Cancer Council Queensland

Prevalence of Coal Mine Dust Lung Disease in Queensland, 1983/84 – 2019/20

FINAL REPORT

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This report was prepared for Resources Safety and Health Queensland by Cancer Council Queensland for the purposes of the following Tender:

PREVALENCE STUDY OF COAL MINE DUST LUNG DISEASE (OHHFY20-2)

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We acknowledge that each of the statistics presented in this report represent Queensland coal miners who have been diagnosed with a serious disease, and the impact this has had on their lives and those of their families and friends.

We thank the staff at Resources Safety and Health Queensland and the Office of Industrial Relations for the provision of data and guidance with the interpretation and reporting of these results.

Table of Contents

Executive Summary

Background

Coal mine dust lung disease comprises a group of occupational lung diseases, including coal workers' pneumoconiosis and silicosis, that are caused by the cumulative inhalation of respirable coal mine dust particles.

In many countries, including Australia, the lack of prevalence rates for coal workers' pneumoconiosis and other coal mine dust lung diseases limits the ability to quantify the historical trends and current disease burden.

This report has two key aims:

1. To carry out a systematic review and meta-analysis to synthesise published international estimates on prevalence, mortality, and survival for coal mine dust lung disease.
2. To estimate the prevalence of coal mine dust lung disease in the Queensland mining population from 1983/84 to 2019/20 using data on cases of coal mine dust lung disease provided by Resources Safety and Health Queensland.

Key findings from the systematic review

The research question for the systematic review:

> What was the estimated prevalence and mortality or survival for coal mine dust lung disease among coal mine workers based on international cohort studies published between January 2000 and February 2021?

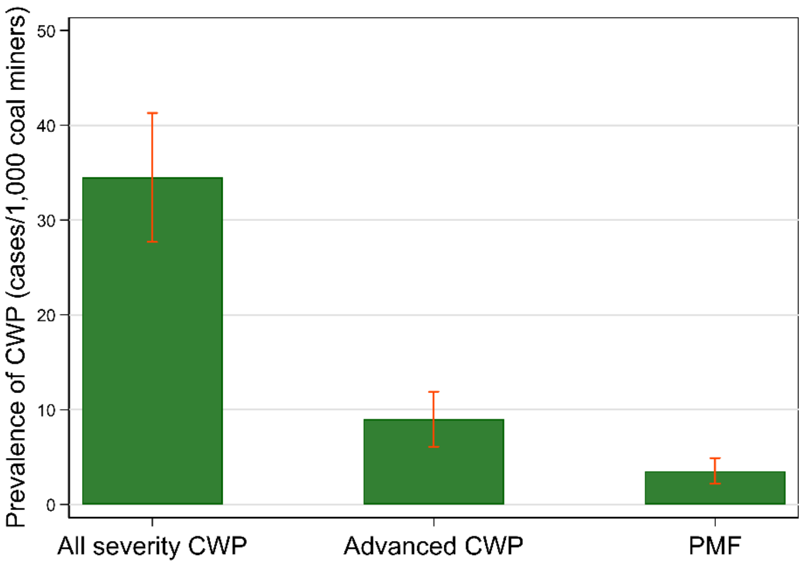
Key findings were:

- 24 out of 31 studies on prevalence of coal workers' pneumoconiosis or other coal mine dust lung diseases were from the United States.
- In the United States, following decades of declining prevalence, there was an increase in pneumoconiosis prevalence and severity nationwide. Possible contributors include inadequate dust control levels, increased dust exposure reflecting changes in working practice and mining techniques and changes in dust composition.
- The pooled overall prevalence **internationally** for coal workers' pneumoconiosis of any severity among underground miners over 11 studies was 34.5 cases per 1,000 coal miners (95% CI: 27.7-41.3). Prevalence rates ranged from 20.7 to 55.4 cases per 1,000 coal miners.
- The pooled overall prevalence of **advanced** coal workers' pneumoconiosis (ILO profusion sub-category of ≥2/1) among underground coal miners was 9.0 cases per 1,000 coal miners (95% CI: 6.1-11.9) based on three studies from the United States.
- The pooled overall prevalence for coal workers' pneumoconiosis among **underground miners** as **progressive massive fibrosis**, the most severe form, was 3.5

cases per 1,000 coal miners (95% CI: 2.2-4.9) over seven studies from the United States.

- The pooled overall prevalence for coal workers' pneumoconiosis of **any severity** among **surface miners** in the United States across four studies was 18.0 cases per 1,000 coal miners (95% CI 16.1-19.9%).
- The significant variability (P <0.001) in outcomes between the studies means that pooled estimates should be interpreted with caution.
- There was a lack of prevalence rates for coal mine dust lung disease of any type including coal workers' pneumoconiosis in Australia.
- One article (from China) was found on survival among miners with coal workers' pneumoconiosis but no five-year survival estimates.
- Four population mortality studies indicated that pneumoconiosis mortality rates had reduced over time in the United States and Australia compared to the general population.

The figure below summarises the pooled published prevalence rates for coal workers' pneumoconiosis by disease severity from the meta-analysis.



CWP: Coal workers' pneumoconiosis, PMF Progressive massive fibrosis

Characteristics of Queensland miners diagnosed with coal mine dust lung diseases

Key characteristics of the Queensland cohort of 166 cases of coal mine dust lung disease up to the end of the 2019/20 financial year (30 June 2020) were:

- 90 were from health assessments or reports from site senior executives via Resources Safety and Health Queensland, 66 from the Office of Industrial Relations pertaining to accepted worker's compensation claims and 10 from other sources.
- All (100%) were males, with an average age at diagnosis of 56.8 years. This contrasts with about 90% of coal miners in Queensland being male.
- 21.7% were current smokers, 41.0% had smoked previously and 22.3% were never smokers.

- 78.3% were coal miners only (the rest had also worked in other mine types), and 45.2% had worked solely in Queensland.
- 43.4% of the cases were surface miners and 31.9% underground miners while 5.4% had worked in both types of mines. This contrasts with the total coal mining population in Queensland, where about 81% of coal miners work in surface mines.
- 4.8% had a coal mining tenure of 0-9 years, 22.9% 10-19 years, and 41.5% of ≥20 years.
- The majority of cases (56%) were among people who had formerly worked in coal mines, rather than current miners.
- The most commonly diagnosed coal mine dust lung diseases were:
    - chronic obstructive pulmonary disease (29.5%)
    - coal workers' pneumoconiosis (22.3%)
    - multiple coal mine dust lung diseases (16.9%) - cases with multiple conditions having various combinations of coal workers' pneumoconiosis, chronic obstructive pulmonary disease, mixed dust pneumoconiosis or silicosis as well as 'other' conditions such as lung cancer
    - silicosis (13.3%), and
    - mixed dust pneumoconiosis (9.6%).
- The percentage of records with missing information varied substantially, for example it was 0% for mining sector type, 19% for coal mine type and around 30% for mine locality and coal mine tenure.
- The proportion of records with missing information on key characteristics depended on the data source.
- Cases notified through the OIR or other unidentified sources had a consistently lower number of records with complete data for each of the categorical characteristics than those in the RSHQ data extract.

Estimated prevalence of coal mine dust lung disease in Queensland

<u>Prevalence counts</u>

A prevalent case of coal mine dust lung disease in Queensland was defined as a coal miner known to have been diagnosed with coal mine dust lung disease in Queensland prior to 30 June 2020, and who was alive on 30 June 2020.

Due to the extent of missing information, especially on date of diagnosis, for the study cohort and very limited information about mortality among the cases, various assumptions had to be made when calculating the prevalence rates to impute missing data. Multiple simulations were then used to estimate a feasible range of values for the required data.

We estimated that for coal mine dust lung disease in Queensland on 30 June 2020, there were:

1. Between 135 and 149 prevalent cases
2. Between 56 and 65 prevalent cases among underground coal miners
3. Between 82 and 95 prevalent cases among surface miners

Note: some coal miners worked in both types of coal mines: these subtotals will not add to the total prevalent count.

Of the 166 cases, it was estimated that 44% (n=73) were diagnosed among coal miners who were working at the time of diagnosis, while 56% (n=93) were diagnosed among former coal miners. The difference between the total number of reported cases and total estimated prevalent cases reflects that some people diagnosed with coal mine dust lung disease had died before 30 June 2020.

Prevalence rates

Prevalence rates were calculated by dividing the number of prevalent cases (the numerator) by the population at risk (the denominator) for a specific year which is referred to as the prevalent year.

A key consideration was that the numerator needed to be a subset of the denominator.

We used two methods to estimate prevalence rates of coal mine dust lung disease as on 30 June 2020.

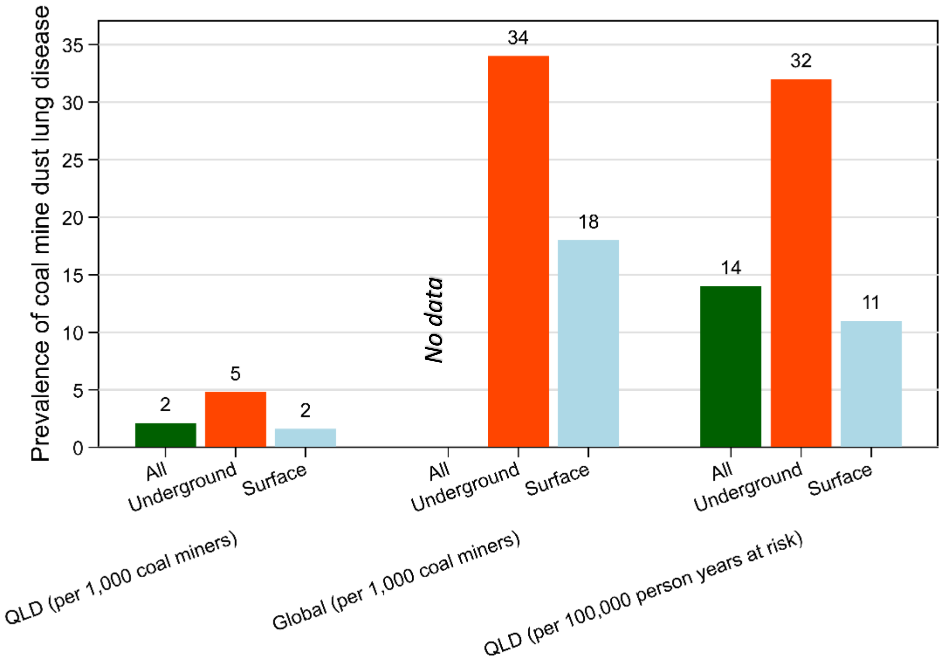
Method 1: Rate per 1,000 coal miners

Numerator: includes current and former coal miners diagnosed with coal mine dust lung disease and who were alive in the prevalent year
Denominator: number of full-time equivalent coal miners who had ever worked in Queensland coal mines up to and including the prevalent year and who were alive in the prevalent year
Estimated Prevalence Rate overall: 2.05 cases per 1,000 coal miners (range 1.94 to 2.14 cases per 1,000 coal miners)
Estimated Prevalence Rate by mine type was higher among underground miners (4.3-5.0 cases per 1,000 coal miners) than surface miners (1.5-1.7 cases per 1,000 coal miners)

Method 2 Rate per 100,000 person years at risk

Numerator: cases who were alive in the prevalent year (includes current and former coal miners)
Denominator: cumulative number of person years of work at coal mines between 1983/84 up to the prevalent year
Estimated Prevalence Rate overall: 14 cases per 100,000 person years' work in coal mines (range 13 to 14 cases per 100,000 person years)
Estimated Prevalence Rate by mine type was higher among underground miners (29-33 cases per 100,000 person years) than surface miners (10-11 cases per 100,000 person years)

The figure below summarises these estimated prevalence rates for 2019/20 in Queensland, in terms of the estimated population of "ever" (since 1983/84) coal miners who were still alive, and in terms of the total person years at risk working in Queensland coal mines. In addition, the summary estimate from the meta-analyses of international studies (converted to the per 1,000 scale) is also provided in the figure below.



