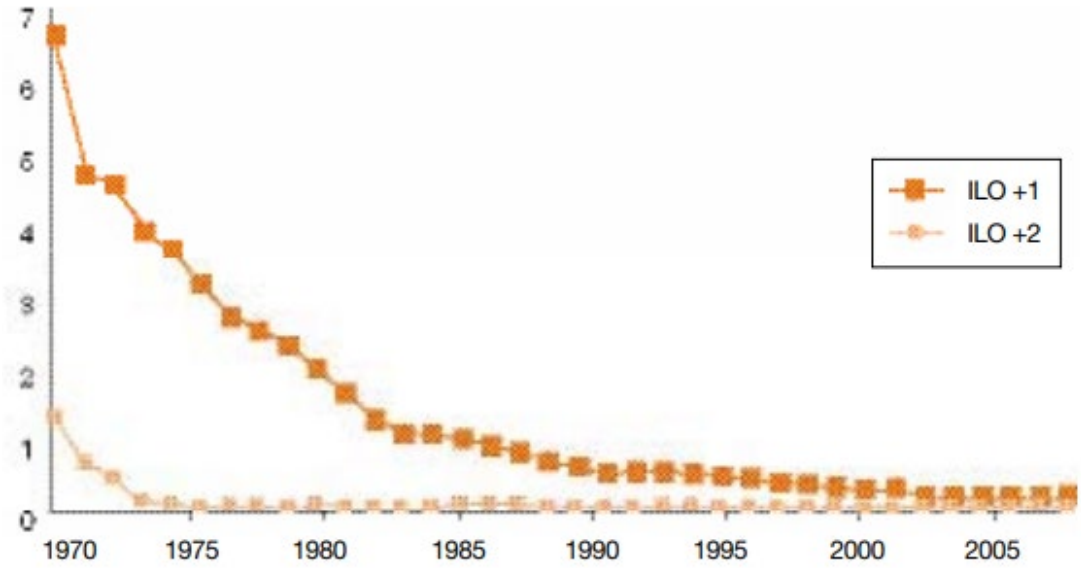
The NSW health surveillance scheme for coal mine workers is designed to support secondary prevention of disease as described above. In addition, it provides useful information to determine fitness for work. However, because the abnormalities identified on chest x-ray and spirometry may be nonspecific and have non-occupational causes, careful consideration of medical, avocational, and occupational histories may provide alternate explanations for abnormal findings. This is especially important when there are two or more confounding exposures, such as a tobacco-smoking coal mine worker with emphysema. Thus, in addition to assuring the capability to detect early abnormalities associated with CMDLD, a process to determine the relative contributions of any abnormalities must be methodologically sound.

NSW coal mine workers are required, under the Coal Services Health Monitoring Requirements for Coal Mine Workers Order No. 43, to undergo medical assessments by approved medical providers prior to commencing work at a coal mine, and at least every three years. The parts of

the health assessment relevant to the early detection of CMDLD include the medical history, physical examination, spirometry to assess lung function, and a chest x-ray with appropriate classifications. Pre-placement medical assessments may be performed by approved medical practitioners, while periodic medical assessments may be carried out by an approved medical practitioner or a registered nurse supervised by an approved medical practitioner. In addition, exit medical assessments are offered to coal mine workers who are retiring or leaving the industry.

As of March 2021, when this review was proposed, 10 cases of CMDLD had been reported to the NSW Resources Regulator, as specified in schedule 1 of the *Workers' Compensation (Dust Diseases) Act 1942*. Prior to this, there had been a marked decline in the reported prevalence of pneumoconiosis in NSW surface and underground coal mine workers (Figure 1), with prevalence rate reported to be "less than 0.5%".[2] According to Coal Services' 2015 Annual Report, there had been no new cases of pneumoconiosis "for decades."[3] CMDLD was re-identified in Australia beginning in 2015, in the Queensland coal mining industry, which prompted review of health surveillance procedures within Queensland, as well as in NSW. As part of continued efforts to identify avenues for improvement in the detection of dust disease, this review was commissioned.

Figure 1 – Prevalence rate of pneumoconiosis among New South Wales coal industry employees, 1970-2008 (Source: Coal Services Annual Report 2007/08)



Coal mining in New South Wales

As of the end of 2021, there were 40 coal mines in operation in the state of New South Wales, 22 open cut mines and 18 underground mines.[4] These 40 mines directly employed a total of 14,195 coal mine workers (source: CS Health). Table 1 shows employment data for NSW coal mines by type of mine, along with data on numbers of mine workers and administrative employees based

on active workers' compensation policies. In fiscal year 2022, there were 37,766 mine workers, including 7,309 underground and 13,292 open cut workers.

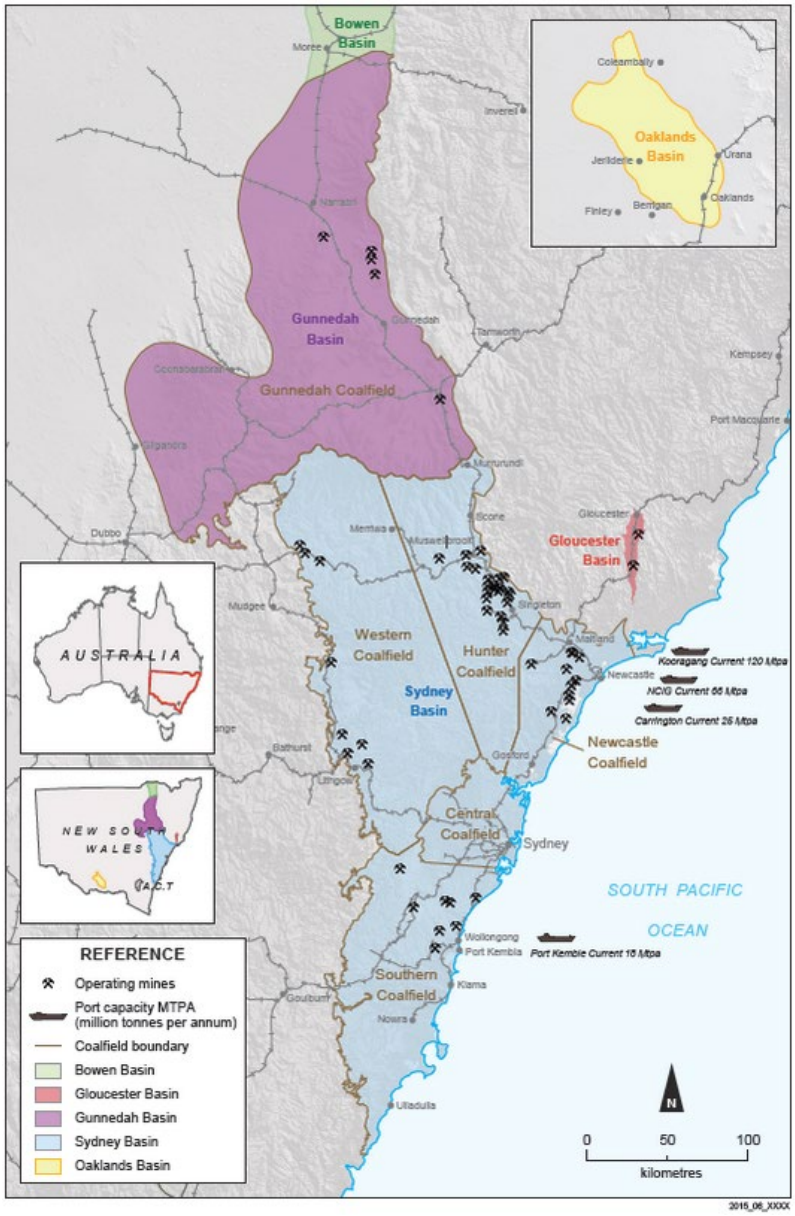
Table 1- New South Wales coal mine employment data, fiscal years 2021-2022. (Source: CS Health)

	Number of Employees		% of Total Employees	
Activity Area	**FY21**	**FY22E**	**FY21**	**FY22E**
Underground Mine	**6,989**	**7,309**	**19.66%**	**19.35%**
Open Cut Mine	**13,279**	**13,292**	**37.35%**	**35.20%**
Operational Mining Services	**10,024**	**11,669**	**28.19%**	**30.90%**
Onsite	8,924	10,253	**25.10%**	**27.15%**
Offsite	1,100	1,416	**3.09%**	**3.75%**
Administration	**5,261**	**5,496**	**14.80%**	**14.55%**
Onsite	3,552	3,747	**9.99%**	**9.92%**
Offsite	1,709	1,750	**4.81%**	**4.63%**
Total	**35,553**	**37,766**		

Employee numbers (ETR) are based on active workers' compensation policies as at July 2022, all numbers are rounded and some calculations may not replicate exactly.

Major coal deposits in NSW range in rank from bituminous metallurgical and thermal coals to sub-bituminous thermal coals. The major coal resources are located in the Sydney-Gunnedah Basin, with minor resources in the Gloucester and Oaklands Basins[5] (Figure 2).

Figure 2 – New South Wales coalfields. (Source: NSW Resources Regulator)



Exposure limits and risk of pneumoconiosis

The risk of CMDLD is related to cumulative coal mine dust exposure. Therefore, limits on workplace exposure play a critical role in the prevention of CMDLD. Per the NSW *Work Health and Safety (Mines) Regulation 2014*, mine operators are, as far as is reasonably practicable, to minimise the exposures of mine workers to dust. The workplace exposure standard (WES) for respirable coal dust in New South Wales was 2.5 mg/m³ until 1 February 2021, when it was decreased to 1.5 mg/m³.[6] The Australian WES for respirable coal dust containing less than 5% quartz was 3 mg/m³ until 1 October 2022,[7] when it decreased to 1.5 mg/m³.[8] SafeWork Australia

and New South Wales have the same WES for respirable crystalline silica of 0.05 mg/m³. Additionally, New South Wales enacted an exposure standard for diesel particulate matter of 0.10 mg/m³, which began on 1 February 2021.

Objective of the Review

The review team was tasked with determining whether the health assessment performed under the Coal Services Health (CS Health) surveillance scheme for coal workers is adequately designed and implemented to detect health conditions most effectively among NSW coal workers, with a particular focus on occupational dust lung disease. In conjunction with the review, the review team was asked to recommend any necessary changes to improve the scheme. The full scope of the review is included in Appendix A. Sources of information are listed in Appendix B.

Of note, several issues were raised in written and verbal submissions which were outside the scope of this review. These included concerns with the model and structure of Coal Services, timeliness of provision of services, methods and timeliness of communication between CS Health and its clients and industry, and governance of the External Doctor Network, among others. The review team recommends that these be addressed in ongoing tripartite meetings such as the NSW Mine Safety Advisory Council.

Ethics Approval and Data Security

Ethics approval for the review was granted by the University of Illinois Chicago Institutional Review Board.

To protect the health-related information evaluated during the review, all records were de-identified. CS Health accessed and extracted health data for this review from their records. These data were de-identified through redaction or encoding of identifiers including the name, address, and birth date. The de-identified data were sent to the University of Illinois Chicago via password-protected file transfer. At no time did the UIC review team have access to personal identifiers or identifiable medical data. Access to the de-identified data was limited to the review team.

History of Health Surveillance for NSW Coal Mine Workers

Health surveillance for coal mine workers in NSW began with the formation of the Joint Coal Board (JCB) in 1947, which resulted from the Royal Commission into Health and Safety of 1939, which recommended a minimum dust concentration standard. The JCB established medical bureaus in each major NSW coal region and began medical examinations of exposed

workers, as well as promoting dust controls. Industry circulars issued by JCB provided guidance to industry on health screening requirements, but attendance was poor.

A decision by the Commonwealth Government to repeal the Commonwealth's *Coal Industry Act 1946* led to the dissolution of the JCB. The *Coal Industry Act 2001* was enacted on 1 January 2001 and created Coal Services Pty Limited to assume the functions formerly performed by the JCB. Coal Services is an independent organisation owned jointly by two shareholders, the NSW Minerals Council (NSWMC) and the Mining and Energy Union (MEU). The board of Coal Services is comprised of two representatives each from NSWMC and MEU, two independent representatives, and an independent Managing Director/CEO.

Coal Services has statutory functions directed by the *Coal Industry Act 2001*, including occupational health and rehabilitation services, the provision of workers' compensation, collection of statistics related to the coal industry, monitoring dust in coal mines, mines rescue emergency services, and provision of training for the NSW coal industry.

In 2009, only 60% of coal mine workers attended health surveillance. Order 41, which was drafted by Coal Services in consultation with stakeholders and approved by the Minister in February 2011, made pre-placement and periodic health assessments compulsory for coal mine workers. In addition, Order 41 set forth minimum qualifications for health professionals conducting health assessments; set minimum guidelines for medical assessments; required all medical data to be reported to CS Health for inclusion in the coal industry health database; ensured that coal mine workers are provided with appropriate time to attend medicals; and remove the requirement that CS Health provide all medical services.