Note: global prevalence is pooled prevalence for coal workers' pneumoconiosis of any severity internationally from meta-analysis and was estimated separately for underground and surface mines; QLD: Queensland

Although the prevalence rates for Queensland per 1,000 coal miners were substantially lower than the global estimate from the meta-analysis of international published studies, in both instances prevalence rates were higher among underground coal miners compared with surface coal miners.

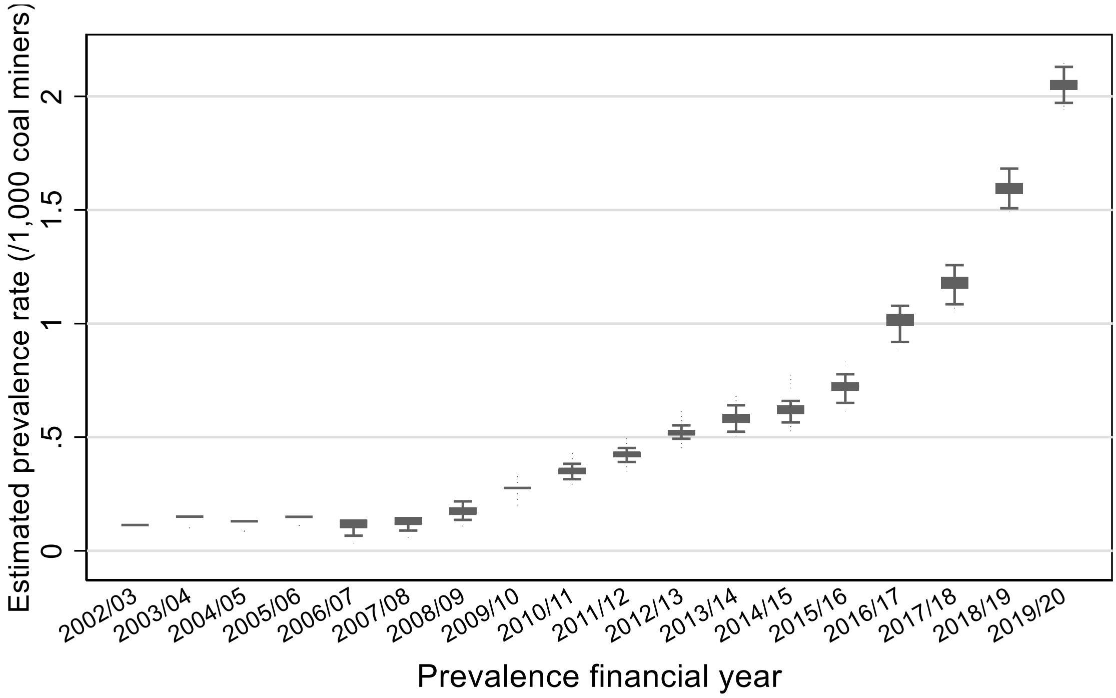
However, this comparison should be made with caution. The methods used for calculating Queensland prevalence rates were different to those used in the published literature for generating global pooled prevalence rates, which were based on the proportion (that is, the number of cases divided by the number of coal mine workers) at a specified point in time. To our knowledge, the published papers did not include people who had formerly worked in coal mines before the study, or former coal miners who were subsequently diagnosed with coal mine dust lung disease.

For that reason, along with the different methodologies, numerator and denominators, direct comparison between the results of this study and those in the published literature should be made with caution.

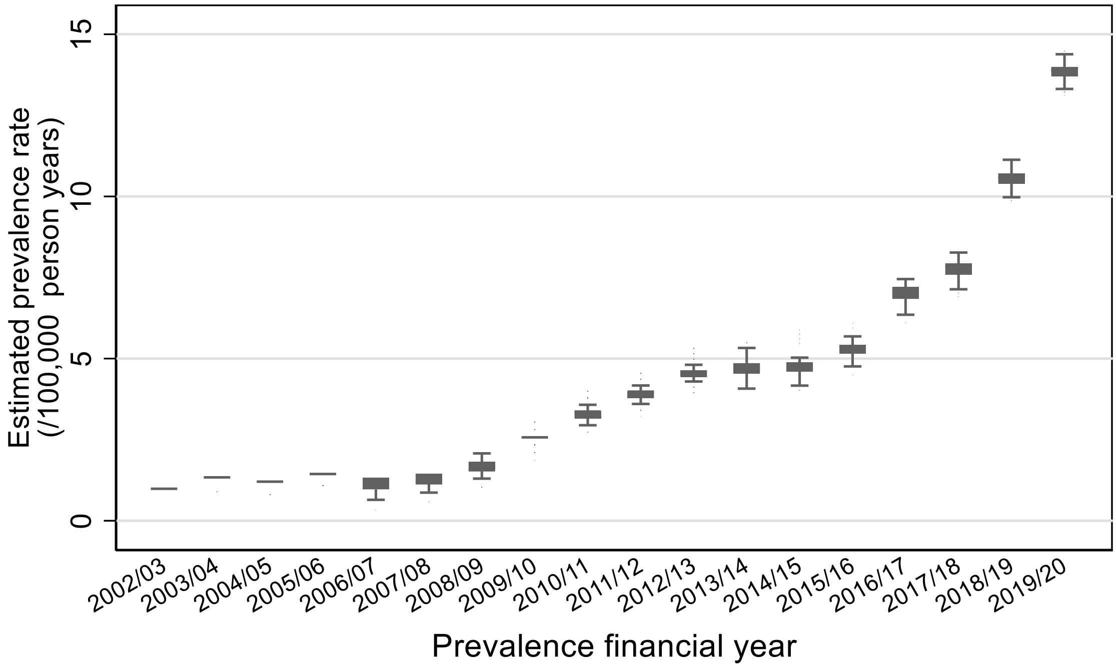
Changes in prevalence over time

Regardless of the method used to calculate the prevalence rates, the prevalence rate of coal mine dust lung disease in Queensland has increased over time. For example, the prevalence rate per 1,000 coal miners (former or current) increased from 0.1 cases per 1,000 coal miners in 2006/07 to 2.1 cases per 1,000 coal miners in 2019/20. This pattern of increasing prevalence over time is consistent with that reported in the United States where after a downwards trend over 30 years from 1970s onwards, the prevalence of coal workers' pneumoconiosis started to increase again in the 2000s.

The figures below show the change in prevalence rates over time for Queensland miners expressed in terms of per 1,000 coal miners (Method 1) and in terms of per 100,000 person years at risk (Method 2).



Adjusted for background population mortality and estimated CMDLD case mortality
All prevalent cases – current and previous miners

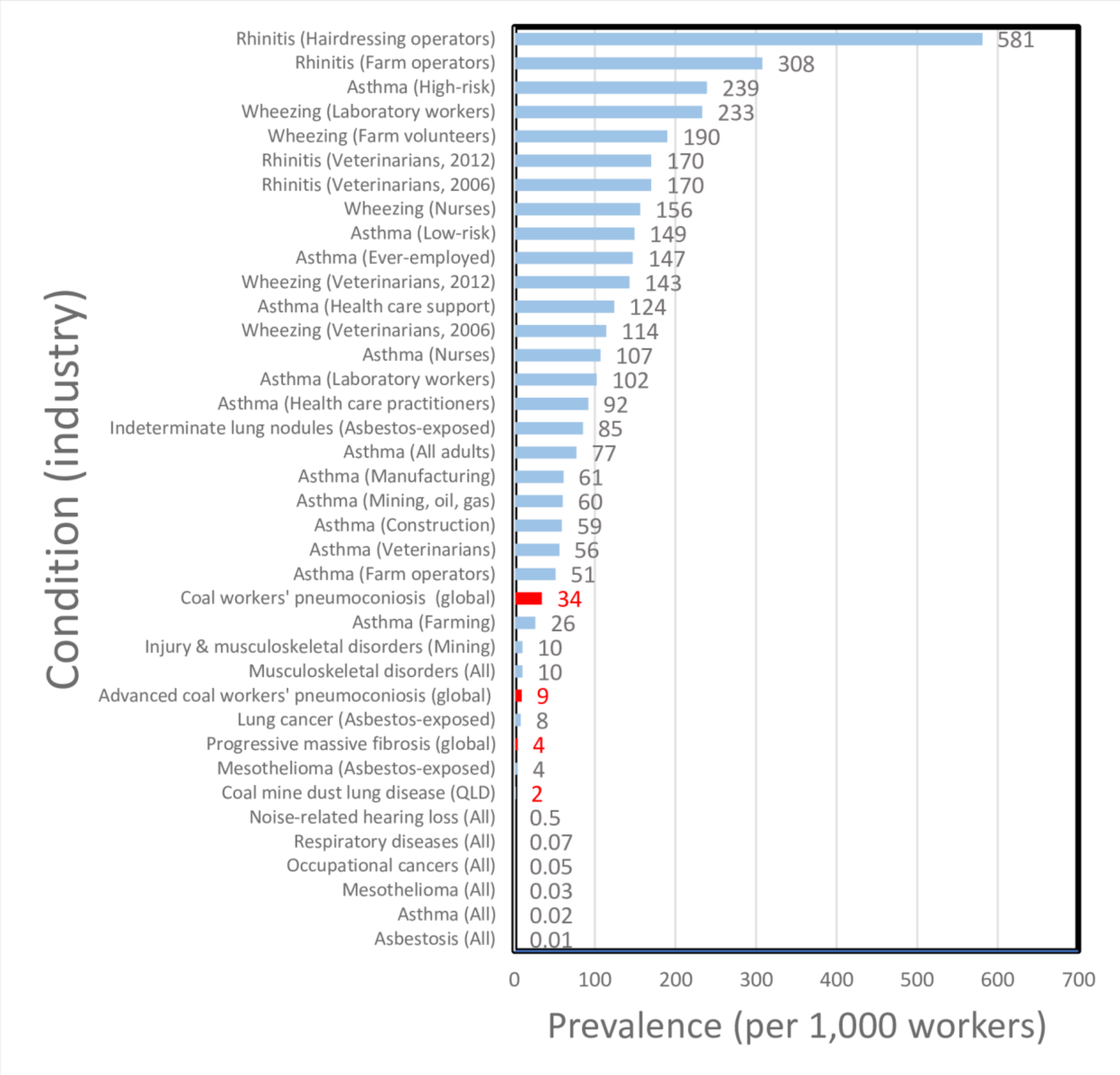


Adjusted for background population mortality and estimated CMDLD case mortality
All prevalent cases – current and previous miners

Comparison to prevalence for other occupational conditions

Literature searches found relatively few reliable and robust prevalence rates for any occupational conditions in many countries, including Australia.