In response to emerging evidence of pneumoconiosis in Queensland in 2015, CS Health commissioned an independent review of chest x-ray imaging beginning in 2016. A sample of approximately 5% of periodic chest x-rays completed since 2012, a total of 320 x-rays, were reviewed by one radiologist. It was concluded that there were no missed cases of coal workers' pneumoconiosis and no missed or unreported abnormalities. The investigating radiologist disagreed with the original x-ray report in some instances, in which he felt that the original identified abnormalities were either not present or less significant than originally suggested. After this review, CS Health began a quarterly audit of 5% of x-rays performed each quarter.

In 2017, CS Health proposed changes to Order 41 that were enacted in 2018 as Order 43. Order 43 included a requirement that all x-rays be classified according to the ILO system by an approved radiologist and increased the frequency of chest x-ray screening for underground and at-risk surface coal mine workers. In January 2021, the Board of Coal Services approved beginning consultation with industry on possible changes to Order 43.

Medical Assessment Forms

The review team evaluated the content and design of the medical assessment forms used for pre-placement and periodic examinations. Prior to the examinations, the prospective or current coal mine worker completes a client medical pre-questionnaire. Information collected includes:

- Work history, including employer, field of occupation including details such as coal mine work setting, job title, and dates of employment;
- Current and prior workers' compensation claims;
- Medical history, including questions about prior diagnosis of heart disease, high blood pressure, diabetes, emphysema, and sleep apnoea;
- Symptoms such as chest pain, musculoskeletal complaints, headaches, and dizziness;
- Difficulties with specific movements or tasks; and
- An assessment for excessive sleepiness.

The pre-placement health assessment forms incorporate the information provided by the coal mine worker in the client medical pre-questionnaire. In addition, the health assessment form includes sections on

- Medications;
- Allergies;
- Clinical findings including
    - Anthropometric measurements of height, weight, hip and waist circumference,
    - Blood pressure and heart rate,
    - Lipid and glucose measurements,
    - Urinalysis,
    - Vision testing;
- Cardiovascular assessment including risk assessment;
- Audiometry and questioning related to noise exposure;
- A respiratory questionnaire including questions about shortness of breath, wheezing, cough, phlegm, respiratory illnesses, and tobacco smoking;
- Spirometry with
    - Pre-bronchodilator forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC,
    - Predicted values,
    - Lower level of normal,
    - Identified pattern, i.e., normal, obstructed, restricted, or mixed,
    - Post-bronchodilator FEV_1, FVC, and FEV_1/FVC, if required;
- Respiratory system review with determination of normal versus abnormal respiratory rate, breath sounds and chest examination;
- chest x-ray findings;
- Nervous system evaluation;
- Musculoskeletal evaluation;

- Abdomen & skin evaluation;
- Health review section with determination of fitness for proposed/current role and recommendations for review and any restrictions;
- Respiratory fit testing; and
- Hearing protection fit testing.

There are selected differences between the pre-placement and periodic medical assessment forms. In addition to the above, the periodic health assessment form for nurses and doctors includes

- Hazard exposure assessment, including coal, silica and asbestos dusts;
- Use of personal protective equipment;
- Alcohol use;
- Psychological health assessment; and
- Physical exercise frequency.

The periodic medical assessment form excludes the sections on respiratory system review and hearing protection fit testing found in the pre-placement form.

The manual completion version of the pre-placement and periodic medical assessment forms are 17 and 20 pages in length, respectively. From the standpoint of dust diseases, the included requested information in these forms is sufficient to prompt the coal mine worker and medical practitioner to consider abnormal respiratory symptoms, relevant prior history, and risk factors for development of coal mine dust lung disease.

One small but potentially useful detail to consider including in the spirometry section of the medical assessment forms is an indication of the spirometry reference values used in determining the predicted normal and lower level of normal values for FEV_1, FVC, and FEV_1/FVC. This could be particularly useful for spirometry tests in which the Global Lung Function Initiative (GLI) reference equations were not used to determine these predicted reference values, or if the reference equations used are not known. (Further discussion of reference equations for spirometry is found in the "Spirometry Review" section.)

Another area for potential improvement is within the work history section. Here, there is only space for three entries for employer and job information. Many coal mine workers have held more than three job positions, and so the form may be leading to incomplete assessment of the risk of dust exposure. As CMDLD is the result of cumulative coal mine dust exposure, incomplete information may therefore result in underappreciation of the risk of disease. Although there is space to record additional information in the "Work History comments" subsection, the review team recommend a more structured approach to collecting this information, at least with additional space for description of prior jobs held in the pre-placement medical assessment form, and a place to summarise the estimated number of years of coal mine employment to date in the pre-placement and periodic medical assessment forms.

Recommendation

- **Recommendation 1:** The medical assessment forms should be modified to better document the work history, at least at time of pre-placement evaluation, with a more comprehensive listing of prior jobs held by the prospective coal mine worker. For both pre-placement and periodic medical assessment forms, there should preferably be a summary of years of prior coal mine employment.

Doctors – Training, Expertise, and Accreditation

There are two groups of doctors who perform Order 43 health assessments for NSW coal mine workers. The first group are doctors directly employed by CS Health, who perform health assessments at CS Health clinics. The second group of doctors comprise the External Doctor Network (EDN) and are CS Health-accredited providers who evaluate workers in their own facilities.

Internally employed CS Health doctors are required to have unrestricted medical registrations with the Australian Health Practitioner Regulation Agency (AHPRA), with desired expertise in occupational medicine. They are required to undergo a one-day face-to-face industry induction course, which includes content on dust diseases, surface and underground mining techniques, personal protective equipment, and workplace safety. The course concludes with case studies and an assessment test. CS Health doctors are also required to complete an approved spirometry training program and participate in continuing education through in-services and annual refreshers. As of December 2021, there were 16 CS Health medical officers.

Order 43 health assessments may also be performed by CS Health-accredited external provider clinics. Doctors at these clinics, like CS Health medical officers, must have an unrestricted medical registration with the AHPRA. They must also complete an induction course, although supervising doctors registered with Respiratory Safety and Health Queensland are permitted to complete an online module rather than face-to-face induction training. External doctors must also undergo approved spirometry training and annual refresher and webinar.

Medical practitioners participating in the EDN are also required to complete a minimum of 25 Order 43 health assessments per calendar year. The accreditation of external doctors is reviewed by CS Health yearly, and includes audit of their AHPRA registration, review of Order 43 health assessments, and review of training with external training providers.

Assessment

CS Health has well organized training and maintenance of education programs for their providers. Efforts should continue to maintain consistency of approach by both CS Health and EDN providers.

Clinical Pathways Guideline

Health surveillance screening for occupational lung disease results in the identification of radiographic, physiologic, and other abnormalities of varying severity. A formalised framework for addressing these abnormalities is useful to determine which workers require more intensive or frequent monitoring, and which workers should be reassigned to lower dust positions or even be recommended for removal from additional dust exposure entirely.

In response to the re-identification of mine dust lung disease, the Queensland Department of Natural Resources, Mines and Energy in 2017 adopted the Clinical Pathways Guideline (CPG) for their Coal Mine Workers' Health Scheme (CMWHS). Its purpose was to provide guidance to the appropriate medical specialists regarding the management of abnormal findings from medical surveillance exams performed as part of the CMWHS. This included recommendations for repeat testing, follow-up investigations, and referral to appropriate medical specialists. CS Health adapted this guideline for use within the health surveillance scheme for coal workers in NSW. CS Health describes their use of the Queensland CPG as "a guide to appropriate practice to be followed subject to clinical judgment and patient preferences." (Personal communication with CS Health)

The CPG, as adapted and applied by CS Health, is illustrated in Figure 3. In communications with CS Health, the review team was provided the following additional clarifications of their modifications of the Queensland CPG:

Spirometry

- Normal FEV_1, FVC, and FEV_1/FVC, and no accelerated longitudinal decline: No further immediate action. The worker is considered fit for work, and review as a routine assessment is planned in three years.
- FEV_1 or FVC below the lower limit of normal (LLN) but also greater than 70% predicted by GLI: Repeat spirometry in 12 months.
- FEV_1/FVC is below the LLN and a new change: Worker is referred to their general practitioner to test for bronchodilator reversibility. Follow-up spirometry and review with CS Health in 3-12 months.
- FEV_1 or FVC < 70% predicted by GLI, or longitudinal decline of FEV_1 or FVC of more than 15% of predicted GLI: An investigation of the entire case file and supporting documentation is performed to see if a referral is indicated. After discussion at the level of CS Health Senior Medical Officer or Head of Medicine, cases without adequate explanations for detected abnormalities are referred to respiratory physicians for investigation.

Chest x-ray

- Small opacity profusion score of 0/- or 0/0: No further immediate action required.
- Small opacities of profusion 0/1: chest x-ray is referred to a second reader for additional classification.

- Small opacities of profusion greater than 0/1 (i.e., at least 1/0) on first or second read: The worker is referred for high-resolution CT scan (HRCT).
- The referral pathway following the HRCT, per CS Health, "depends on the outcome of the HRCT."

Per CS Health, an individual with symptoms or a report indicating a respiratory abnormality undergoes a full review of their case file and any supporting documentation by a CS Health doctor. Review team feedback on the management of spirometry and chest x-ray abnormalities is discussed in detail below in the corresponding sections of this report.

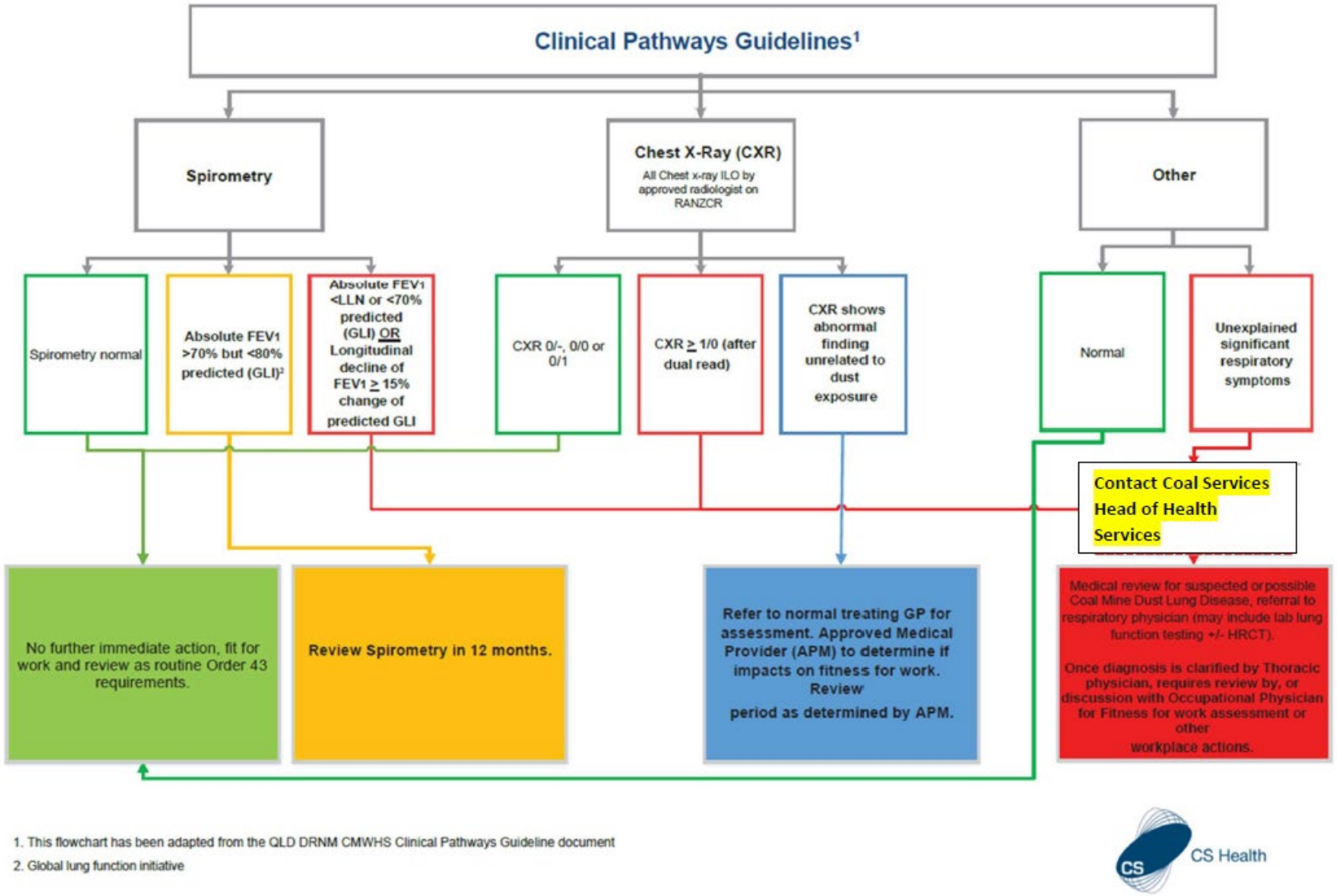
The review team notes that, in contrast to the many other CS Health documents provided for review, the documents relating to the CS Health's adaptation of the CPG appear to be informal. The CS Health adaptation of the Queensland CPG is presented to doctors undergoing industry induction, and additional information about the CPG was provided to the review team by CS Health in response to specific questions. However, it appears no document describing formally established procedures exists. Instead, the CS Health CPG was presented to the review team as a series of "CS Health process variations" that differ from the Queensland CPG.

The review team recognises that the Queensland CPG is a useful starting point for CS Health's approach to the management of abnormal health assessment findings. However, they have made significant modifications to this process which are only informally documented and therefore unlikely to have been uniformly understood by CS Health physicians. The management of these abnormalities is critical and therefore it is essential that the CS Health process be clearly and formally documented. This document should also include explicit criteria to be used by CS Health in determining which workers are referred for respiratory physician evaluation for possible CMDLD, as opposed to follow up by general practitioners for non-occupational disease.

Recommendation

- **Recommendation 2:** CS Health should develop clear formal guidelines for the management of abnormal findings on spirometry and chest x-rays, or workers with significant symptoms. This documentation should include clearly stated criteria for determining which workers are to be evaluated further for dust diseases, as opposed to non-occupational diseases by the worker's own treating medical providers.

Figure 3–- CS Health Clinical Pathways Guideline. (Source: CS Health)



Confirmed Cases of Coal Mine Dust Lung Disease

The review team proposed to interview current or former coal mine workers with coal mine dust lung disease who were willing through stakeholders. The review team made clear that we would take every measure available to ensure confidentiality and limit the disclosure of potentially sensitive information. After multiple attempts, no individual with CMDLD agreed to be interviewed by the review team. The review team did receive information about an individual with lung cancer, and this case is discussed in the "Special Case Review" section (Page 44) of this report.

Another of the review team's originally proposed tasks for this review was to interview the coal mine workers in ten cases in which pneumoconiosis had been identified and reported to the NSW Resources Regulator for further investigation. After the review team was engaged to perform the review, NSW Resources Regulator contacted the ten individuals for permission for the review team to interview and evaluate medical data. None of the ten individuals accepted this offer.

In these 10 cases, NSW Resources Regulator previously completed investigations of schedule 1 dust diseases from *Workers' Compensation (Dust Diseases) Act 1942*.[9] Reportable diseases are:

Aluminosis
Asbestosis
Asbestos-induced carcinoma
Asbestos-related pleural diseases
Bagassosis
Berylliosis
Byssinosis
Coal dust pneumoconiosis
Farmers' lung
Hard metal pneumoconiosis
Mesothelioma
Silicosis
Silico-tuberculosis
Talcosis

The two most relevant reportable diseases for this review are coal dust pneumoconiosis (i.e., coal workers' pneumoconiosis) and silicosis. We have compiled a summary of the completed investigations from publicly available information as reported by NSW Resources Regulator in Appendix C. Between December 2016 and May 2021, 14 cases were reported to NSW Resources Regulator and investigated. The review team were unable to further confirm which 10 of these cases comprised the selected group of cases, although it is noted that three of the 14 investigated cases were determined by NSW Resources Regulator not to have lung disease due to dust exposure in NSW coal mine workplaces, and not all cases were attributed to coal mining. All

individuals comprising the reported cases were male, with ages ranging from their early 40s to late 80s.

After the rediscovery of CMDLD in Queensland in 2015, Coal Services volunteered to report cases of CWP and silicosis to the NSW Resources Regulator. In 2018, the Minister for Resources formally requested that Coal Services report confirmed cases of CWP or silicosis. In 2020, the Deputy Premier advised Coal Services that notification requirements were changing. In 2021 this was clarified, such that only dust diseases listed in Schedule 1 of the *Workers' Compensation (Dust Diseases) Act 1942* are reported.

The review team observe that, under the legislation *Workers' Compensation (Dust Diseases) Act 1942*, NSW Resources Regulator would not be tasked with investigating cases of other lung diseases thought to be related to coal mine dust exposure, including COPD, emphysema, chronic bronchitis, and dust-related diffuse fibrosis. The review team recommend that these manifestations of coal mine dust lung disease should be reported as well to improve oversight of the health surveillance scheme and the understanding of the prevalence of CMDLD in NSW.

Recommendation

- **Recommendation 3:** All cases of CMDLD, including emphysema and chronic bronchitis, should be made reportable to the relevant regulatory bodies, in the same manner as CWP or silicosis. This will accurately reflect the spectrum of lung disease attributable to coal mine dust exposure, and allow the regulator to have an accurate understanding of the prevalence and morbidity resulting from CMDLD in NSW and would improve oversight of the health surveillance scheme.

Chest X-Ray Review

Background

In NSW, underground coal mine workers and surface coal mine workers involved in production, processing or maintenance tasks undergo chest x-rays every 3 years, or a shorter interval if recommended in the worker's last medical assessment report. All other coal mine workers undergo chest x-rays every 6 years. Radiologists who evaluate chest x-rays for the presence of pneumoconiosis must be registered as a medical practitioner in Australia and hold a specialist registration as a Fellow of the Royal Australian and New Zealand College of Radiologists and must also be listed on the Coal Workers Pneumoconiosis Register held by the Royal Australian and New Zealand College of Radiologists. Most, but not all, radiologists reporting on x-rays ordered by CS Health are B Readers, a special certification administered by the US National Institute for Occupational Safety and Health (NIOSH) which requires successful completion of an examination of the provider's skill in classifying chest radiographs for pneumoconiosis. The B Reader certification is not a requirement for radiologist evaluating x-rays performed as part of EDN examinations.

Within the NSW health surveillance scheme for coal mine workers, the International Labour Office (ILO) International Classification of Radiographs of Pneumoconiosis[10] is required in evaluating coal mine worker chest x-rays. In this system, the coal mine worker's posteroanterior chest x-ray is classified for the presence and severity of radiographic features of pneumoconiosis, including small opacities (less than or equal to 10 mm) and large opacities (greater than 10 mm). This is achieved through direct comparison of the subject's chest x-ray to standard radiographs provided by the ILO. In the case of small opacities, a profusion score is chosen by the reader of the chest x-ray, indicating the abundance of small opacities in the affected parts of the lungs (Table 2). The profusion scores 0/-, 0/0, and 0/1 are characterised as being "negative" for small opacities of pneumoconiosis, while a score of 1/0 or greater indicates the presence of small opacities. A chest x-ray with profusion score 1/0 or greater is not, by itself, diagnostic of pneumoconiosis, but rather must be taken in the context of other data, including occupational exposure history.

Table 2 - ILO Classification of small opacities (less than or equal to 10 mm)

ILO Major Profusion Category	ILO Minor Profusion Category	Classification of pneumoconiosis
Category 0	0/-	Negative
	0/0	
	0/1	
Category 1	1/0	Simple
	1/1	
	1/2	
Category 2	2/1	
	2/2	
	2/3	
Category 3	3/2	
	3/3	
	3/+	

In the NSW health surveillance scheme, each chest x-ray is assigned to one radiologist for ILO classification. If that radiologist finds a profusion of small opacities that is borderline negative (i.e., 0/1), then the chest x-ray is sent to a second radiologist, who was historically not required to be a certified B Reader. This second radiologist also provides an ILO classification of the chest x-ray, and CS Health uses the small opacity profusion from this second classification as the final result. Coal mine workers whose first or second chest x-ray shows small opacity profusion 1/0 or greater are referred for high-resolution CT (HRCT) scan.

Table 3 shows the data for ILO small opacity profusion scores from chest x-rays performed from 2017 through late 2021. Note that these data are for chest x-rays, and not for unique miners, some of whom may have had more than one chest x-ray during the observation period. During this time period, 347 (0.5%) of chest x-rays were classified as having small opacities of 1/0 profusion or greater. In February 2022, CS Health presented data on chest imaging surveillance

to the NSW Standing Dust Committee, reporting that 172 (1.0%) of the 17,322 chest x-rays performed in all of 2021 had an ILO small opacity profusion of 1/0 or greater. These coal mine workers were all referred for HRCT, and those thought to have changes consistent with CMDLD were referred to respiratory physicians for further evaluation.

Table 3 - ILO small opacity profusion scores for chest x-rays performed 2017 through late 2021 (Source: CS Health)

Pneumoconiosis grade	Number
0/-	48
0/0	68000
0/1	608
1/0	195
1/2	24
2/1	11
2/2	10
2/3	4
3/2	1
3/3	5
3/+	0
Total	**69003**

Note: The above excludes one case in which profusion was characterised as "2/0", which is not a valid classification for profusion score within the ILO system.

Methods

The purpose of this section of the review was to evaluate the quality of the chest imaging component of the health surveillance scheme. Failure to provide a high-quality program could result in missed cases of early CWP. The review of chest x-rays acquired in 2021 and associated radiologist reports was divided into two parts. In the first part, the review team evaluated chest x-rays from a sample of 100 miners which had been classified as normal, with no evidence of pneumoconiosis. This would allow us to detect false negative classifications within the limitations of an extremely small sample size. (Note: We would need a sample of about 600 chest x-rays to have a 95% chance of detecting one false negative assuming 80% sensitivity and 50% specificity for plain chest radiography.)[11] The chest x-rays were evaluated for quality and degree of agreement with the original findings. In the second part, the review team evaluated a sample of chest x-rays that had been found to have small opacities suggestive of pneumoconiosis, as well as chest x-rays that had been performed on individuals who were referred for respiratory physician evaluation for CMDLD. These chest x-rays were also evaluated for quality and degree of agreement with the original findings. This would allow us to evaluate false positive classifications.

Case selection

The review team was provided with a de-identified list of coal mine workers with normal chest x-ray and spirometry results from their 2021 examinations for the health surveillance scheme. The review team attempted to enrich the sample by restricting our cases to those miners with at least 20 years of underground experience, and therefore an increased likelihood of having a positive finding. CS Health datasets had incomplete data on mining tenure (see comments on this below), which forced the review team to select coal mine workers whose first health assessment and most recent health assessment were at least 30 years apart and whose most recent employment was recorded as underground mining. Workers whose most recent health assessment were exit or retired mine worker examinations were excluded from this analysis. Individual cases were then selected at random by the review team, and CS Health provided the de-identified records for each selected case, including chest x-ray image.

In addition to the 100 cases with normal chest x-ray classifications, the review team evaluated a sample of cases from 2021 classified as abnormal and possibly consistent with pneumoconiosis. De-identified chest x-ray images for these cases were provided by CS Health, where available.

Chest radiograph classification

De-identified copies of digital chest x-ray images were provided by CS Health. Each chest x-ray was classified initially by two NIOSH-certified B Readers blinded to the history of the case and prior radiologist classification, with the exception of knowing that the chest x-ray was from a coal mine worker. B Readers classified each chest x-ray using the International Labour Office (ILO) international classification of radiographs of pneumoconioses.[10] This system is used to identify and characterise radiographic opacities consistent with pneumoconiosis using comparison to standard chest radiographs.

In the ILO system, chest radiographs are provided with ratings of quality. Each B Reader rated the quality of the chest radiographs they classified as follows:

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

Large opacities, pleural abnormalities, and other radiographic abnormalities are also characterised using the ILO system. Large opacities (greater than 10 mm) consistent with pneumoconiosis is classified as complicated pneumoconiosis.

Two NIOSH-certified B Readers classified all images. Additional B Readers were employed when the initial two readers did not agree. The following is a list of B Readers participating in the review:

1. Robert Cohen, MD – Respiratory physician, B Reader.

2. Kathleen DePonte, MD – Radiologist, B Reader.
3. Robert Tallaksen, MD – Radiologist, B Reader.
4. William Clapp, MD – Respiratory physician, B Reader.
5. Jonathan Chung, MD – Radiologist, B Reader.

The process of classification of small and large opacity (presence and profusion) and reaching a final determination was as follows:

1. Two classifications were considered to be in agreement if one of the following occurred:
    a. Both found one or more large opacities greater than 10 mm in size consistent with complicated pneumoconiosis (category A, B, or C);
    b. Both found small opacities of less than or equal to 10 mm 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 profusion category of each other, in this instance the higher minor category is selected (see ILO classification 12-point scale, Table 4) except if there was a reading sequence of [0/1, 1/0] or [1/0, 0/1], which was not considered agreement; or,
    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.

We compared the final determinations of the classifications by the review team B Readers with the original radiologist's report for agreement on the presence of small opacities and large opacities. We also evaluated the quality ratings of the chest radiographs and compiled identified technical quality issues.

Results

Normal chest x-rays

The review team sought to select 100 cases of coal mine workers with 20 or more years of underground coal mine experience from which to evaluate health assessment materials, including chest x-ray images and associated radiologist reports. Detailed occupational data, including years of coal mine employment, occupations held, and work setting (e.g., underground or open cut), were not available from CS Health in the form of a dataset. Rather, occupational data were found in individual cases' health assessment records, often as scanned copies of handwritten records. Given that the time and resources needed to select cases using tenure criteria would have been prohibitive, the review team was forced to use time between health assessments as a surrogate

for tenure. Therefore, the review team selected cases noted to have the most recent employment as underground with at least 30 years between the first and the most recent health assessments.