The next figure below presents these reported prevalence rates (per 1,000 workers) by occupational conditions defined in Australian and international studies (blue) and coal mine dust lung disease (red) from meta-analysis of global prevalence and current estimates for Queensland calculated for this report.



1. More details are provided in Table 22.

Considerations of methods

The prevalence rates of coal mine dust lung disease in Queensland as of 30 June 2020 presented in this report were calculated using two different methods. Each method used a different definition for the denominator, although the numerator was the same.

The two methods capture different aspects of the underlying disease progression and characteristics that are likely to impact results. Method 1 calculated the prevalence of coal mine dust lung disease among current and former coal miners without considering the impact of mining tenure. By contrast, Method 2 considered the impact that the number of years working in a coal mine may have had by using the cumulative person years worked as the denominator.

Recommendations

The following recommendations are provided for consideration:

1. Establish a consistent systematic reporting process to provide complete information about coal mine dust lung disease cases;
2. Establish an ongoing follow-up process of all coal mine dust lung disease cases to obtain context-specific information about morbidity and mortality associated with the disease in Queensland; and
3. Ensure historical and current information about the population of surface and underground coal miners in Queensland is readily available.

List of Tables

List of Figures

List of Abbreviations

ASMR	Age standardised mortality rate
CCQ	Cancer Council Queensland
CI	Confidence interval
CMDLD	Coal mine dust lung disease
CMWHS	Coal Mine Workers’ Health Scheme
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
CWP	Coal workers' pneumoconiosis
DDF	Dust-related diffuse fibrosis
DNRME	Department of Natural Resources, Mines and Energy
DOB	Date of birth
GU	Griffith University
HRCT	High-resolution computed tomography
ILO	International Labour Organization
MDP	Mixed dust pneumoconiosis
OIR	The Office of Industrial Relations
PMF	Progressive massive fibrosis
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta Analyses
QLD	Queensland
RSHQ	Resources Safety and Health Queensland
SA2	Statistical Areas, Level 2
UK	United Kingdom
USA	United States

1. Introduction

Coal mine dust lung disease comprises a group of occupational lung diseases caused by the cumulative inhalation of respirable coal mine dust particles including carbon, quartz, and silicates. (1, 2) These diseases include coal workers' pneumoconiosis (CWP) commonly called black lung disease, mixed dust pneumoconiosis (MDP), silicosis, dust-related diffuse fibrosis (DDF) and chronic obstructive pulmonary disease (COPD).

While there are no curative treatments, (3) CWP and other diseases in the coal mine dust lung disease spectrum can be prevented by reducing exposure to dust through technological improvements (1, 4) and enforcing statutory dust standards by regulatory means.(2) In many high-income countries, government guidelines specify occupational exposure limits for respirable dust, however the recommended limits vary widely. (2, 3)

Although the prevalence of coal mine dust lung disease decreased markedly from the 1970s to 1990s in the United States, reflecting introduction of modern dust control standards, the prevalence has increased slightly again since the 2000s. (1, 2, 5) The increases have occurred even among cohorts of miners who were subject to regulatory guidelines their entire working life. Contributing factors to the recent increase in the prevalence of CWP and progressive massive fibrosis (PMF) potentially include mines having fewer employees, longer working hours and higher coal mine dust levels due to modern mechanised mining technologies. (1, 2, 5) This increase has renewed public health concerns about these diseases and highlighted the need for greater understanding of coal mine dust lung disease risk and optimal preventive measures in the modern era.

In many countries, including Australia, the lack of prevalence rates for occupational lung diseases, including CWP, primarily reflects the lack of mandatory reporting systems. (3) It also limits the ability to quantify the historical trends and current disease burden of CWP and other types of coal mine dust lung disease in those countries.

Given this gap in knowledge, we first carried out a systematic review and meta-analysis to synthesise published international estimates on prevalence, mortality, and survival for coal mine dust lung disease, with a focus on CWP. We also utilised data on cases of coal mine dust lung disease provided by Resources Safety and Health Queensland (RSHQ) to describe the people in Queensland diagnosed with the disease and estimate the prevalence of coal mine dust lung disease in the Queensland coal mining community. We estimated the population of coal miners in Queensland using a combination of data from RSHQ including Health Assessment volumes and quarterly numbers of coal mine workers from levy data, making various assumptions about the unknown or missing information required for the calculation of these estimates.

2. Summary of systematic review and meta-analysis

The systematic review was conducted according to published PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines. (6)

The clinical question to guide the review was defined following the structured PICOS framework, which is a way of specifying the research question in terms of the combination of what the population of interest is (“Population”), what type of intervention was being considered (“Intervention”), what measures were being assessed or compared (“Comparison”), what the study outcomes of interest were (“Outcomes”) and the study design (“Study design)”.

The PICOS question was:

Among coal mine workers (Population), under current coal dust control strategies (Intervention), from the start of the study time period (Comparison) what was the estimated prevalence or mortality or survival (Outcome) for coal mine dust lung disease using cohort studies (Study design)?

The electronic databases PUBMED and EMBASE were systematically searched for all indexed articles from 1 January 2000 onwards to focus on more contemporary estimates. Searches were last performed on 15 February 2021.

Studies were eligible if they met the following inclusion criteria:

1. Study cohort included active and/or former coal mine workers and/or subgroups; and
2. Outcome measure was coal mine dust lung disease prevalence, mortality, or survival among coal miners; and
3. Quantitative estimates of coal mine dust lung disease prevalence were presented or could be calculated from reported information; or
4. Quantitative estimates of coal mine dust lung disease mortality or survival were reported.

The scope of the review was limited to English-language peer-reviewed original research articles. Reviews, editorials, commentaries, and conference abstracts were excluded, although when identified through the systematic searches their reference lists were examined for relevant articles.

A total of 405 articles were identified through the initial search queries with two more identified through other sources. The removal of duplicates left 225 potentially eligible records. After initial screening of the title and abstracts, 106 were excluded. Of the remaining 119 full-text articles that were evaluated for eligibility, 40 were retained for the review, of which 15 were eligible for meta-analysis.

2.1. Study characteristics

Location: Of the 40 included studies (including prevalence, mortality, and survival outcomes), 29 were from the United States (USA), four from China, three from the United Kingdom (UK), and one each from Australia, Ukraine, South Africa, and Turkey.

CWP definition: All included studies either used the International Labour Organization (ILO) classification system (7) or one based on it (the studies located in China) to define CWP and silicosis.

Data source: Data for all studies were sourced from population-based surveillance of coal miners (n=19), surveys (n=7), and various administrative databases, including clinical records, death registry and autopsy databases.

Outcome measures: Thirty-one studies reported coal mine dust lung disease prevalence; eight provided some measure of mortality from coal mine dust lung disease and one presented survival statistics.

Follow-up duration: Twelve studies reported long-term coal mine dust lung disease prevalence rates (at least 15 years follow-up), seven medium term (6-14 years) and 12 short-term (≤ 5 years).

2.2. Summary of results and key findings

To the best of our knowledge, this is the first systematic review and meta-analysis on contemporary prevalence of CWP worldwide. Prevalence rates stratified by CWP disease severity and by mine type (underground versus surface) were summarised. Combining the study-specific estimates through meta-analysis effectively increased the sample size and improved the precision of the summary effect. Limited studies for other diseases in the spectrum of coal mine dust lung disease such as silicosis and COPD meant that summary estimates for them could not be generated.

Thirty-one articles on coal mine dust lung disease prevalence were included in this review, with the majority (n=28) reporting prevalence of CWP and/or least one CWP subtype by disease severity. A summary of key characteristics of these 31 prevalence studies are presented in FIGURE 1, FIGURE 2 and FIGURE 3.

FIGURE 1 COUNTRIES AND DATA SOURCES FOR N=31 PREVALENCE STUDIES INCLUDED IN THE SYSTEMATIC REVIEW.

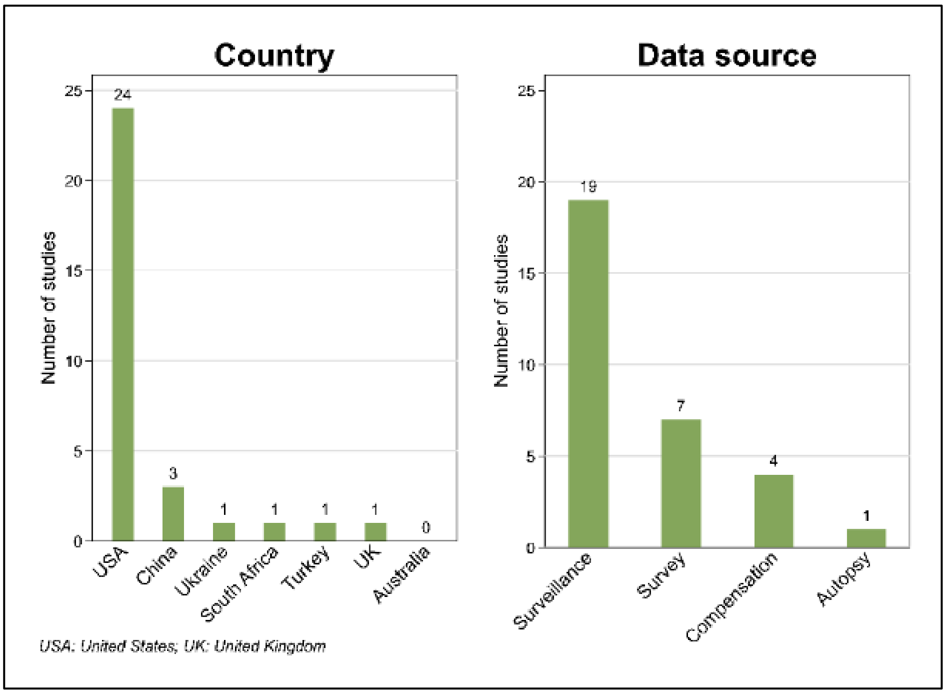


FIGURE 2 COAL MINE TYPE CONSIDERED BY N=31 PREVALENCE STUDIES INCLUDED IN THE SYSTEMATIC REVIEW.