The review team received the de-identified health assessment data and chest imaging sent as digital image files. Occupational histories were found mostly in scanned copies of hand-written forms. These forms were of varying levels of completeness and detail. Of the cases received, 26% did not have at least 17.5 years of underground coal mine employment documented in the available records.

The review team proceeded with evaluation of the available cases while noting the limitations caused by the lack of detailed occupational data and the means to readily identify additional cases within the time constraints of the review. A total of 99 chest x-rays were classified by at least two review team B Readers. All images were found to be category 0 for small opacities and all classifications were in agreement with the original radiologist classifications. Review team B Readers classified 97 of the chest x-rays as having profusion score 0/0, and two chest x-rays as 0/1. No large opacities were detected by review team B Readers.

Abnormal chest x-rays

In 2021, CS Health reported 172 individuals with chest x-rays classified as small opacity profusion of 1/0 or greater. The review team were informed that CS Health did not have immediate access to chest x-rays performed as part of EDN examinations, but did have the chest x-rays ordered from CS Health locations. They provided the review team with 79 of these cases.

Review team B Readers re-classified these 79 chest x-rays and agreed on the presence of small opacities in 21 of the 79 cases (27%; Table 4). There was disagreement between the final determination reached by the review team and the original radiologist classification on the remaining 58 (73%) chest x-rays. Notably, the original radiologists classified these images as having small opacities of profusion 1/0 or 1/1 in 31 and 25 cases, respectively, while the review team determined that these images were negative for opacities of pneumoconiosis.

Table 4 - Small opacity profusion scores from chest x-rays found to be abnormal in 2021

Original radiologist determination	Number	Review team B Read	Number
1/0	38	Category 0	31
		Category 1	7
1/1	31	Category 0	25
1/2	3	Category 0	1
		Category 1	2
2/1	2	Category 0	1
		Category 1	1
2/2	3	Category 2	2
		Category 3	1
2/3	2	Category 1	2
Total	**79**		**79**

In two of the cases in which there was agreement on the presence of opacities consistent with pneumoconiosis, review team B Readers also found large opacities consistent with pneumoconiosis. In one of these two cases, the original radiologist also identified a large opacity, but not in the other case. In both cases, subsequent tissue biopsy reportedly demonstrated granulomas, with diagnoses of sarcoidosis in both individuals.

In 26 cases, the original chest x-ray profusion classification reflected the findings of a second reading radiologist after the first radiologist identified opacities of profusion 0/1. We also compared the review team B Reader classifications with the classifications of the first radiologist for all cases, excluding the finding of the second radiologist for this analysis. In this comparison, there was agreement on the presence or absence of pneumoconiotic opacities on 48 of 79 cases (61%). This included agreement on the absence of significant pneumoconiotic opacities in 26 of 26 cases (100%).

Discussion

Our review did not identify a high false negative rate for the detection for radiographic opacities consistent with pneumoconiosis. However, this result should be interpreted with some caution. It is possible that the sample population was insufficiently "enriched" for long-tenured underground coal miners, who are at greater risk of pneumoconiosis. This is due in part to the lack of easily accessible occupational history data. The information held by CS Health is kept in a format that is difficult to access for analysis. Specific fields collecting data on years of coal mine employment, work setting, and other measures of exposure, could easily be added to the main data set and would permit an analysis of individual coal mine worker's risk for CMDLD and also for epidemiological analysis.

It is also probable that the target sample of 100 chest x-rays was too small to detect false negative classifications. We cannot therefore conclude with confidence that radiographic pneumoconiosis is not being missed. Given the relatively small number of cases of

pneumoconiosis that have been reported to the NSW Resources Regulator, it is possible that the overall prevalence of radiographic disease is low. However, there is uncertainty about the prevalence of disease, as it appears that CS Health is not able to systematically monitor the prevalence of radiographic abnormalities in the NSW coal mine worker population based on duration of mining tenure.

The review team's re-classification of chest x-rays originally found to be positive for possible pneumoconiosis identified a high rate of disagreement (74%). It is probable that differences in the reading tendencies of evaluators is the primary reason for this disagreement. Although the ILO system for classification of chest x-rays is designed to mitigate differences in individual reader tendencies through the comparison of the chest x-ray of interest to standard radiographs, variability in individual grading of radiographic opacities is expected. Chest x-rays performed as part of the NSW health surveillance scheme are classified by single radiologists, except cases in which the small opacity profusion is graded 0/1 (a borderline negative finding), where a second radiologist's classification is then obtained and used as the final determination. In contrast, the protocol used by the review team obtained two B Reader classifications for each chest x-ray, with additional classifications as needed to resolve substantive differences in the findings. This approach is used in the surveillance of US coal mine workers and, more recently, was adopted by Queensland's Coal Mine Workers' Health Scheme. The dual reader approach has the primary benefit of mitigating the potential bias posed by the reading tendencies of the specific radiologist selected to classify a given x-ray. Given its design, this dual reader approach is particularly useful in borderline cases, such as determining the presence or absence of opacities consistent with simple pneumoconiosis, or those of progressive massive fibrosis.

Radiologists classifying chest x-rays for the health surveillance scheme are not required to be certified B Readers, although many of the chest x-rays performed under the scheme are evaluated by B Readers. This heterogeneity of certification status among the evaluating radiologists may contribute to variability in the finding of pneumoconiotic opacities. Previous research in US coal mine worker health surveillance found that non-B Readers classify substantially more chest x-rays as having evidence of pneumoconiosis and classify higher small opacity profusion than B Readers.[12] Order 43 was enacted during a time when B Reader certification was uncommon in Australia, but the review team observe that this has changed substantially in the intervening years.

The health surveillance scheme's current procedure surrounding the management of chest x-ray profusion scores of 0/1 presents risk of bias. Because the radiologists who provide the second classification in the event of an initial 0/1 profusion score are contracted specifically to perform these second classifications, the radiologists are aware of the borderline nature of these cases. This knowledge may affect the second reader's scoring. Additionally, the current approach lends greater weight to the second reader's score, as it is the second reader whose small opacity profusion is taken as the final score and will determine whether the coal mine worker undergoes further evaluation for possible pneumoconiosis. This approach *a priori* concludes that the second reader is correct and the first reader is not, which is not likely to be consistently true. Adjudication of these images may be a better process.

In the sample of chest x-ray reports evaluated by the review team, there was substantial overlap in the original radiologists who read x-rays from internally performed versus externally performed examinations, but not complete overlap. The review team were unable to obtain copies of chest x-rays from individuals who underwent examinations via the EDN, as CS Health does not have ready access to these studies. We were therefore unable to assess the level of agreement between our team's B Readers and radiologists who classified these externally performed chest x-rays. In addition to being a limitation to this review, the lack of routine access or possession of these chest x-rays is a hindrance to CS Health's ability to fully monitor the quality of externally performed examinations.

Recommendations

- **Recommendation 4:** CS Health should record occupational exposure data in a more detailed and structured format, with data including years of coal mine employment, work setting, and other measures of exposure.
- **Recommendation 5:** CS Health should require that all chest x-rays taken as part of health surveillance are classified by certified B Readers given the now large number of radiologists holding this certification in Australia.
- **Recommendation 6:** The review team recommend the use of the dual read protocol for the classification of chest x-rays taken as part of health surveillance. Two certified B Readers would perform chest x-ray classifications, with additional B Readers as needed to resolve discordant chest x-ray classifications. All participating B Readers should be blinded to the coal mine worker's work history, other B Readers' ILO classification(s) of the chest x-ray, and whether the classification is being obtained in the context of adjudicating disagreements.
- **Recommendation 7:** Differences in the procedures surrounding chest imaging for coal mine workers who undergo examinations at CS Health locations and EDN should be eliminated. These include the lack of access to the chest x-rays performed as part of EDN examinations, as well as differences in the requirements for the pool of radiologists who classify chest x-rays.

Spirometry Review

Background

Order 43, which went into effect in July 2018, dictates that spirometry be performed as part of pre-placement, periodic, and exit medical assessments. Spirometry is carried out by an approved medical practitioner or registered nurse who has completed an approved course in spirometry. Interpretation of the spirometry is performed by an approved medical practitioner.

Spirometry testing requirements are covered in the Medical Officer Induction program, which must be completed by both internal and external medical officers prior to conducting Order 43 medical examinations. All CS Health registered nurses are expected to complete formal training

as well. Both the registered nurse and the medical practitioner are required to submit their certificates of spirometry training prior to being given the authority to conduct spirometry testing.

Spirometry is undertaken at CS Health offices, on mobile health vans, on site at certain CS Health customer facilities, and at CS Health-accredited external provider practices. Quality control measures are to be performed on spirometers, including daily calibration. External providers are audited annually by a CS Health compliance team and are expected to send electronic proof of calibration of their testing equipment. Order 43 also specifies that an Annual Calibration Statement is provided every 12 months by a doctor or associated medical practice certifying that the equipment used to perform medical assessments has been properly calibrated.

Spirometry test results are also audited. CS Health medical officers have their interpretations audited on a continuous random monthly basis by Senior Medical Officers. External Medical Practitioners have their medicals audited for compliance by the External Order 43 compliance team. Any spirometry result that is not acceptable and has not been flagged for early review is escalated for further review.

CS Health medical officers have access to repositories where they are able to access historical spirometry results. In contrast, external providers must contact CS Health to discuss potential concerns with a CS Health Senior Medical Officer; external providers do not have access to the repository of prior spirometry results.

CS Health specifies that spirometry be performed according to American Thoracic Society (ATS)/European Respiratory Society (ERS) standards. The ATS/ERS standards for spirometry were updated in 2005, and then most recently in 2019.[13,14] Per communication with CS Health, the updated 2019 standards were to be applied in the performance of spirometry beginning in November 2021. Because the normal values for lung function vary considerably based on the subject's age, sex, and height, reference equations derived from normal populations are used to predict the normal range for spirometry measurements for a given worker. There are a number of reference sets available to choose from and each provides slightly different ranges of normal values. Therefore, the prevalence of abnormal findings in a population depends in part on which set of equations is selected. In addition, the percent of reference of a particular result will also vary if different references are used. This makes it difficult to evaluate changes over time in percent of reference unless care is given to use the same set of reference equations for all measurements of an individual in longitudinal analyses. The world's major respiratory specialty societies, including the Thoracic Society of Australia and New Zealand, recommend using reference equations developed by the Global Lung Function Initiative, published in 2012[15] which were derived from a large, internationally representative pool of study participants.

The objective of this section of the review was to assess the quality of spirometry tests performed as part of the health surveillance scheme, evaluate the nature of the spirometry datasets held by CS Health, and review the management of selected cases of individuals with abnormal spirometry.

Methods

Normal spirometry exams

As described in the chest x-ray review section (Page 19), the review team sought to select 100 cases of coal mine workers with 20 or more years of underground coal mine experience who had been found to have normal spirometry tests in 2021 and no radiographic findings of pneumoconiosis. CS Health provided de-identified copies of the 2021 spirometry reports, as well as prior spirometry reports. A respiratory physician on the review team evaluated the de-identified copies of the spirometry reports for study quality. Spirometry data were also re-interpreted to confirm that the study was indeed normal.

Abnormal spirometry exams

The review team evaluated a sample of spirometry reports from cases previously characterised as abnormal during examinations performed from October 2020 to March 2021. These cases were available from assessments performed by CS Health examiners and also by EDN providers. CS Health provided separate de-identified lists of internally performed and externally performed spirometry tests to the review team. The review team ordered the lists chronologically by date of examination, randomly selected an examination from October 2020, and selected every eighth case subsequently, resulting in a sample of 50 internally performed and 50 externally performed cases. This sampling approach was selected to provide a broad sample across examination settings and during the time period of interest. The spirometry tests were also re-interpreted by the review team respiratory physician to evaluate test quality and to confirm that the test was indeed abnormal. Impairment in FEV_1 was graded according to ATS/ERS guidelines (Table 5).[16]

Table 5–- Levels of Impairment by ATS/ERS Guidelines

Impairment level	FEV_1 predicted value
Mild	≥ 70%
Moderate	60-69%
Moderately severe	50-59%
Severe	35-49%
Very severe	< 35%

Datasets

CS Health provided the review team with datasets containing abnormal spirometry results. These were then evaluated for their utility in identifying spirometric abnormalities and in identifying accelerated longitudinal decline in spirometry parameters.

Review of cases

The review team evaluated de-identified health assessment forms and testing data from a sample of cases with abnormal spirometry that had been performed between October 2020 and March 2021. The review team focused on cases meeting one of the following criteria:

1. Forced expiratory volume in 1 second (FEV_1) less than 60% predicted;
2. FEV_1 60-69% predicted in a coal mine worker most recently working at underground coal mines;
3. FEV_1 60-69% predicted in a coal mine worker most recently working at open cut coal mines and aged 55 years or greater.

Of note, the review team were able to select from internally performed cases only, as the spirometry data were not available in dataset format for the externally performed studies.