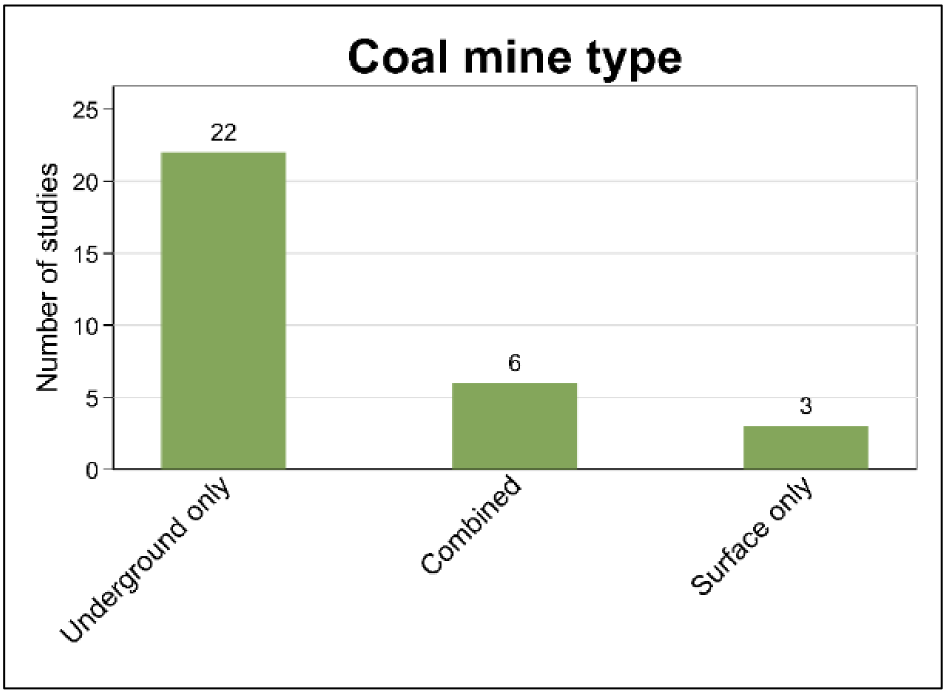
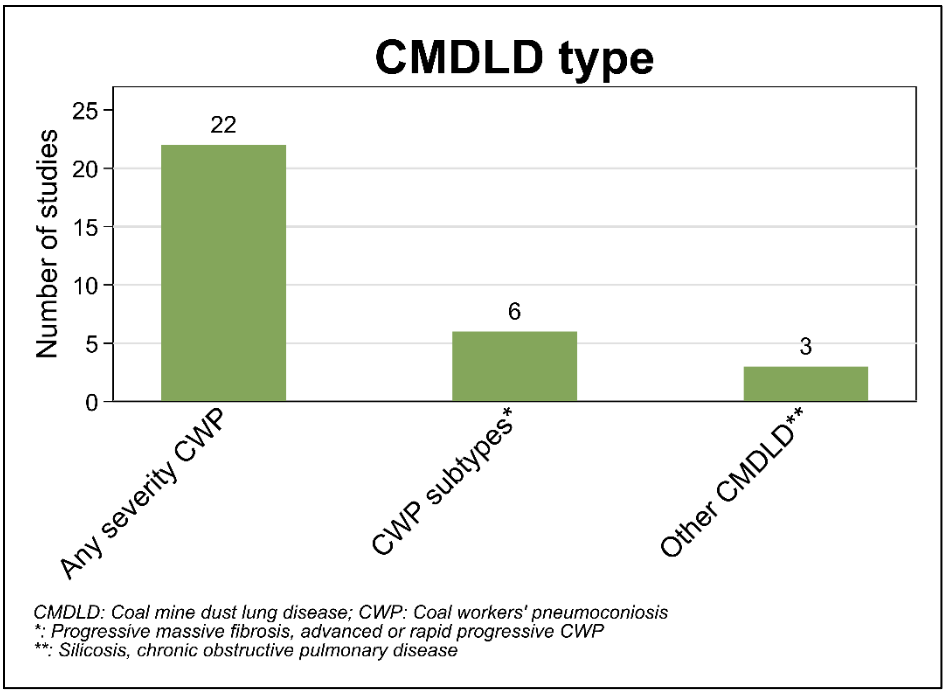


FIGURE 3 COAL MINE DUST LUNG DISEASE TYPES CONSIDERED BY N=31 PREVALENCE STUDIES INCLUDED IN THE SYSTEMATIC REVIEW



Fifteen of the 31 prevalence studies were retained for meta-analysis. Articles were excluded on the grounds that they either reported estimates for population sub-groups only, were not comparable in terms of underlying population or did not have sufficient information to be included.

Our comprehensive systematic review found that the majority of prevalence studies (24 out of 31) on the prevalence of CWP or other coal mine dust lung disease were from the USA and 12 of 15 studies included in the meta-analysis were from the USA.

Although all the studies included in the systematic review reported prevalence rates as a percent (or per 100 coal miners), for this report these rates have been converted to per 1,000 workers, for ease of comparison with the prevalence rates calculated for Queensland in this report.

There was considerable variability in the prevalence of CWP by country. The estimated prevalence of CWP among coal miners ranged from 8 cases per 1,000 coal miners in the UK (1998-2000), (8) 12-62 cases per 1,000 coal miners in Turkey, China and South Africa (1960-2014) (9-13) and 21-30 cases per 1,000 coal miners in several studies from the USA based on national surveillance data (14-22) of the current coal miner workforce over similar time periods. Two other studies from the USA used compensation data to report widely varying estimates of 2 cases per 1,000 coal miners among Medicare beneficiaries (23) and 338 cases per 1,000 coal miners among miners who applied for benefits through the federal black lung benefits program (24), probably reflecting differences in data collection methods.

In addition, operational characteristics of the mine also influenced the prevalence of CWP. (15, 25) For example, workers from larger mines (at least 50 employees) had a lower CWP prevalence than those from smaller mines in the USA (20 versus 56 cases per 1,000 coal miners) from 1996-2002. (15) CWP prevalence also increased with longer coal mining tenure from 24 cases per 1,000 coal miners (≤24 years) to 54 cases per 1,000 coal miners (at least 25 years tenure) (1996-2002) in the USA. (15) The term 'coal mining tenure' in the context of this review refers to the duration of employment in the coal mining industry.

Regional patterns were also observed in the prevalence of CWP for USA. Underground miners from the Central Appalachian region (USA states of Kentucky, West Virginia, and Virginia) had consistently higher prevalence of CWP in the late 2000s (65-101 cases per 1,000 coal miners) than underground miners from other mining regions in the USA (16-36 cases per 1,000 coal miners). (19, 21) This same regional pattern was also observed for tenure-specific prevalence rates among both short (21) and long-term tenured miners. (21, 26) For example, among underground miners with at least 25 years tenure, CWP prevalence from 2013-2017 was four-fold higher in Central Appalachia than other states combined (200 versus 50 cases per 1,000 coal miners). (26)

There was a suggestion that CWP prevalence was higher among bituminous underground coal miners than for surface miners. The overall CWP prevalence among surface miners in the USA was around 20 cases per 1,000 coal miners nationally (15, 20, 27, 28), and about twice that in Central Appalachia. (27, 28)

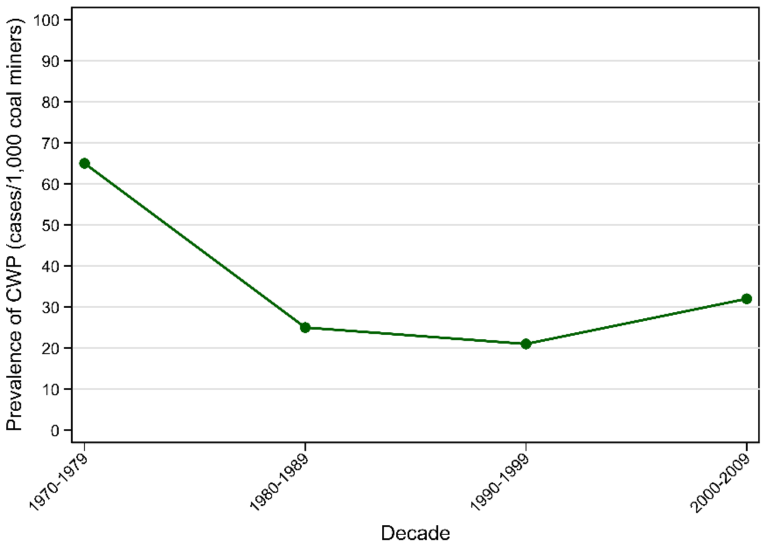
Progressive massive fibrosis (PMF) is considered the most severe stage of CWP and other types of pneumoconiosis. The estimated prevalence of PMF ranged from 2 to 71 cases per 1,000 coal miners across 15 included studies, all from the USA. (15-20, 22, 24, 25, 27, 29-33) The magnitude of the estimates varied by data source, study time period and region. For example, the long-term PMF prevalence (since the 1970s) among claimants to the USA federal black lung benefits program (29) was around four times higher than the corresponding estimate based on national surveillance data for underground miners over a similar time period (15 versus 3 cases per 1,000 coal miners). (17) This is to be expected, since the black lung benefits cohort only included those coal miners who had made a compensation claim for a debilitating lung disease.

In the context of this review, advanced CWP was defined as an ILO profusion sub-category of ≥2/1. If there was development of PMF and/or an increase in small opacity profusion greater than one ILO sub-category over five years, this was indicative of rapidly progressive CWP. The prevalence of advanced forms of CWP was also higher among Central Appalachian miners (27, 31, 34) than other regions. (14, 18, 19) For example, the overall short-term prevalence of rapidly progressive or advanced CWP was 12 cases per 1,000 coal miners (2005-2009) (19) and 8 cases per 1,000 coal miners (2010/2011) (27) respectively in the USA, although two-year estimates were higher among Central Appalachian miners than elsewhere (13 versus 4 cases per 1,000 coal miners).

One study each reported that the prevalence of silicosis among surface miners from 1996/1997 in the USA was 67 cases per 1,000 coal miners (35) while COPD prevalence among underground miners in the Ukraine from 2000/2002 was 149 cases per 1,000 coal miners. (36)

The prevalence of CWP was also found to vary over time with one study from the USA reporting that after a downwards trend over 30 years from 1970s onwards, it started to increase again in the 2000s (Figure 4). (17) This temporal trend was especially evident among long-tenured miners, both nationally and regionally. (26) Only one study reported trends in PMF prevalence and found it began increasing since 1978 in the USA with a sharper increase from 1998 to 2016. (29)

FIGURE 4 PREVALENCE OF COAL WORKERS' PNEUMOCONIOSIS (CWP) AMONG UNDERGROUND COAL MINERS IN THE UNITED STATES, BY DECADE, 1970/2009.



Data sourced from Laney AS and Attfield MD. Coal workers' pneumoconiosis and progressive massive fibrosis are increasingly more prevalent among workers in small underground coal mines in the United States. Occup Environ Med 2010; 67: 428-431. Published prevalence rates (%) were converted to rates per 1,000 coal miners.

Pooled prevalence estimates

Meta-analysis was used to combine prevalence rates from different studies, effectively increasing the sample size and, consequently, the precision of the estimates. The pooled overall prevalence for CWP of any severity among underground miners was 34.5 cases per 1,000 coal miners (95% CI: 27.7-41.3) over 11 studies (Figure 5) with a high heterogeneity between studies (I^2 =99.6%, P <0.001). For PMF, the pooled estimate among underground coal miners was 3.5 cases per 1,000 coal miners (95% CI: 2.2-4.9) in the USA over seven studies (Figure 6). Combined estimated prevalence of advanced CWP among underground coal miners was 9.0 cases per 1,000 coal miners (95% CI: 6.1-11.9) over three studies in the USA (Figure 7). For both PMF and advanced CWP, heterogeneity between the studies was high (PMF: I^2 =99.7%, advanced CWP: I^2 =94.8%) and statistically significant (P <0.001). No publication bias was detected for any of these meta-analyses (Egger P >=0.50).

Figure 5 Variation in overall prevalence of coal workers' pneumoconiosis (CWP) among underground coal miners.

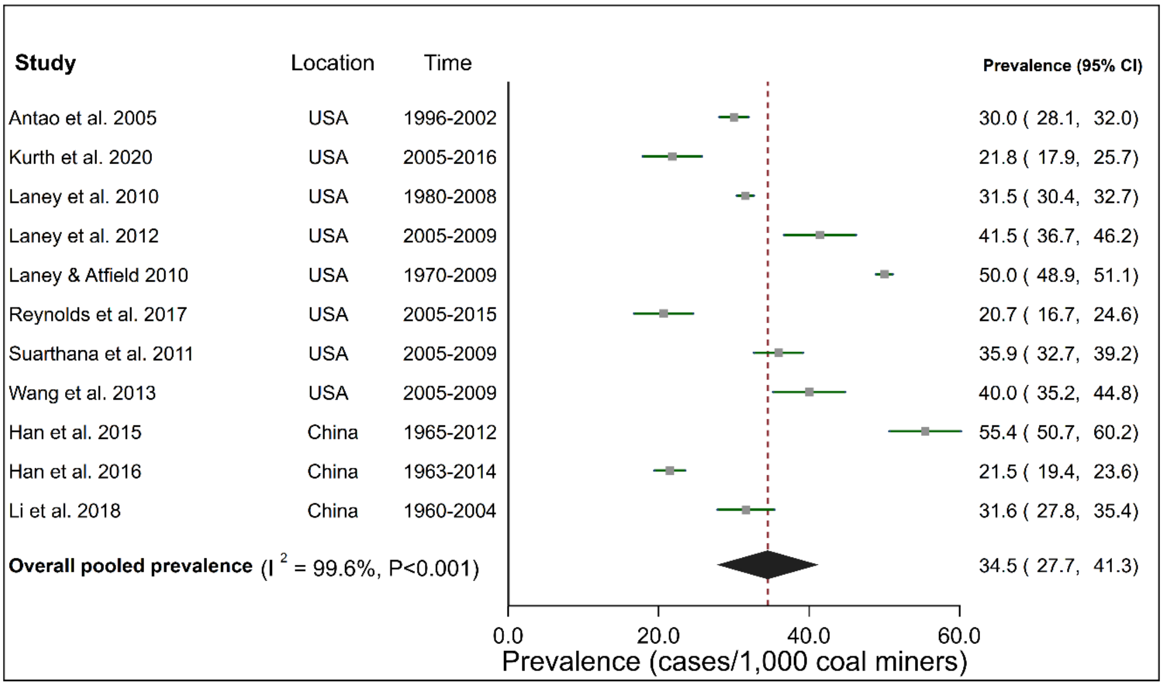


Figure 6 Variation in prevalence rates of progressive massive fibrosis (PMF) in the United States (USA).

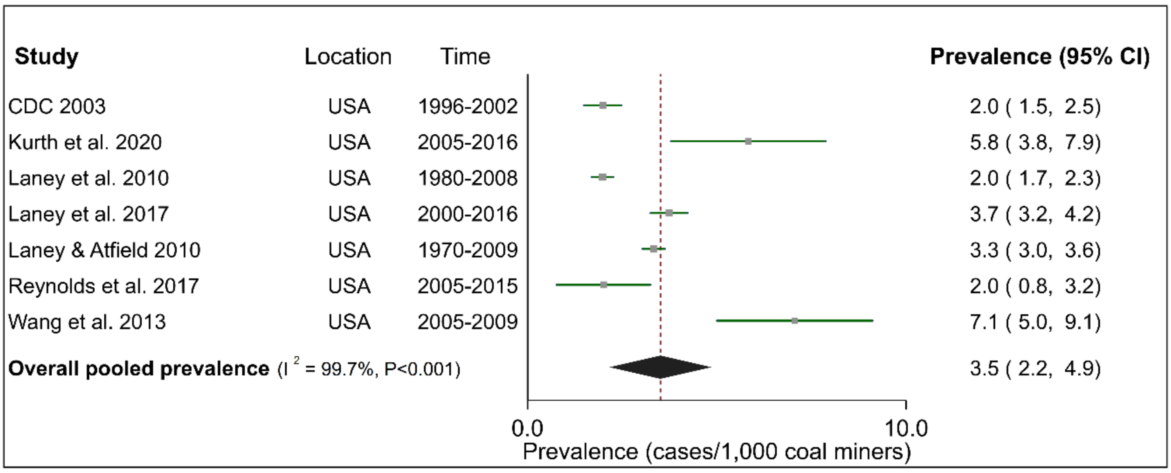
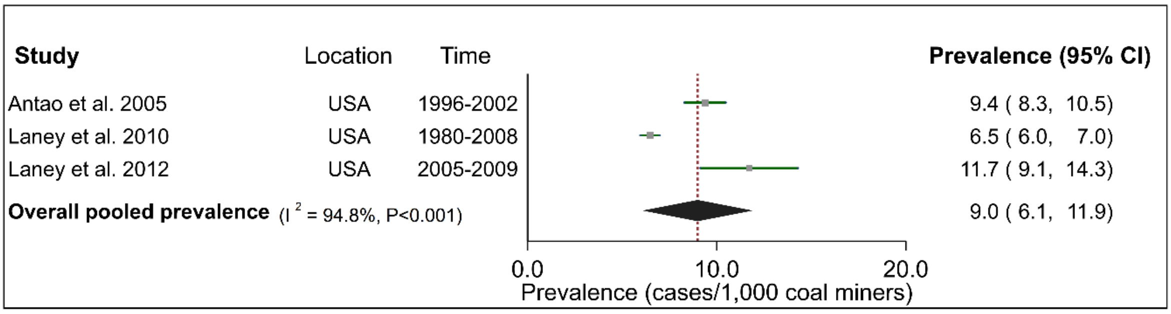
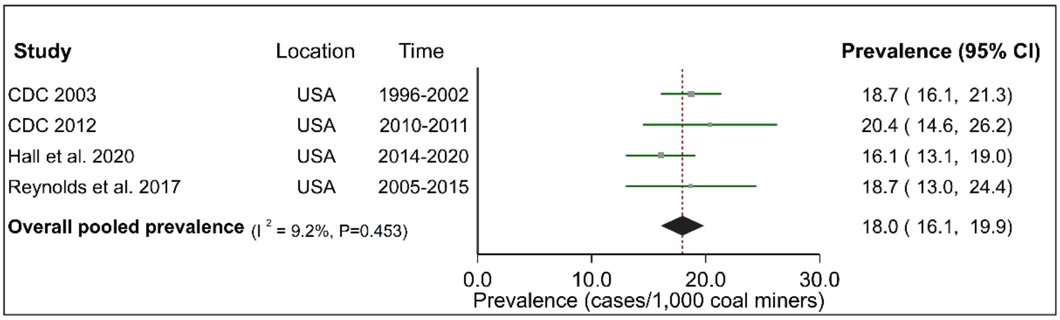


Figure 7 Variation in prevalence rates of advanced coal workers' pneumoconiosis in the United States (USA).



Summary estimates of CWP prevalence among surface miners in the USA across four studies was 18.0 cases per 1,000 coal miners (95% CI 16.1-19.9%) with low but significant heterogeneity (I2 =9.8%, P <0.001) (Figure 8) between studies.

Figure 8 Variation in prevalence rates of coal workers' pneumoconiosis among surface miners in the United States (USA).



The review highlighted the lack of published prevalence rates for coal mine dust lung disease of any type including CWP in Australia. In contrast to the United States, for example, there is no national reporting system in Australia. However, in July 2019, Australia's first dust-related lung disease register was established in Queensland, to which diagnosed cases of certain occupational dust lung diseases state-wide must be notified under statutory requirements. (37) Since 2015, RSHQ has received reported cases of coal mine dust lung disease, including through its compulsory Health Assessment scheme for coal miners and accepted claims from the workers' compensation scheme.

There was also a lack of studies on coal mine dust lung disease prevalence from countries other than the USA.