Coal mine workers in the first category (<60% predicted) were selected based on the severity of the spirometric abnormality, which is characterised as moderately severe, or worse, using ATS/ERS guidelines.[16] The workers in the second and third categories were selected if they had moderate FEV_1 impairment and likelihood of significant previous coal mine dust exposure. Some of these coal mine workers had been referred for further evaluation by a respiratory physician to provide opinion on whether the respiratory abnormalities were related to coal mine dust exposure. Where available, the spirometry reports from these later examinations were reviewed as well.

Results

Normal spirometry exams

The studies sent as part of the normal spirometry set were found to be generally of good quality, meeting ATS/ERS standards. These studies therefore had a sufficient number of "acceptable" trials without artefacts negating their validity, and "repeatable" or reproducible measured values that are consistent with maximal studies. In 4/99 cases (4%), the spirometry did not meet these acceptability and repeatability criteria. In only one of the four cases did the spirometry test appear to have been stopped prematurely, in which the coal mine worker should have been asked to continue to attempt additional forced exhalation trials. In the other three cases, spirometry testing was appropriately stopped, whether due to symptoms affecting the worker's ability to continue testing, or their having provided eight (or more) attempts.

All of the sampled tests used the GLI reference equations to determine normal ranges. Unsurprisingly, the review team found that the FEV_1, FVC, and FEV_1/FVC values measured during these spirometry exams were in the normal range. For the four spirometry tests performed with suboptimal technical quality, the results of FEV_1, FVC, and FEV_1/FVC measurements were in the normal range as well. None of the 2021 studies when compared to prior tests results from that same coal mine worker had evidence of an accelerated longitudinal decline of FEV_1, defined as decrease in percent predicted value of 15% or more. There were two cases in which measured FVC values were lower by 15% of predicted normal value or more. The determination of longitudinal decline was limited because many of the older spirometry test reports were performed on non-computerised spirometers, and did not have sufficient data with which to calculate percent predicted values.

Abnormal spirometry exams

Data from a pool of 4,534 individuals who underwent spirometry from October 2020 to March 2021 was filtered by CS Health and 863 spirometry tests with abnormal results were found. Of these, 462 were internally performed tests while 401 were performed by external providers (Table 6). Of the 863 tests, 60% were originally characterised as demonstrating obstructive defects, 32% restrictive defects, and 7% mixed obstructive and restrictive defects.

Table 6 - Patterns of spirometric abnormality among coal mine workers undergoing spirometry October 2020 to March 2021.

Examination setting	Obstructive	Restrictive	Mixed	Borderline	Total
Internal providers, excluding Hunter Valley Operations	251	141	28	7	**427**
Hunter Valley Operations (HVO)	8	22	5	0	**35**
External providers	260	112	29	0	**401**
Total	**519**	**275**	**62**	**7**	**863**

The review team selected a sample of 50 internally performed spirograms and 50 externally performed spirograms and evaluated the tests for quality. The flow-volume loop and/or volume-time curves were available for review in 99% of reviewed reports. Of the evaluated studies, 92% met ATS/ERS acceptability criteria for FEV_1, and 89% for FVC. Of spirometry tests meeting acceptability criteria for FEV_1, 98% (90/92) met repeatability criteria for FEV_1. Of spirometry tests meeting acceptability criteria for FVC, 98% (87/89) met repeatability criteria for FVC. Overall, 84% of tests met acceptability and repeatability criteria, with internally and externally performed studies having the same 84% rate of valid spirometry tests.

The coal mine workers in the sample were 93% Caucasian and 95% male. GLI was indicated as the source of the reference values for 90% of the spirometry tests evaluated. GLI was indicated as having been used for 88% of externally performed tests, and 92% of internally performed tests. Other than GLI, most frequently the reference equations of Gore, et al.[17] were used, including 8% of internally performed tests.

The FEV_1 impairment level observed in the sampled spirometry reports is summarised in Table 7. Mild FEV_1 impairment was observed most frequently, among 46% of the sample. Moderately severe impairment or worse (FEV_1 < 60% predicted) was observed in 10% of the sample of abnormal spirometry tests.

Table 7 - Level of impairment in 100 subjects with abnormal spirometry.

FEV_1 impairment level	N (%)
Mild (≥ 70%)	46 (46%)
Moderate (60-69%)	44 (44%)
Moderately severe (50-59%)	7 (7%)
Severe (35-49%)	3 (3%)

The review team observed that while tobacco smoking history and the presence or absence of non-occupational respiratory disease was typically recorded in the comments section of these spirometry reports, it was comparatively infrequent that the number of years of coal mining or other information related to occupation was reported. Only 23% of the spirometry reports had information on coal mine employment, including years of coal mine experience, mine type, or job position. In contrast, 94% of the reviewed spirometry reports (99% of external and 95% of internal studies) had dedicated parts of the report for smoking data or included smoking information in the free-text comments field.

Datasets

The review team evaluated the abnormal spirometry datasets provided by CS Health. These comprised three separate groups of test results: 1) those performed at the time of examinations by CS Health medical providers, with the exception of HVO examinations; 2) tests performed as part of HVO examinations; and 3) tests performed as part of EDN examinations. The available data variables are listed in Appendix D. We identified variability in the recording of the data depending on whether the examination was performed internally at CS Health clinics or via the EDN. Highlighted differences and other notes on the recorded data include:

1. The reference equation set used in determining predicted values was indicated only on the internal excluding HVO dataset.
2. The external provider spirometry data differed significantly from the internal data, including the recording of spirometry parameters such as FEV_1 and FVC, predicted values for these parameters. Also, the data fields relating to occupational exposure, the position description and work setting, were largely unpopulated.
3. None of the datasets appear to systematically record LLN values for FEV_1, FVC, or FEV_1/FVC ratio.
4. Three internally performed spirometry reports were indicated to have used the reference equations of Gore, et al.[17], but the corresponding data within the dataset indicated that the predicted values were based on GLI. A similar comparison could not be performed with the externally performed studies due to absence of data in the external dataset.

Of the 427 internal spirometry tests performed from October 2020 to March 2021, 85 had FEV_1 less than 70% predicted, which would prompt medical review for suspected or possible CMDLD according to the CS Health CPG (Figure 3). The review team was informed by CS Health that seven of the 85 had previously or since been referred by CS Health for respiratory physician evaluation for possible CMDLD. Only one of the seven workers had been instructed to "minimise dust exposure", although it should be noted that this worker had been diagnosed with hypersensitivity pneumonitis and not a CMDLD; no dust restrictions were recommended for the six other workers.

Review of cases

Selected cases with abnormal spirometry were further reviewed by the review team in order to evaluate their management. Cases meeting the following criteria were requested:

1. Forced expiratory volume in 1 second (FEV_1) less than 60% predicted
2. FEV_1 60-69% predicted in a coal mine worker most recently working at underground coal mines
3. FEV_1 60-69% predicted in a coal mine worker most recently working at open cut coal mines and age 55 years or greater

There were 22 cases meeting one of the above three selection criteria. Of these, five cases had $FEV_1 < 60\%$ predicted. All five were open cut coal mine workers at the time of examination. These included three cases with severe impairment (FEV_1 35-50% predicted). These three individuals had current occupations listed as labourer, plant operator, and tradesman.

Prior spirometry examinations for the 22 cases, where available, were also evaluated by the review team. With the limitation that the review team could not re-calculate percent predicted values for GLI due to incomplete information, the review team noted FEV_1 appeared to have longitudinally declined by 20% predicted or more in eight cases. This would indicate a missed opportunity to intervene before they had developed moderately severe or worse impairment.

Four of the 22 cases had been sent to a respiratory physician for further evaluation. In all four cases, the respiratory physician excluded the effect of coal mine dust on the workers' lung disease, including in two workers with over 30 years of coal mine employment. There was no mention of coal mine dust exposure as a potential contributor to the existing impairment in any of these cases. Also, there was no record of any concern regarding future exposure to coal mine dust causing worsening impairment and disease. There were also questionable interpretations of data and findings. In one case, a worker with an FEV_1 near 50% predicted was deemed by a respiratory physician to have this due to a paralysed hemidiaphragm, which would be unusual in the absence of other respiratory conditions. In another case, the FEV_1 decline in a worker was attributed to age-related changes. This explanation is impossible given that FEV_1 decline as a percent of reference is already corrected for age. This worker was a non-smoker with approximately 40 years in coal mining, mostly aboveground.

Of the 22 cases, only one individual had documented dust restrictions within the included records; this coal mine worker had a FEV_1 near 70% predicted and worked as an underground miner. There were no recorded dust restrictions in the health assessment records for other cases, including the five workers whose FEV_1 was less than 60% predicted. CS Health confirmed that none of the other 21 cases were placed under dust restrictions.

Discussion

The review team found generally good quality in the spirometry tests evaluated by the review team. There was a comparable rate of acceptable and repeatable spirometry consistent with other Australian state-operated coal mine worker health surveillance programmes.[18] This is a reassuring finding given that sub-optimal spirometry tests may yield falsely reduced measurements of FEV_1 and FVC, unnecessarily raising the spectre of early disease. A suboptimal spirometry test may also obscure the detection of subsequent accelerated lung function decline by falsely lowering the baseline values used as a reference for future

measurements. Thus, the review team encourage CS Health to continue their success in maintaining and improving spirometry quality.

The review team observed that while most reference values for spirometry parameters were determined using the recommended GLI equations, 10% of both internally and externally performed studies from our review of abnormal studies did not use GLI. There was no indication that CS Health had separately re-calculated the percent of reference using GLI for these non-GLI cases. Also of note, there was contradictory information in some cases where the CS dataset indicated GLI was used, and the original spirometry report from which that data was abstracted indicated another reference equation set. These are potential sources of error in the identification of abnormal spirometry or accelerated decline in lung function. The review team recommends that CS Health should standardize all spirometry results as percent predicted GLI and then evaluate them for the degree of impairment and the presence of accelerated longitudinal declines.

It is the opinion of the review team that several additional improvements could be made to the collection of spirometry data by CS Health. This would facilitate the detection of abnormal lung physiology among coal mine workers and importantly allow for broader epidemiologic analysis of the health of this population. Several basic measurements and demographics should be collected and added to their database. This includes variables used to determine predicted values (age, height, sex, and ethnicity), which could then easily calculate the percent of reference for all prior studies and then detect those workers who might have accelerated declines. This would also include the collection of basic spirometry measures of FEV_1, FVC, and FEV_1/FVC from externally performed spirometry studies so that these can also be used in longitudinal evaluations.

Among the 100 abnormal spirometry tests that were evaluated by the review team, 54 had FEV_1 values of less than 70% predicted, consistent with moderate impairment or worse. The review team have observed that, although over 800 abnormal spirometry tests were identified during the period October 2020 through March 2021, there appear to be comparatively few referrals to respiratory physicians to evaluate abnormal spirometry. Upon further investigation CS Health provided two reasons why so few respiratory physician referrals had been made:

1) CS Health did not refer cases that met their criteria for a diagnosis of “asthma”. Rather these cases were considered non-occupational and referred to their general practitioner. Their criteria included:
    a. Excessive variability of respiratory symptoms such as cough, wheeze or breathlessness
    b. Reversibility of spirometric measurements by at least 12% and 200 ml with salbutamol. In response to this finding, the practice of CS Health is to refer the worker for further evaluation with their general practitioner if asthma is not previously diagnosed.
2) Subjects with a new finding an obstructive pattern of impairment (a low FEV_1/FVC ratio) and no reversibility in spirometric measurements with salbutamol were generally not referred to a respiratory physician but recommended to have more frequent spirometry.

> Referral was to be considered if spirometry values continued to decline or if there were "unexplained" values below 70% predicted. There were no clear criteria for what constituted "unexplained" values.

The review team disagrees that a presumptive diagnosis of asthma can be made based on the presence of a response to bronchodilators during spirometry. These workers are then considered not to have an occupational component to their impairment and are referred to their general practitioner for treatment and further management. Many workers with COPD caused by occupational and non-occupational exposures may also have a response to bronchodilators. Obstruction observed on pulmonary function testing that persists after administration of bronchodilator such as salbutamol is strong evidence of COPD and argues against asthma. In fact, response to bronchodilators, with persisting spirometric abnormality, in patients with COPD is exceedingly common: for example, in one carefully performed study, 53.9% of moderate-to-very-severe COPD had improvement of at least 12% and 200 mL on FEV_1.[19] Additionally, the above approach to using the bronchodilator response to determine management risks disregard for the possibility of two or more causes to an individual's disease, such as COPD due to coal mine dust exposure and non-occupational asthma.