<u>Survival from coal mine dust lung disease</u>

Only one article, from China, (38) was found on survival for miners with CWP, but it did not report a specific estimate for five-year survival.

<u>Mortality due to coal mine dust lung disease</u>

Eight published articles were found on mortality due to pneumoconiosis, of which five were from the USA. Reductions in CWP mortality rates were reported in the USA (39-41) and Australia. (42) However, these mortality rates are in terms of the whole population, rather than specifically rates among coal miners, probably because it is difficult to determine the size of the population that have had occupational exposure to coal mine dust. For example, in the USA, the CWP mortality rates (ASMR per 1 million population) decreased significantly from 4.7 in 1999 to 1.0 in 2018. (40) In Australia, CWP mortality rates (ASMR per 1 million males) decreased from 0.6 (1988-1990) to 0.1 in 1994-1996, then remained around 0.1 until 2002 when the study ended. (42) Four other studies found that cumulative exposure to coal mine dust was associated with increased mortality from pneumoconiosis or COPD at long-term follow-up of population-based cohorts of coal miners compared to the age-matched general male population in the USA (43, 44) and the UK. (45, 46)

Mortality rates may have been underestimated due to misclassification of CWP deaths in coding the cause of death. In addition, mortality rates were calculated based on the entire population and as such cannot account for the effect of any change in the proportion of the population who have worked as coal miners on CWP mortality trends.

Possible explanations of results

Possible contributors to increases in the prevalence of coal mine dust lung disease in the modern era include longer working hours resulting in greater exposure, changes in mining processes associated with increased mechanisation, increased dust exposure, changes in dust composition, poorer compliance to current dust standards and inadequate dust control levels. (1, 5, 14, 25)

3. Quantitative study of coal mine dust lung disease cases in Queensland

Given the lack of prevalence data on coal mine dust lung disease in Australia, and particularly Queensland, this report estimated how prevalent coal mine dust lung disease was in Queensland, considering the size of the mining workforce population. This will provide an indication of the extent of the number of cases of disease diagnosed in Queensland to inform policy and prevention.

This section describes the study cases, statistical methodology, and details about the population at risk, or the population of coal miners in Queensland.

3.1. Ethics approval

Ethics approval to conduct this study (GU Ref No: 2020/324) was obtained from the Griffith University Human Research Ethics Committee.

Data access was approved by the Acting Executive Director - Occupational Health & Hygiene, Resources Safety and Health Queensland (RSHQ).

3.2. Data

RSHQ receives reports of coal mine dust lung disease from a variety of sources including Appointed Medical Advisers via the Coal Mine Workers' Health Scheme (CMWHS), Site Senior Executives at a mine and the Office of Industrial Relations (OIR) via the workers' compensation scheme.

RSHQ also obtained approval to provide Cancer Council Queensland (CCQ) researchers with the OIR dataset on the condition that the personal information provided was confidential information and treated accordingly by the CCQ researchers.

RSHQ provided CCQ with a list of confirmed cases that they considered to be within the scope of this study. As of 30 September 2020 (the data ascertainment cut-off), there were a total of 168 cases of coal mine dust lung disease made available.

Given the financial year reporting requirements of RSHQ, the results in this study were reported by financial year, with a study cut-off date of 30 June 2020. This meant that those cases of coal mine dust lung disease that were diagnosed between 1 July 2020 and 30 September 2020 (n=2) were excluded from this study, leaving a total number of cases of n=166 that comprised the study population for analysis.

All data were transferred and stored using secure processes agreed to by the data custodians.

3.2.1. Data extraction

After discussions with RSHQ, information on the following data items were extracted from the study records provided in PDF format (Table 1). Note that while names were recorded for the study dataset, these were only used for data checking purposes and not in any analysis or reporting.

TABLE 1 VARIABLES DOWNLOADED FROM THE DATASET.

Data item	Description	Percent missing (%)
Notification source	RSHQ, OIR or unidentified sources	0.0
Worker code	As provided by RSHQ, unique identifier for internal use	0.0
Sex	Sex	0.0
DOB	Date of birth, used for calculation of age groups	1.2
Residential address (suburb/town)	Residential address at the time of diagnosis (if available) or address of usual or most recent residence	16.3
Residential postcode	Residential postcode at the time of diagnosis (if available) or postcode of usual or most recent residence	16.3
Ever worked coal mine name 1 to 5	Names of coal mines where the worker was employed. Numbered 1 to 5 and ordered from most recent to least recent place of employment; coal mines in Queensland only	13.9
Coal mine type	Whether the worker was employed at either surface or underground mines or both, determined using the name of the coal mine that miners have worked in (see above data item)	19.3
Mining sector(s)	Coal; Coal & minerals, Coal & quarries, Coal, Minerals & quarries	0.0
Year's mining total	Length (in years) of mining occupational exposure	25.9
Number of years worked in coal mines	Length (in years) of exposure to coal dust	29.5
State/Territory of coal mine(s)	List of state/territory of coal mines ever worked	33.1
Locality of mine	Whether the mining experience was Queensland only, or also included Interstate; International; or both Interstate and International	28.9
Year first started work in coal mines	Used for calculation of age at entry into coal mine industry	12.7
Number of years worked in surface coal mines	Number of years worked in surface coal mines	41.0
Number of years worked in underground coal mines	Number of years worked in underground coal mines	39.2
Number of years worked in other types of mines	Possible occupational exposure history in mining and resources (excluding coal mines) and/or quarrying	43.4
Number of years worked in other dusty jobs	Other possible occupational exposure history in manufacturing, construction, power, transport or other	51.2
Most recent job type	Refers to standardised coal mine worker positions[1], there are six major categories: managers, professionals, tradespersons and related workers, clerical and service workers, production and transport workers and labourers and related workers	9.0
Similar Exposure Group (SEG) 1-4	Used to identify a group of workers who have the same general exposure to risks. List from most commonly to least commonly applicable[2]	68.7
Employer type	Mine operator; contractor to one or more mines; supplier to one or more mines; labour hire	13.9
Smoker status	Ex-smoker; Current smoker; Never-smoker	15.1
Years first started smoking cigarette	How many years since they started smoking	63.3
Age at first smoking (years)	Age when they first started smoking	33.7
Quantity cigarette(s)/day	Quantity of cigarettes smoked per day (based on most recent information available)	31.3
Cease smoking (Y/N)	Whether the person has reported quitting smoking	37.4
Year ceased smoking	When they quit smoking (if applicable)	72.9

Data item	Description	Percent missing (%)
Age ceased smoking	What age they quit smoking (if applicable)	59.0
Date of most recent chest X-ray	Date of the most recent chest X-ray	14.5
Whether X-rays were dual read or not? (Y/N)	Examination of chest X-rays to the ILO classification is conducted by at least two B-readers. The dual read B-reader process was previously provided by the University of Illinois at Chicago (USA-based B-reading, since July 2016) and since March 2019 has been provided by Lungscreen Australia.	14.5
Date of radiograph	Date of chest X-rays taken under the scheme[3]	14.5
Date of reading	Date of dual-read service provided by USA-based B-reader (chest X-rays taken before 1 March 2019) or Lungscreen Australia	45.8
Type of reading	Reader B; Adjudicated Australian radiologists must register as a B-reader to provide the first examination of a chest X-ray to the ILO classification; Lungscreen Australia perform the second B-read and any adjudications	45.8
Any parenchymal abnormalities? (Y/N)	Parenchymal abnormalities include both small opacities and large opacities	45.2
Small opacities profusion category	Profusion of small opacities refers to the concentration of small opacities (i.e. any area in the chest radiograph that is whiter than it should be) in affected zones of the lung. The category of profusion is based on comparison with the standard ILO radiographs. Four categories are defined as: Category 0, Category 1, Category 2, or Category 3[4]	66.9
Small opacities profusion subcategory	Profusion is classified into 1one of 12 ordered subcategories: 0/-, 0/0, 0/1, 1/0, 1/1, 1/2, 2/1, 2/2, 2/3, 3/2, 3/3, 3/+	68.1
Small opacities shape/size primary	For CMDLD there are categories of shape (rounded, irregular), and size (3 sizes). Two letters must be used to record shape and size, separated by an oblique stroke (for example q/s). For small, rounded opacities, the three size ranges are denoted by the letters p (diameters ≤1.5mm), q (1.5mm<diameters≤3mm) and r (3mm<diameters≤10mm). The three size ranges of small irregular opacities are denoted by the letters s (diameters ≤1.5mm), t (1.5mm<diameters≤3mm) and u (3mm<diameters≤10mm). The letter for the predominant shape and size (primary) is recorded before the oblique stroke, while the letter for the less frequently occurring shape and size (secondary) is recorded after the oblique stroke[4]. Possible range: p/, q/, r/, s/, t/, u/	68.1
Small opacities shape/size secondary	Possible range: /p, /q, /r, /s, /t, /u	68.1
Large opacity size	Large opacities, defined as opacities having the longest dimension exceeding 10 mm, is classified into three categories with increased size of large opacities: Category A, Category B, or Category C	68.1
Source of ILO classification	Where the ILO classification was obtained from: Lungscreen (Australia); USA-based	45.8
Chest CT or HRCT scan (Y/N)	Whether a chest CT scan or HRCT scan was carried out	53.6
Date of CT scan	Date of CT or HRCT scan	60.8
Date of respiratory test (most recent available)	Date of most recent respiratory test	9.0
Overall spirometry result	Normal; abnormal; mild obstruction, severe obstruction, mild restriction	13.9

Data item	Description	Percent missing (%)
Diagnosis established	CWP, Silicosis, Multiple CMDLD; COPD; Mixed dust pneumoconiosis (MDP); Asbestosis; Other mine dust lung disease (for example, diffuse dust-related pulmonary fibrosis (DDF), lung cancer)	0.0
Subcategory of CMDLD - 1 (Multiple CMDLD, or MDP, or other mine dust lung disease)	Categorised as CWP; Silicosis, COPD, DDF, Lung cancer	46.4
Subcategory of CMDLD – 2 (Multiple CMDLD, or MDP, or other mine dust lung disease)	Categorised as CWP; Silicosis, COPD, DDF, Lung cancer	88.0
Respiratory physician report available (Y/N)	Whether the respiratory physician report was available	8.4
Date of Respiratory physician report	Often used as date of diagnosis	59.6
Respiratory symptoms: Wheezing (Y/N)	Whether wheezing was recording on the medical record	28.3
Respiratory symptoms: Cough (Y/N)	Whether a cough was recorded on the medical record	55.4
Other comorbidities - Asthma (Y/N)	Whether asthma was recorded on the medical record	22.9
Date of most recent record	Date of the most recent medical record for a person	7.2
Most recent record type	Type of most recent medical record available for a person	7.2
Comments	Open ended text field for additional information to be recorded	Not applicable

[1] Standardised coal mine worker positions available on the DNRME website: https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0003/1386048/standardised-coal-mine-worker-positions.pdf
[2] Similar Exposure Group (SEG) information available on the DNRME website: https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0008/977498/similar-exposure-groups.pdf
[3] The Coal Mine Workers' Health Scheme
[4] Based on ILO international Classification of radiographs of pneumoconiosis (7)

3.3. Methods

3.3.1. Definition of coal mine dust lung disease

Advice from RSHQ was that while there is not a formal definition of coal mine dust lung disease based on legislation or any published document, the operational definition developed to ensure a level of confidence that a coal mine dust lung disease case was legitimate was as follows:

> RSHQ records cases of coal mine dust lung disease that are reported to them as lung conditions that are determined to be caused by mine-related dust exposure. Cases are reported to RSHQ through assessments that diagnose a coal mine dust lung disease under the Coal Mine Workers' Health Scheme, normally based on a Respiratory Physician report; notifications received from the Office of Industrial Relations of an accepted workers' compensation claim for an injury of a coal mine dust lung disease; or a notification to a Mine Inspector by the Site Senior Executive of a mine site.
> Coal mine dust lung disease types include the following types:

- COPD
- Silicosis
- CWP
- Mixed dust pneumoconiosis
- Asbestosis
- Other coal mine dust lung disease (for example, diffuse dust-related pulmonary fibrosis, lung cancer).

If “Other” was recorded in the column “Type of CMDLD” of the spreadsheet “Supplementary data on confirmed CMDLD cases” provided by the RSHQ, “Other” was assigned as “Diagnosis established” in the analysis data set.

3.3.2. Geographical areas

Information about the residential street address and postcode at the time of diagnosis (if available) or the street address of the usual or most recent residence was used to obtain the 2016 Statistical Areas Level 2 (SA2). (47) SA2 areas are medium-sized general purpose geographical areas developed by the Australian Bureau of Statistics whose purpose is to represent a community that interacts together socially and economically. There are 528 SA2 areas that cover Queensland. These SA2 areas were then used to allocate remoteness and area-level socio-economic status to each coal mine dust lung disease record.

Remoteness was defined using the Australian Bureau of Statistics Remoteness Areas, which divides geographical areas in Australia into five categories of remoteness: major city, inner regional, outer regional, remote and very remote on the basis of relative access to services. (48)

Area level socio-economic status was defined using the Australian Bureau of Statistics Index of Relative Socio-economic Advantage and Disadvantage. (49) This is a general socio-economic index that summarises a range of information about the economic and social conditions of people and households within a geographical area, including both relative advantage and disadvantage measures. The values of this index are generally grouped into five quintiles, representing least disadvantaged areas to most disadvantaged areas.

3.3.3. Date of diagnosis

According to RSHQ, the date of diagnosis referred to the date on which a Specialist Physician first diagnosed a coal mine worker with coal mine dust lung disease. If this date could not be determined, RSHQ used the date on which an Appointed Medical Adviser reported a coal mine dust lung disease diagnosis on the CMWHS Health Assessment report, Section 4.

Cases referred to the RSHQ by the OIR (but not other sources) did not necessarily have a date of diagnosis. If RSHQ were originally notified by OIR then subsequently received a completed CMWHS Health Assessment report, Section 4 for that worker, they were able to record a date of diagnosis in their database. If they did not receive the Section 4 form, no date of diagnosis was recorded. RSHQ refer instead to 'date they were notified' or similar. For this reason, the date of diagnosis would be an unreliable variable for those cases.

Two methods were used to determine the date of diagnosis for the cases.

Method 1:
Where available, we used the RSHQ provided "Date of Respiratory Physician report" to assign the date of diagnosis for coal mine dust lung disease for our data set. If this information was missing, the "most recent record date" was used if the "most recent record type" was CMWHS Section 4.

Method 2:
Otherwise, the date of diagnosis was considered to be the "Date of reading" of the X-ray by the B-reader where available, or the "Date of CT scan". This assumption was made because X-ray dual reading and medical review (which may include a HRCT scan) is an essential process during a coal mine dust lung disease diagnosis.

3.3.4. Prevalence rates

Prevalence represents the proportion of people in a defined population who have a particular disease or attribute at a specified point in time (point prevalence) or over a specified period of time (period prevalence). While prevalence includes both newly diagnosed and pre-existing cases in the population, incidence is limited to new cases in the population only.

Point prevalence is defined as the prevalence measured at a particular point in time, for example on 30 June 2020. It is interpreted as the proportion of people with a particular disease on a particular date.

Period prevalence is defined as the prevalence measured over an interval of time, such as 1 July 2019 to 30 June 2020. It is interpreted as the proportion of people who have had a particular disease at any time during that interval including those who died from it.

While the term "prevalence" is a proportion or rate, for this report we will use the term "prevalence count" and "prevalence rate" to clearly distinguish whether the measure refers to the number of prevalence cases, or the prevalence as a rate. Note that point and period prevalence can be calculated as expressed as counts or rates.

It can be problematic to calculate prevalence rates for diseases that are related to occupational exposure and have a lag between exposure and disease onset. The population at risk of the disease may no longer be exposed to the risk at the time of disease onset and so care must be taken to ensure that the numerator and denominator for the rate refer to the same population.

The population of coal miners changes over time, with workers commencing and leaving their employment on an ongoing basis. In addition, once a person is diagnosed with coal mine dust lung disease, they may continue to be actively working within the coal mine industry (even with a modified role) or they may leave the occupation completely.

Period prevalence rate is calculated by:

$$\frac{\text{Number of new and existing cases during the defined time period}}{\text{Population years at risk over the same time period}} \text{ X } 100\%$$

Point prevalence rate is calculated by:

$$\frac{\text{Number of new and existing cases at a specific point in time}}{\text{Population of coal miners at a specific point in time}} \text{ X } 100\%$$

3.3.5. Population at risk

Please note that for the purposes of this report, the list of coal mine dust lung disease cases was considered complete up to 30 June 2020. Many of the initial calculations to estimate populations were carried out by calendar year, and then converted to financial year. For example, the estimated population for the 2015-2016 financial year would be half the population for the 2015 calendar year plus half the population for the 2016 financial year.

The required population size and characteristics were not available from one data source. Therefore, we needed to make various assumptions when combining different datasets to estimate the full-time equivalent number of miners employed each year and the tenure of employment for each coal miner.

3.3.6. Population - Health Assessment Records

An Excel spreadsheet was provided by RSHQ that contained information about all known Health Assessments ever undertaken. Of these Health Assessments, the vast majority were for males (90.6%), with less than one in ten (9.4%) being for females.

Information was available from the assessment records on the date of the first and last assessment for each coal miner. The estimated coal mining population in Queensland was based on the number and timing of these Health Assessments. For example, if a coal miner first had a Health Assessment in 1986/87 and their most recent assessment was in 2004/05, they individually would be counted in the population for each financial year from 1986/87 to 2004/05.

However, as there were no data available as to their occupational history before and after an assessment, some assumptions needed to be made.

After discussions with RSHQ, it was decided that for anyone entering the coal mining industry from the mid-1980s, the date of their first health assessment could be reasonably assumed to be their start in the industry, unless there was some earlier work history in their records. It is noted this might not be accurate as it assumes 100% compliance with Health Assessment requirements. For miners who began work prior to the implementation of compulsory Health Assessments, the start date would need to be based on their work history, although this information was not always available in the assessment records and so assumptions needed to be made as described on the following pages.

RSHQ also advised that the Health Assessment data for the 2020 calendar year was likely to be incomplete because of the lag in completed assessments. For this reason, we have assumed that the population of coal miners in the first six months of 2020 was the same as that for the first six months of 2019.

There is also a risk of overestimating the population by including the pre-employment Health Assessments for people who did not in fact commence working in the coal mining industry. The Health Assessments database did not distinguish these workers from others who had an initial assessment. However, those workers who had their pre-employment Health Assessment after 2014 may not have had follow-up (five year) Health Assessment data included in the database. For this reason, we have excluded those workers from the Health Assessment-based population estimates whose first Health Assessment was in 2014 or earlier and who only had one recorded Health Assessment. This means that people who worked less than five years in Queensland coal mines prior to 2014 would not be included in the population at risk.

After the last Health Assessment, no further information was available about occupational history or when a miner left the coal mining industry, apart from the implication that an individual left the occupation within a five-year period after their last assessment. These 'original data' assumed that the individual left the occupation at their date of last assessment.

Hence, to estimate the date of an individuals' departure from the occupation, we used various assumptions about the possible distribution of the number of years worked in the coal mining industry after the date of the last Health Assessment. Four probability distributions were considered (Figure 9), with each distribution scaled so that the potential additional years spent in the occupation were between zero and five. These distributions were the gamma distribution (with shape parameter one and scale parameter five), the normal distribution (mean one and variance five), the reverse gamma distribution (with shape parameter one and scale parameter five), and the uniform distribution. For each of these assumptions, the most recent possible financial year was 2019/20.

In addition, we included a fifth option of assuming that the individual did not work as a coal miner after the date of their last Health Assessment ("Original").

Applying these assumptions to the observed data, we obtained the following population estimates by financial year (Figure 10).