Obstructive lung disease from coal mine dust can occur in the presence or absence of CWP, can occur in the presence of x-rays which are negative, and can be associated with significant clinical impairment. Coal mine dust is an important cause of emphysema[20–22] and associated impairment.[23] Centrilobular emphysema is the most common type of emphysema associated with coal mine dust exposure and occurs in non-smoking mine workers.[24] The effect of cigarette smoking on emphysema is additive to the effect of coal mine dust exposure.[20] All types of emphysema, including centriacinar, panacinar, and bullous emphysema, are associated with both mine dust exposure and cigarette smoking.[25] It is not possible to distinguish emphysema due to coal mine dust from that caused by cigarette smoking. Coal mine dust also causes chronic bronchitis.[26,27,28] Most importantly, coal mine dust exposure is associated with impairment in lung function as measured by spirometry, even in the absence of radiographic evidence of CWP.[29] Examination of multiple cohorts of miners is notable for evidence of an excess lifetime risk of significant loss of lung function attributable to dust exposure.[30] After adjusting for age and smoking status, the magnitude of decline in function is proportional to estimated cumulative coal mine dust exposure.[31–34] In addition to being a marker for respiratory symptoms, the magnitude of FEV_1 decline is associated with increased risk of death from cardiovascular and non-malignant respiratory disease.[35]

Among the sample of 22 medical charts from individuals with abnormal spirometry the review team evaluated, only one case was found where it was recommended that the coal mine worker work in an environment with lower coal mine dust exposure. This observation was confirmed with CS Health. In our review, we identified five cases with an FEV_1 less than 60% predicted, three of whom had FEV_1 values less than 50% predicted. Additionally, four of the five cases had spirometry with documented prior significant declines of at least 15% predicted, some with much larger declines. Several other coal mine workers had large declines in spirometry, including four underground workers.

It is concerning that three of the 22 cases had "severe" FEV_1 impairment and did not have any documentation of dust restrictions, and apparently worked in environments in which continued dust exposure was possible. Absent other extenuating circumstances, the review team believes these workers should likely have been returned to work with restrictions regarding their future exposures, regardless of what was judged to be the cause of their severe impairment. As of late 2021, CS Health did not have formal return-to-work guidelines for their physicians to use when evaluating workers with pulmonary impairment who work in dusty jobs. These types of guidelines take into account differing levels of impairment and provide recommendations regarding levels of exposure that could be considered reasonable to protect these workers from progressive disease. The fact that 21 out of 22 workers with significant respiratory impairment were apparently allowed to return to work in dusty jobs without restrictions raises the importance of such guidelines. We note that these 22 cases are only a small sample of what is likely a larger pool of similar cases, as the review team was limited to the data that was only available for internally performed examinations.

During this part of the review, the review team encountered respiratory physician evaluation reports in which it was implied that emphysema and chronic bronchitis were not considered to be coal mine dust lung diseases as their coal mine dust exposure was not felt to be contributory in the absence of radiographic CWP. This approach to CMDLD is not supported by the published scientific literature; the identification of nodules of CWP is not required to attribute other lung diseases at least in part to coal mine dust exposure. Further discussion relating to respiratory physician evaluation can be found in the next section, in which we review cases referred in 2021 by CS Health.

Recommendations

- **Recommendation 8:** CS Health should consider expanding and standardising their data collection to include important variables from spirometry that would and permit epidemiologic analysis of data, and early detection of CMDLD. This includes collection of data from externally performed tests, and ensuring that all providers utilise the same reference equations (GLI) in determining predicted values of spirometric parameters of interest.
- **Recommendation 9:** Given the large number of cases with abnormal spirometry and few cases of lung disease attributed at least in part to coal mine dust exposure, a detailed external review of these cases is strongly recommended. It is the recommendation of the review team that such a review include all cases in which the FEV_1 was less than 70% predicted and include detailed work history with assessment of level of coal mine dust exposure, history of tobacco smoking and other exposures, and other lung disease. As some respiratory physicians appeared to imply that they do not attribute obstructive lung diseases to coal mine dust exposure unless CWP is present, the review team does not believe prior evaluation by a respiratory physician should exempt a case from this additional review.

Review of Cases Referred for Respiratory Physician Evaluation

Background

After a coal mine worker has undergone a health assessment under the health scheme, a CS Health Senior Medical Officer determines whether to refer the worker for further evaluation by a respiratory physician. The Senior Medical Officer provides a referral letter to the respiratory physician describing the reason for referral and providing key details, including a brief occupational history or other assessment of coal mine dust exposure. The respiratory physician examines the worker and may order further testing their discretion. This testing may include complex lung function testing (spirometry, static lung volume and diffusion capacity measurements), additional chest imaging, and even tissue biopsy. The respiratory physician then provides an opinion as to whether there are respiratory abnormalities related to coal mine dust exposure.

A diagnosis that results in change in status to medical certification must be reported to and discussed with CS Health before the worker is contacted. Diagnoses of dust-related diseases are reported to the NSW Resources Regulator within 30 days of confirmed diagnosis.

Of note, there is no requirement for respiratory physicians evaluating such cases to have had specific training in occupational lung diseases including CMDLD. No specific training is provided by CS Health. Respiratory physicians are given the option, but not required, to visit a coal mine to improve their general awareness of the working environment.

Methods

The review team received de-identified medical records for 44 individuals who had been referred in 2021 by CS Health for specialty evaluation by respiratory physicians due to a concern for possible mine dust lung disease. These referrals came about because of abnormal chest imaging, spirometry, or respiratory symptoms detected during their routine surveillance examinations. CS Health provided records from the examination that resulted in the referral as well as prior spirometry and chest x-ray results where available. Each individual's de-identified data was evaluated by a respiratory physician from the review team. Spirometry tests were evaluated to confirm that each test met acceptability and repeatability criteria. We obtained de-identified Digital Imaging and Communication in Medicine (DICOM) chest images for the referred cases. At least two NIOSH-certified B Readers classified these chest radiographs, using the same protocol to adjudicate discordant classifications as described above.

DICOM HRCT images were obtained, where available, as well. HRCT scans were evaluated by at least two board-certified B-reader radiologists, and classified for the presence or absence of small opacities, large opacities and emphysema according to the International Classification of HRCT for Occupational and Environmental Respiratory Diseases (ICOERD) system. Disagreements on HRCT findings were resolved in a consensus meeting. The results of the

HRCT classifications were compared to the findings described in the HRCT reports provided by CS Health and assessed for agreement.

Results

Of the 44 individuals referred for evaluation by respiratory physicians in 2021, the large majority (98%) were male (Table 8). Most (84%) had at least 10 years of coal mine employment. Forty-five percent were referred for abnormal chest imaging, 23% for abnormal spirometry, and 5% for both abnormal chest imaging and abnormal spirometry. An additional 5% were referred for evaluation of abnormal respiratory symptoms. The majority (55%) worked at open cut mines, while 27% worked underground. Five percent worked in a CHPP setting and 9% worked in workshops.

Table 8 - Characteristics of 44 miners referred for respiratory physician consultation in 2021.

	n (%)
Total	44
Male	43 (98%)
Tobacco smoking as reported to CS Health	
Never smoker	15 (34%)
Former smoker	10 (23%)
Current smoker	19 (43%)
Geographical Location	
Hunter Valley region	27 (61%)
Newcastle region	6 (14%)
Illawarra region	4 (9%)
Gunnedah region	3 (7%)
Western region	3 (7%)
Non-mining role	1 (2%)
Chest X-ray small opacity profusion score at CS Health	
0/1 profusion	24 (55%)
Category 1	3 (7%)
Category 2	3 (7%)
Years of mining	
<10	4 (9%)
10-20	17 (39%)
20-30	11 (25%)
30-40	9 (20%)
Unknown	3 (7%)
Work setting	
CHPP	2 (5%)
Open cut	24 (55%)

	n (%)
Other (low/no exposure)	2 (5%)
Underground	12 (27%)
Workshop	4 (9%)
Reason for evaluation	
Abnormal radiology only	20 (45%)
Abnormal radiology and spirometry	2 (5%)
Abnormal spirometry only	10 (23%)
Abnormal respiratory symptoms	2 (5%)

Each of the 28 HRCT scans available for evaluation was classified by at least two review team radiologists using the ICOERD system. In 18 of 28 HRCT scans (64%), there was full agreement on the presence or absence of small opacities, large opacities, and emphysema between review team radiologists and the original classifying radiologist. Disagreement was encountered most frequently in the assessment for small opacities, occurring in 7/28 cases (25%), including 6 cases in which the original radiologist identified nodules while the consensus finding by the review team did not. There were also 4 cases of disagreement (14%) on the presence of emphysema.

As of April 2022, a respiratory physician consultation was completed on 39 of the 44 cases referred by CS Health. In two cases, the patient was found to have or thought most likely to have CMDLD in the form of simple CWP or silicosis. A third individual was thought by a "balance of probability" to have dust-related lung disease.

Fourteen cases referred because of abnormal chest imaging were considered to have a variety of non-work-related lung diseases including sarcoidosis, hypersensitivity pneumonitis, respiratory bronchiolitis, and respiratory bronchiolitis interstitial lung disease as the most common diagnoses. These are lung diseases that can occur in the general population and may have nodules in their lungs that mimic CWP on chest imaging. Eight of these workers had documented coal mining tenure of at least 15 years. In some cases, the worker underwent additional evaluation at the direction of the respiratory physician, including follow-up CT scans and biopsy, but these records and data were not available to CS Health because the studies were ordered by the respiratory physician. The review team was therefore unable to assess the full evidence supporting the final diagnoses in these cases. In another case, nodules were identified on a HRCT scan ordered by a CS Health provider, then followed by a CT scan ordered by the respiratory physician. This second CT scan reportedly demonstrated improvement in the nodules, although it is again notable that CS Health does not have access to this scan because studies ordered by respiratory physicians are not accessible by CS Health.

In five cases, the respiratory physician deemed the radiographic abnormality to be minor or nonsignificant. In several instances, the radiologist originally evaluating the HRCT had reported identifying few nodules, congruent with the respiratory physicians' conclusions.

There were seven cases where the miner was referred for evaluation of abnormal nodules identified by the radiologist on HRCT scan, with disagreement by the respiratory physician about the presence of the lung nodules. In several instances, the respiratory physician attributed these "nodules" to blood vessels, a normal anatomic structure within the lung. In one of these cases, the respiratory physician had evaluated the HRCT scan prior to the miner's scheduled evaluation. The respiratory physician provided an opinion of the lack of abnormal nodules, which subsequently led to the cancellation of the in-person evaluation. These were instances in which there was clear disagreement between the respiratory physician and radiologist as to the presence of abnormal lung nodules on CT scan. Review of six HRCT scans that the review team was able to obtain by two review team radiologists found the presence of nodules in two of the six cases. Review team radiologists identified technical quality issues with regard to CT imaging acquisition which were felt possibly to contribute to some of the misidentification of lung nodules.

There were eight cases referred for abnormal spirometry in which an evaluation by a respiratory physician had been performed. Six of these cases were found by the respiratory physician to be related to smoking and/or asthma. Three had $FEV_1 < 70\%$ predicted. Of the eight cases, four had documented coal mine employment histories of at least 15 years. In no case was coal mine dust felt by the respiratory physician to be a contributor to the worker's lung disease.

One of the cases had been referred for evaluation for abnormal chest imaging and was noted to be entering the coal mining industry for the first time. This individual was deemed to not have coal mine dust lung disease. As described above, five of the cases had not yet been seen or sufficiently evaluated for the respiratory physician as of April 2022 to provide an opinion about the presence of dust disease. It is notable that two have $FEV_1 < 70\%$ predicted, and a third mine worker had been referred for accelerated longitudinal decline in lung function.

Discussion

Review of the cases referred to respiratory physicians for further evaluation raised several issues. At least some of the respiratory physicians used by CS Health for these consultations do not appear to recognise that emphysema and chronic bronchitis attributable to coal mine dust exposure does not require the presence of the scars of CWP. This is evident based on several observations:

1) There was absence of any discussion in the physicians' communications describing their considerations for the underlying cause of coal mine dust as a cause or contributor to emphysema and chronic bronchitis, despite, in some instances, mine workers having had 40 years of coal mine employment.
2) A worker with over 30 years of coal mine employment was evaluated for accelerated lung function decline, which was attributed to smoking alone – smoking cessation was recommended, but no dust restrictions were recommended.
3) A worker was diagnosed with both simple CWP and chronic bronchitis, with the chronic bronchitis attributed to cigarette smoking only.

Of note, not all cases of obstructive lung disease in coal miners are attributable to coal mine dust exposure. However, the absence of any cases attributed at least in part to coal mine dust exposure, even among workers with extensive exposure histories, is notable.

Several respiratory physicians used by CS Health appeared to favour picking only one exposure as cause of disease versus another, rather than considering multiple contributors to disease. This is most relevant in the case of the obstructive lung diseases chronic bronchitis, emphysema, and chronic obstructive pulmonary disease, in which a variety of exposures are known to be potential causes. The additive effects of coal mine dust exposure and tobacco smoking to obstructive lung diseases are well described, and medical providers should consider coal mine dust exposure as a potential cause of lung disease even in workers who are current or former tobacco smokers, or if they have known non-occupational lung disease.

In response to these results, the review team requested additional information from CS Health regarding diagnoses of obstructive lung disease attributed at least in part to coal mine dust exposure. The review team were provided with additional de-identified materials from 32 cases of workers who had been diagnosed with obstructive lung diseases by respiratory physicians from 2017 to 2022. Review of these materials revealed coal mine dust was considered to be a significant contributory factor in eight (25%) of these cases. This finding is notable for the small number of cases of obstructive lung disease who had been referred for respiratory evaluation by CS Health over the course of approximately five years, and the very small number found to have disease attributable at least in part to coal mine dust exposure.

There were several instances in which the respiratory physician disagreed with the radiologist findings of lung nodules on HRCT scan. This is a concerning finding, as it suggests that the radiologist is incorrect about the presence of a radiographic abnormality, or the respiratory physician is overly aggressive in excluding the presence of the abnormality, or both. Based on our review of the health records, it appears that the respiratory physicians' evaluation of the HRCT scan was accepted as correct. Further quality evaluations are needed to determine whether there is excessive over- or underreading of HRCT abnormalities. CS Health could consider developing a process such utilisation of a multi-disciplinary team (MDT), which often includes radiologists, occupational medicine physicians, and respiratory physicians, to review these cases given the frequency of this type of disagreement and the implications for additional clinical investigation.

A number of miners with abnormally low lung function, including those with $FEV_1 < 70\%$ predicted, were allowed to return to work without dust exposure restrictions. While the review team recognises that the respiratory physicians did not diagnose coal mine dust-related lung diseases in these cases, this approach does not account for the need to preserve the workers' remaining lung function. Recommendations to avoid significant exposures to respiratory hazards are standard practice in such cases. To provide a non-occupational example, allowing a worker with significantly impaired lung function to perform coal mining work without limiting dust exposure is analogous to allowing an asthmatic with similarly impaired function to begin

cigarette smoking. Regardless of the putative underlying cause(s) of a worker's lung disease, the severity of lung function abnormalities should, by themselves, prompt consideration for reducing future dust exposure. This topic is discussed further in the next section, "Returning Workers with CMDLD to Work."

Another important concern is the inability of CS Health to access to results of studies obtained by consulting respiratory physicians, including CT scans and lung biopsies. CS Health can request specific reports from the respiratory physician, but the respiratory physician is not obligated to share the report. As these are directly relevant to the investigations relating to the presence of CMDLD, access to these studies is critical to the proper functioning of the health surveillance scheme. These results would allow CS Health to review evidence and confirm whether or not a worker has a CMDLD. The review team recommend establishing a procedure for routinely obtaining these records and test data, where permitted.

Recommendations

- **Recommendation 10:** Respiratory physicians should be educated on the spectrum of disease associated with coal mine dust exposure.
- **Recommendation 11:** An external review should be commissioned of cases referred for respiratory physician evaluation, given the evidence that some respiratory physicians who provide consultations for CS Health appear unaware of the relationship between coal mine dust exposure and obstructive lung disease and lung function decline.
- **Recommendation 12:** CS Health should consider developing a process, such as utilisation of a multidisciplinary team, to resolve cases with discordant interpretations of chest imaging and opinions regarding causation. This is particularly important when a radiologist perceives the presence of the abnormality, but a respiratory physician does not.
- **Recommendation 13:** CS Health should have access to all records and studies resulting from investigations initiated by CS Health, including those ordered by respiratory physicians, to the extent permissible by law. This would allow them to review the quality of such investigations and allow them to confirm the presence or absence of coal mine dust disease.

Returning Workers with CMDLD to Work

The goal of an effective secondary prevention program is to identify early disease, and then intervene to prevent progression to more severe disease. Medical surveillance for CMDLD utilizes chest imaging and spirometry to detect early scars of CWP or early changes in lung function consistent with CMDLD. When abnormalities are detected, workers may be returned to work with restrictions on exposure, or in some cases with more severe impairment, removed from exposure entirely.

CS Health provided the following criteria for recommending a worker's removal from exposure to high dust levels pending evaluation by a respiratory physician:

- Chest x-ray small opacity profusion of 2/1 or greater
- Spirometry values below 70% predicted or a fall of 15% or more
- Abnormal symptoms

We note that the above criteria were communicated directly to the review team; no formal document with these or similar criteria currently exists. After consultation with a respiratory physician, a decision is made by the CS Health doctor in consultation with the CS Health Head of Medicine and the respiratory physician. Based on these decisions, discussions are held with the worker's current workplace to determine whether any alternate roles are available.

After communication with CS Health, the review team was informed that a total of 23 workers had been diagnosed with CMDLD since 2017, which includes cases investigated by the NSW Resources Regulator. Of these cases, stricter exposure limits were enacted for three workers, and two workers had role reassignments. One worker retired specifically due to the diagnosis of CMDLD, and six other workers also retired from coal mining since their diagnosis but the reason was not attributed to the CMDLD.

CS Health informed the review team that it has no formal document outlining criteria used to determine whether a worker should be removed from exposure or returned to work with exposure restrictions. This is not uncommon among health surveillance schemes. For example, screening for pneumoconiosis for coal mine workers in the United States is performed by the federal government, and workers are provided with the results of their chest imaging and given the right to work in a low-dust job (permissible exposure limit < 0.5 mg/m^3 respirable coal mine dust) if their imaging shows ILO category $\geq 1/0$. There are no specific criteria for abnormal spirometry. However, in the US, there is no entity with statutory authority to recommend or mandate a change to a worker's job tasks or position. In Queensland, formalised criteria for recommending reduced dust exposure based on specific degrees of chest imaging and spirometry abnormalities for coal mine workers was only enacted in 2022.[36]

Nonetheless, as Coal Services acts as an overseeing entity in determining the presence of CMDLD in workers via CS Health, as well as engaging in workers' compensation and dust monitoring, the review team recommend that all stakeholders in the NSW coal industry consider developing formal criteria to safely return workers with early CMDLD to work, or recommend removal from exposure for those with advanced disease. While CS Health report use of outside guidance on further dust exposure levels based on lung function, the review team emphasizes the recommendation for formally accepted criteria for restricting dust exposures in NSW workers.

Recommendation

- **Recommendation 14:** Establish formal criteria to return workers with early CMDLD or other non-occupational lung diseases to work, or removal from exposure for those with more advanced disease.

- **Recommendation 15:** While it is beyond the specific scope of this review, consideration should be given to ensuring a firewall within Coal Services between those responsible for determining disability and impairment, and those responsible for managing the affected workers' compensation claims.

Special Case Review

The review team solicited health assessment cases for review from stakeholders other than CS Health. We received records and chest imaging for one case. The individual had undergone a chest x-ray with finding of a 2-cm lower lobe lung nodule. The chest x-ray performed for health surveillance from three years prior had been read as demonstrating a 14-mm well-circumscribed lung nodule, thought possibly to be a granuloma or hamartoma (both are benign types of lung lesions). A chest x-ray another two years earlier had been read as demonstrating no lung nodule.

The lung nodule was investigated with a CT scan, confirming the presence of the lung nodule. The individual underwent surgery to remove this portion of lung, with a confirmed finding of lung cancer.

Review team B Readers blinded to the case history classified health surveillance scheme chest x-rays from five and three years prior to the present time. These chest x-rays were evaluated along with other chest x-rays, and the review team B Readers were not provided indication that the chest x-rays of interest were part of a specific case review. Both B Readers identified a 12-mm nodule on the chest x-ray from three years prior and recommended CT imaging; no lung nodule was detected by the review team on the chest x-ray from five years prior, consistent with the original radiologist's finding. No opacities consistent with pneumoconiosis were identified.

The review team recognise the misfortune of the individual in question, as their lung cancer might otherwise have been detected three years earlier. This is an unfortunate incident, but not uncommon in the practice of medicine. Although detection of abnormalities such as lung cancers is outside the primary scope of the health surveillance scheme, radiologists must remain vigilant to the possibility of serious non-occupational lung diseases as well. The ILO system provides a means to indicate the presence of non-pneumoconiosis abnormalities such as lung cancers, and the presence of a large opacity particularly in the absence of small opacities raises the possibility of lung cancer. This case also illustrates the importance of access to prior chest imaging results. The earliest of the three chest x-rays did not show a lung nodule while the second chest x-ray showed a new lung nodule over 1 cm in diameter. Development of a lung nodule of this size in the two-year interval between the chest x-rays should have been an indication for further investigation.

Recommendation

- **Recommendation 16:** Procedures to follow up on abnormal findings should be reviewed and updated.

Abbreviations

AHPRA	Australian Health Practitioner Regulation Agency
ATS	American Thoracic Society
CHPP	Coal handling and preparation plant
CMDLD	Coal mine dust lung disease
CMWHS	Coal Mine Workers' Health Scheme
COPD	Chronic obstructive pulmonary disease
CPG	Clinical Pathways Guideline
CS Health	Coal Services Health
CT	Computed tomography
CWP	Coal workers' pneumoconiosis
DICOM	Digital Imaging and Communications in Medicine
EDN	External Doctor Network
ERS	European Respiratory Society
FEV_1	Forced expiratory volume in one second
FVC	Forced vital capacity
HRCT	High-resolution computed tomography
HVO	Hunter Valley Operations
ICOERD	International Classification of HRCT for Occupational and Environmental Respiratory Diseases
ILO	International Labour Office
JCB	Joint Coal Board
LLN	Lower limit of normal
MEU	Mining and Energy Union
MSAC	Mine Safety Advisory Council
NIOSH	National Institute for Occupational Safety and Health
NSW	New South Wales
NSWMC	New South Wales Minerals Council
OC	Open cut
PMF	Progressive massive fibrosis
UG	Underground
WES	Workplace exposure standard

References

1. 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):1178-1185. doi:10.1164/rccm.201301-0042CI
2. *Coal Services Annual Report 2007/08*. Coal Services; 2008.
3. *To Protect Miners and Mining; Annual Report 2015*. Coal Services; 2015.
4. Coal Mining Statistics. Coal Services. Accessed August 2, 2022. https://www.coalservices.com.au/mining/statistics-2/
5. Coal in NSW - Industry sectors. NSW Department of Industry. Published November 22, 2019. Accessed August 2, 2022. https://www.business.nsw.gov.au/industry-sectors/industry-opportunities/mining-and-resources/coal/coal-in-nsw
6. Airborne contaminants and dust | NSW Resources Regulator. Accessed August 2, 2022. https://www.resourcesregulator.nsw.gov.au/safety/health-and-safety-management/airborne-contaminants-and-dust
7. Safe Work Australia. *Workplace Exposure Standards for Airborne Contaminants.*; 2019.
8. Workplace exposure standards for airborne contaminants - 1 October 2022.
9. Workers' Compensation (Dust Diseases) Act 1942 No 14 - NSW Legislation. Accessed July 5, 2022. https://legislation.nsw.gov.au/view/html/inforce/current/act-1942-014#sch.1
10. International Labour Office. *Guidelines for the Use of the ILO International Classification of Radiographs of Pneumoconioses*. Revised edition 2011. International Labour Office; 2011.
11. Savranlar A, Altın R, Mahmutyazıcıoğlu K, et al. Comparison of chest radiography and high-resolution computed tomography findings in early and low-grade coal worker's pneumoconiosis. *Eur J Radiol*. 2004;51(2):175-180. doi:10.1016/j.ejrad.2003.10.017
12. Halldin CN, Blackley DJ, Petsonk EL, Laney AS. Pneumoconioses Radiographs in a Large Population of U.S. Coal Workers: Variability in A Reader and B Reader Classifications by Using the International Labour Office Classification. *Radiology*. 2017;284(3):870-876. doi:10.1148/radiol.2017162437
13. Miller MR. Standardisation of spirometry. *Eur Respir J*. 2005;26(2):319-338. doi:10.1183/09031936.05.00034805
14. Graham BL, Steenbruggen I, Miller MR, et al. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. *Am J Respir Crit Care Med*. 2019;200(8):e70-e88. doi:10.1164/rccm.201908-1590ST
15. Quanjer PH, Stanojevic S, Cole TJ, et al. Multi-ethnic reference values for spirometry for the 3–95-yr age range: the global lung function 2012 equations. *Eur Respir J*. 2012;40(6):1324-1343. doi:10.1183/09031936.00080312

16. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. *Eur Respir J*. 2005;26(5):948-968. doi:10.1183/09031936.05.00035205
17. Gore C, Crockett A, Pederson D, Booth M, Bauman A, Owen N. Spirometric standards for healthy adult lifetime nonsmokers in Australia. *Eur Respir J*. 1995;8(5):773-782. doi:10.1183/09031936.95.08050773
18. The Thoracic Society of Australia & New Zealand. Standards for the Delivery of Spirometry for Resource Sector Workers. The Thoracic Society of Australia & New Zealand. Accessed January 21, 2023. https://thoracic.org.au/resources/resources-worker-health/spirometry/
19. Tashkin DP, Celli B, Decramer M, et al. Bronchodilator responsiveness in patients with COPD. *Eur Respir J*. 2008;31(4):742-750. doi:10.1183/09031936.00129607
20. Kuempel ED, Wheeler MW, Smith RJ, Vallyathan V, Green FHY. Contributions of dust exposure and cigarette smoking to emphysema severity in coal miners in the United States. *Am J Respir Crit Care Med*. 2009;180(3):257-264. doi:10.1164/rccm.200806-840OC
21. Ruckley VA, Fernie JM, Chapman JS, et al. Comparison of radiographic appearances with associated pathology and lung dust content in a group of coalworkers. *Br J Ind Med*. 1984;41(4):459.
22. Ryder R, Lyons JP, Campbell H, Gough J. Emphysema in coal workers' pneumoconiosis. *Br Med J*. 1970;3(5721):481.
23. Kuempel ED, Vallyathan V, Green FHY. Emphysema and pulmonary impairment in coal miners: Quantitative relationship with dust exposure and cigarette smoking. *J Phys Conf Ser*. 2009;151:012024. doi:10.1088/1742-6596/151/1/012024
24. Leigh J, Driscoll TR, Cole BD, Beck RW, Hull BP, Yang J. Quantitative relation between emphysema and lung mineral content in coalworkers. *Occup Environ Med*. 1994;51(6):400-407.
25. Green FHY, Brower PS, Vallyathan V, Attfield MD. Coal mine dust exposure and type of pulmonary emphysema in coal workers. In: Chiyotani K, Hosoda Y, eds. *Advances in the Prevention of Occupational Respiratory Diseases: Proceedings of the 9th International Conference on Occupational Respiratory Diseases, Kyoto, 13-16 October 1997*. International congress series. Elsevier; 1998.
26. Rae S, Walker DD, Attfield MD. Chronic bronchitis and dust exposure in British coalminers. *Inhaled Part*. 1970;2:883-896.
27. Leigh J. 15 year longitudinal studies of FEV_1 loss and mucus hypersecretion development in coal workers in New South Wales, Australia. In: *Proceedings of the VIIth: International Pneumoconioses Conference Part II*. Vol 2. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH); :112-121. Accessed December 4, 2011. http://www.cdc.gov/niosh/docs/90-108/

28. Wang X, Yu IT, Wong TW, Yano E. Respiratory symptoms and pulmonary function in coal miners: looking into the effects of simple pneumoconiosis. *Am J Ind Med*. 1999;35(2):124-131.

29. Morgan WK. Industrial bronchitis. *Br J Ind Med*. 1978;35(4):285-291.

30. Oxman AD, Muir DC, Shannon HS, Stock SR, Hnizdo E, Lange HJ. Occupational dust exposure and chronic obstructive pulmonary disease. A systematic overview of the evidence. *Am Rev Respir Dis*. 1993;148(1):38-48. doi:10.1164/ajrccm/148.1.38

31. Cowie HA, Miller BG, Rawbone RG, Soutar CA. Dust related risks of clinically relevant lung functional deficits. *Occup Environ Med*. 2006;63(5):320-325. doi:10.1136/oem.2005.021253

32. Love RG, Miller BG. Longitudinal study of lung function in coal-miners. *Thorax*. 1982;37(3):193-197.

33. Carta P, Aru G, Barbieri MT, Avataneo G, Casula D. Dust exposure, respiratory symptoms, and longitudinal decline of lung function in young coal miners. *Occup Environ Med*. 1996;53(5):312-319.

34. Soutar CA, Hurley JF. Relation between dust exposure and lung function in miners and ex-miners. *Br J Ind Med*. 1986;43(5):307.

35. Beeckman LA, Wang ML, Petsonk EL, Wagner GR. Rapid declines in FEV_1 and subsequent respiratory symptoms, illnesses, and mortality in coal miners in the United States. *Am J Respir Crit Care Med*. 2001;163(3 Pt 1):633-639. doi:10.1164/ajrccm.163.3.2008084

36. Services WCR. Return to work guidelines for mine dust lung diseases now available. Published January 21, 2022. Accessed January 21, 2023. https://www.worksafe.qld.gov.au/news-and-events/newsletters/rehabilitation-and-return-to-work/2022-bulletins/january-2022/return-to-work-guidelines-for-mine-dust-lung-diseases-now-available

Appendices

Appendix A. Scope of the review of the New South Wales health surveillance scheme for coal mine workers.

1) Review and evaluate the adequacy of the scope, processes, quality, communication, and reporting of the Coal Services health surveillance scheme.
2) Evaluate the adequacy of both pre-employment and periodic medical exams, screenings, or assessments and consider their alignment.
3) Evaluate the adequacy of the trained health professionals (both within Coal Services Health and the external doctor network).
4) Evaluate the use of the external doctor network in the scheme including arrangements to assess, review, refer, and communicate the findings from the external doctor network medical assessments.
5) Review health assessments of workers or former workers with recent confirmed cases of dust disease (n=10) and a representative sample of other worker health assessments, including examples identified by Mine Safety Advisory Council (MSAC) members.
6) Review the current health assessment form used in the scheme.
7) Review the standard of clinical processes (e.g., for chest x-ray, spirometry, and general health)
and whether they are in accordance with relevant evidence-based practices.
8) Review the current clinical pathways process to ensure appropriate follow up on abnormal results.
9) Develop a methodology for the review of past chest x-rays and spirometry to estimate the extent of dust disease that may have been undetected by the health surveillance scheme.
10) Review current centralized data collection and analysis procedures to ensure they permit longitudinal evaluation of coal mine workers and epidemiologic analysis of any patterns of disease detected and allow this information to be communicated to relevant stakeholders for necessary action.
11) Where deficiencies are found, make recommendations to improve the current program for the medical assessment of CMDLD.

Appendix B. Sources of information used by the review team.

To accomplish the objectives of this review, the review team worked closely with the NSW Resources Regulator, Mine Safety Advisory Council of New South Wales, and Coal Services Health. In addition, written submissions were provided by stakeholders, and virtual and in-person meetings were held during the review process. The review team thank the following stakeholders for their input:

Industry
The Bloomfield Group
Glencore
Idemitsu Australia
NSW Minerals Council
Theiss Industries
Whitehaven Coal

Labour
Mining and Energy Union

Appendix C. Investigations of dust disease completed by NSW Resources Regulator.

Regulator notified	Dust disease	Worker	Status
6-May-21	Probable Simple Silicosis - Coal Workers Pneumoconiosis	Male, late 40s Still employed as an Open Cut - Coal Surveyor. The worker has undertaken work in the NSW coal industry as a surveyor since 2008. The worker conducted work surveying coal stockpiles manually on foot (a practice no longer undertaken).	The investigation identified that there is a low probability of sarcoidosis or other interstitial lung diseases. The worker has no symptoms and normal lung function. The worker's condition is not expected to worsen provided they work in a low dust environment. It is not possible to determine the exposure location due to the numerous work locations the worker frequented. It is suspected the exposure was a result of working in and around coal stockpiles on foot. Matter closed.
6-May-21	Category 1 - Coal Workers Pneumoconiosis	Male, early 60s, coal miner, boilermaker, machine operator. The worker has worked in the underground coal and steel making industry for about 33 years.	The investigation identified that the worker is at retirement age and has been instructed to refrain from working in dusty environments. The worker is currently asymptomatic. The Regulator formed the view that the worker was exposed to airborne dusts at several mines and coking operations during his career, as such it would be unable to determine the origin, cause and circumstances of the illness. Matter closed.
22-Feb-21	Presumptive - Chronic Simple Silicosis	Male, 60s. Various roles across metal and coal operations, including operator and supervisory roles. The worker has had a long and varied career across gold, lead, zinc, copper, iron ore, and coal operations. The worker has worked in multiple jurisdictions	The worker has been advised that he can return to work but to stay out of dusty environments. The investigation identified that the worker's injuries are cumulative. The Regulator formed the view that the worker was exposed to airborne dusts at several operations during his career, as such it would be unable to determine the origin, cause and circumstances of the illness. Matter closed.

Regulator notified	Dust disease	Worker	Status
		above and below ground including overseas.	
24-Nov-20	Silicosis	Male Late 40's. Worked predominantly in tunnelling (Sydney and Brisbane region) and mining as an operator and supervisor. The worker has spent most of his career as a machine operator in the tunnelling industry. This work has involved tunnelling through Sydney and Brisbane sandstone. Silica is a major component of these sandstone structures.	The worker is asymptomatic but has CT evidence of mild silicosis (ILO score 1/1). Lung Function is normal, he is fit to work but must follow harm minimization measures. The worker should wear at least a P2 cartridge respirator. The worker spent a considerable amount of their career tunnelling Sydney and Brisbane sandstone. Based on the available evidence it would be fair to assume that there is a high likelihood that his exposure has arisen from his time in this industry. This is outside the jurisdiction of the NSW Resources Regulator. Matter closed
14-May-20	Simple silicosis	Male, late 30s. Worked in underground tunnelling in NSW and Queensland, mines in Western Australia, and currently working in coal mines in NSW.	Following an investigation, the Regulator formed the view that the worker's condition was not caused by exposure to silica containing airborne dusts at coal mining workplaces in NSW. Matter closed.
7-May-20	Interstitial lung disease (unconfirmed)	Male, early 50s. Still employed in the industry. Worked in various coal mines in NSW since the late 1990s.	Following an investigation, the Regulator formed the view that the worker had been exposed to airborne dusts at a number of mines and construction sites, as such it would be unable to determine the origin, cause and circumstances of the illness. Matter closed.
12-Sep-19	Pneumoconiosis (unconfirmed)	Male, early 40s. Still employed in the industry. Worked in an underground metal mine for the past nine years. Not known to have worked in any other	Following an investigation, the Regulator formed the view that it would be unable to determine the origin, cause, and circumstances of the worker's condition. Matter closed.

Regulator notified	Dust disease	Worker	Status
		jurisdictions or high-risk industries.	
11-Oct-19	Coal dust pneumoconiosis	Male, early 60s. Still employed in the industry. Largely employed in Queensland open cut mines for over 40 years, before moving to NSW open cut mine in recent years.	Following an investigation, the Regulator formed the view that as a legacy matter it would be unable to determine the origin, cause, and circumstances of the illness. Matter closed.
1-Oct-19	Mixed dust pneumoconiosis	Male, early 40s. Still employed in the industry. Ten years in NSW south coast mines before spending the last few years in the tunnelling industry and only recently returned to the coal mining industry.	Following an investigation, the Regulator formed the view that as a legacy matter it would be unable to determine the origin, cause, and circumstances of the illness. Matter closed.
1-Nov-18	Diffuse dust fibrosis (Originally diagnosed as mixed dust pneumoconiosis)	Male, mid 70s. Retired from industry in early 2000s. Extensive work history in coal mining, spanning more than 50 years, including substantial periods in UK, Queensland, and NSW	Following preliminary inquiries, the Regulator formed the view that as a legacy matter it would be unable to determine the origin, cause and circumstances of the illness. The updated medical assessment determined the worker has diffuse dust fibrosis, not mixed dust pneumoconiosis as first diagnosed. Matter closed.
17-Aug-18	Mixed dust pneumoconiosis	Male, late 80s. Retired from industry in 1980s. Employed in the NSW coal industry in various open cut mines for about 40 years.	Following an investigation, the Regulator formed the view that as a legacy matter it would be unable to determine the origin, cause and circumstances of the illness. Matter closed.

Regulator notified	Dust disease	Worker	Status
19-Dec-16	Idiopathic Pulmonary Fibrosis (Originally diagnosed as mixed dust pneumoconiosis)	Male, early 50s. Retired from industry in 2014. Employed in the NSW open cut coal industry for more than 30 years.	Investigation found that the worker had a spontaneous form of lung disease known as Idiopathic Pulmonary Fibrosis, not mixed dust pneumoconiosis as first diagnosed. Further, no evidence was found that the worker was exposed to hazardous levels of atmospheric contaminant at any of his workplaces. Therefore, based on the available information and in the absence of further medical evidence, the Regulator does not consider the worker's death to be workplace-related.
21-Dec-17	Mixed dust pneumoconiosis	Male, late 50s. Still employed in industry. Employed in the NSW coal industry for about 40 years.	Following an investigation, the Regulator formed the view that as a legacy matter it would be unable to determine the origin, cause, and circumstances of the illness. Matter closed.
21-Dec-17	Silicosis	Male, early 40s. Employed in the coal industry in NSW, interstate and overseas, as well as tunnelling industry	Following preliminary inquiries, the Regulator was informed that the worker did not wish to participate in an investigation. Matter closed.

Appendix D. Spirometry data fields.

Data fields available for spirometry section of review for internally performed tests, excluding Hunter Valley Operations; tests performed at Hunter Valley Operations; and tests performed by CS Health-accredited external providers.

Variable	Internal excluding HVO	HVO only	External providers
Review ID	X	X	X
Region	X	X	X
Age	X	X	X
Height		X	
Gender	X	X	X
Position description	X		X*
Current position		X	
UG/OC/Other	X	X	X*
Spirometry date	X	X	X
FEV_1	X	X	
FVC	X	X	
FEV_1 predicted	X		
FVC predicted	X		
FEV_1 percent predicted	X	X	
FVC percent predicted	X	X	
Reference equation used	X		
Obstructive/Restrictive/Mixed spirometric defect	X	X	X
Comment	X	X	

*Data field mostly unpopulated

HVO: Hunter Valley Operations
UG: Underground
OC: Open cut
FEV_1: Forced expiratory volume in one second
FVC: Forced vital capacity