FIGURE 9 POSSIBLE PROBABILITY DISTRIBUTIONS FOR ESTIMATING THE (UNKNOWN) NUMBER OF YEARS WORKED BY COAL MINERS FOLLOWING THEIR MOST RECENT HEALTH ASSESSMENT

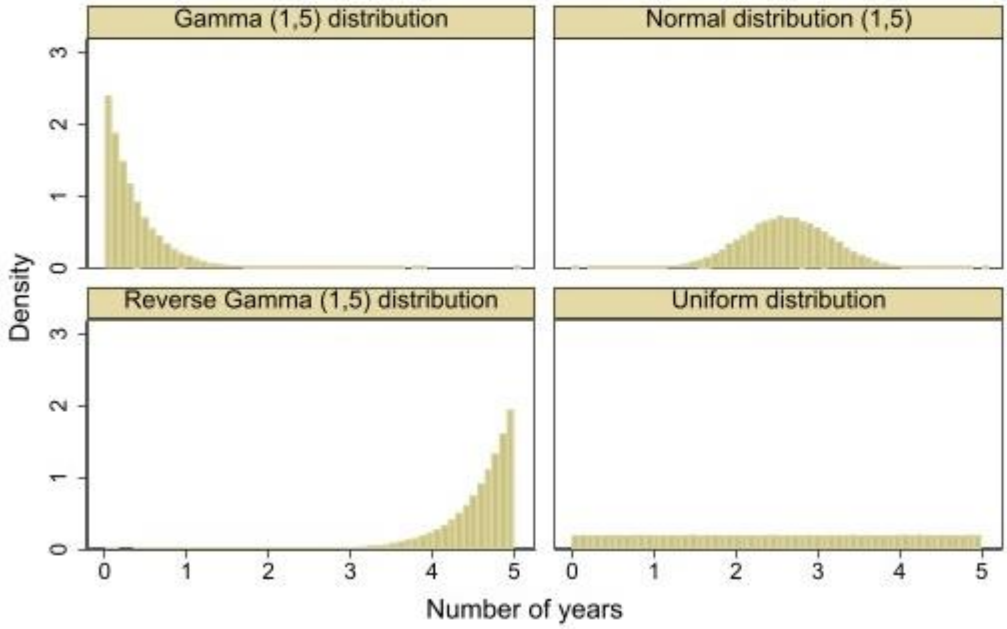
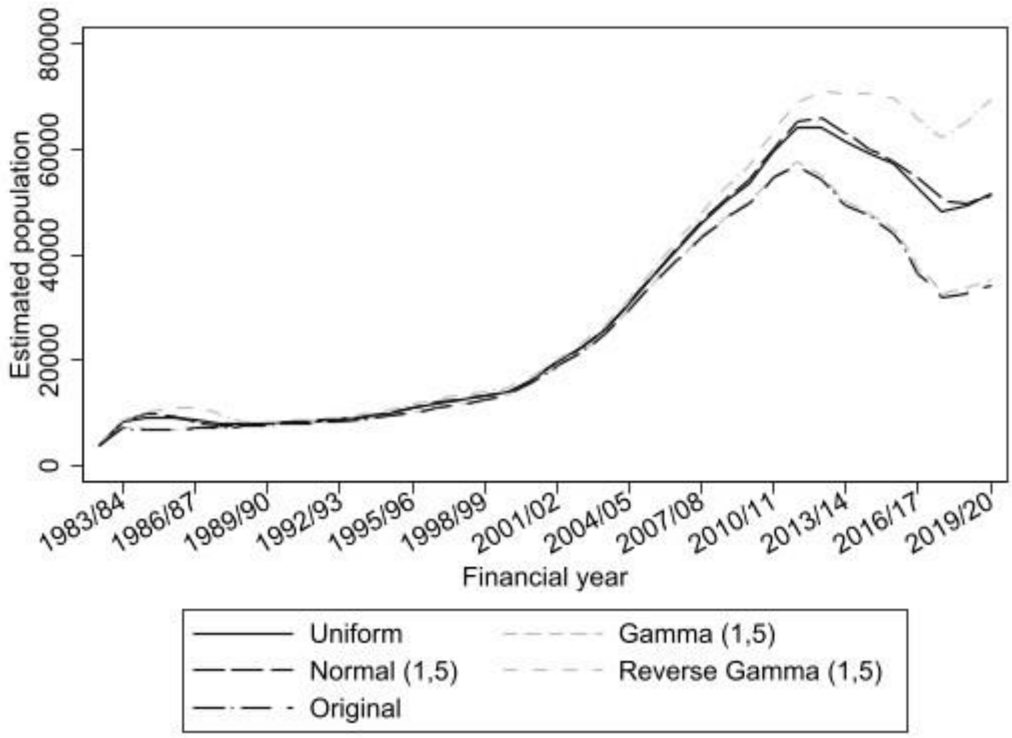


FIGURE 10 ESTIMATED POPULATION OF COAL MINERS IN QUEENSLAND BASED ON VARIOUS ASSUMPTIONS FOR PERIOD AFTER THEIR LAST RECORDED HEALTH ASSESSMENT



As shown above, (Figure 10) the estimated population of coal miners based on their Health Assessment data was relatively low during the 1980s and 1990s, then increased markedly between 2000/01 and about 2013/14, before decreasing again. The extent of the decrease since circa 2013/14 depended on the assumption made about the number of years worked after the date of their most recent Health Assessment.

The estimated population based on the gamma distribution (2019/2020 population: 35,217) was very similar to the "original data" (2019/20 population=34,052), which was expected since this distribution was left skewed, meaning that most of the imputed data would be close to zero years.

Conversely, the highest population estimate (2019/20 population = 69,447) was obtained using the right-skewed reverse gamma distribution, which assumed that most miners would work close to five years after their most recent Health Assessment. The normal (2019/20 population= 51,397) and uniform (2019/20 population= 51,644) distributions generated similar mid-range population estimates.

It is important to note that these estimates represented the numbers of mine workers, and so did not consider any part-time work arrangements.

Rather than taking one of the extreme value distributions, these results suggested that the uniform distribution was the most realistic assumption, in that mine workers had an equal likelihood of ceasing to work in coal mines at some point between zero and five years after their last recorded Health Assessment.

3.3.7. Population - Coal Miners in Queensland from 2013/14 to 2019/20

Since the Health Assessment data was based on number of coal miners, rather than the number of full-time equivalent coal miners, using these data as the population would tend to overestimate the person years at risk, which was the basis for the denominator in the rate calculations. In addition, the Health Assessment data provided no information about the ratio of coal miners working in surface mines compared to underground mines.

To supplement the Health Assessment data, we obtained publicly available data from RSHQ on the quarterly numbers of full-time equivalent mine workers stratified by mine type (underground versus surface) throughout Queensland from the first quarter in 2014 until 31 March 2020. (50) By making various assumptions (as described below), we combined these two sources of population data to estimate the number of full-time equivalent coal miners in Queensland surface and underground mines since 1983/84.

Data was only available for the first quarter of 2020, so it was assumed that the population estimates for the 2019/20 financial year was equal to the average of the first three quarters. Similarly, the population estimate for 2013/14 was based on the January – June average in 2014. We found no evidence that the total miner population varied by quarter between 2014 and 2019.

These data are based on safety and health levy payments to RSHQ and are for full-time equivalents rather than a head count of actual individuals. This is different to the population estimates generated from the Health Assessment data.

FIGURE 11 POPULATION OF FULL-TIME EQUIVALENT COAL MINERS, QUEENSLAND, 2013/14-2019/20

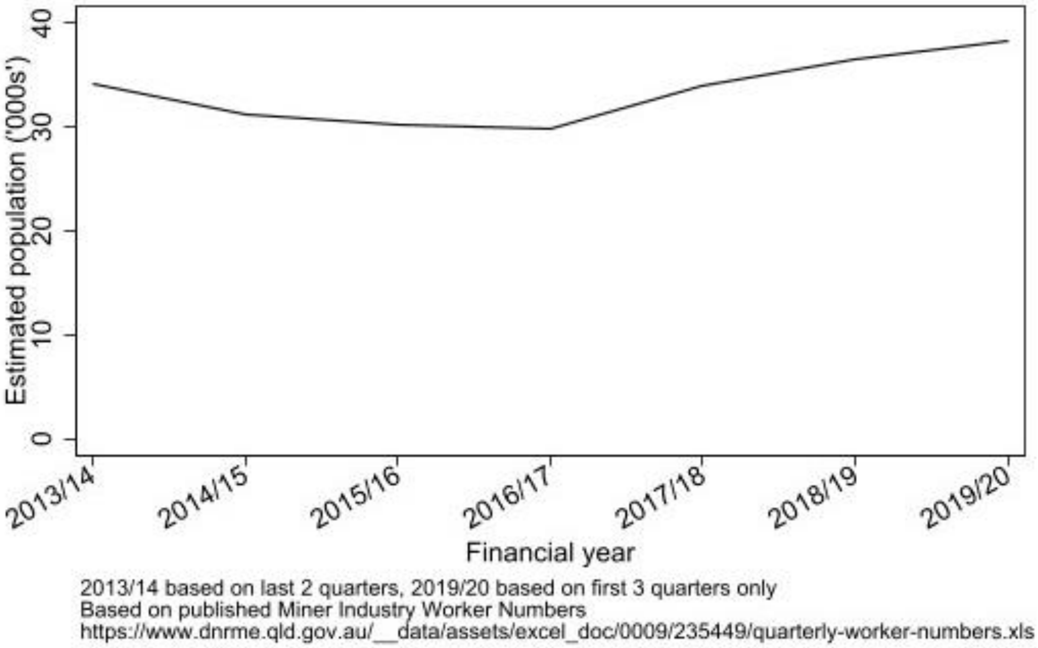
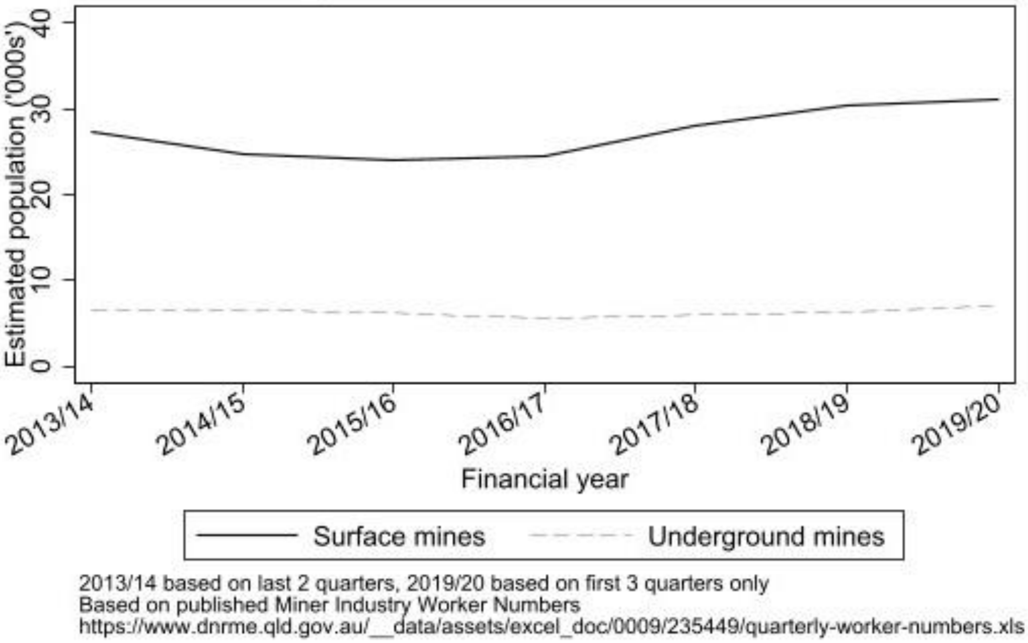
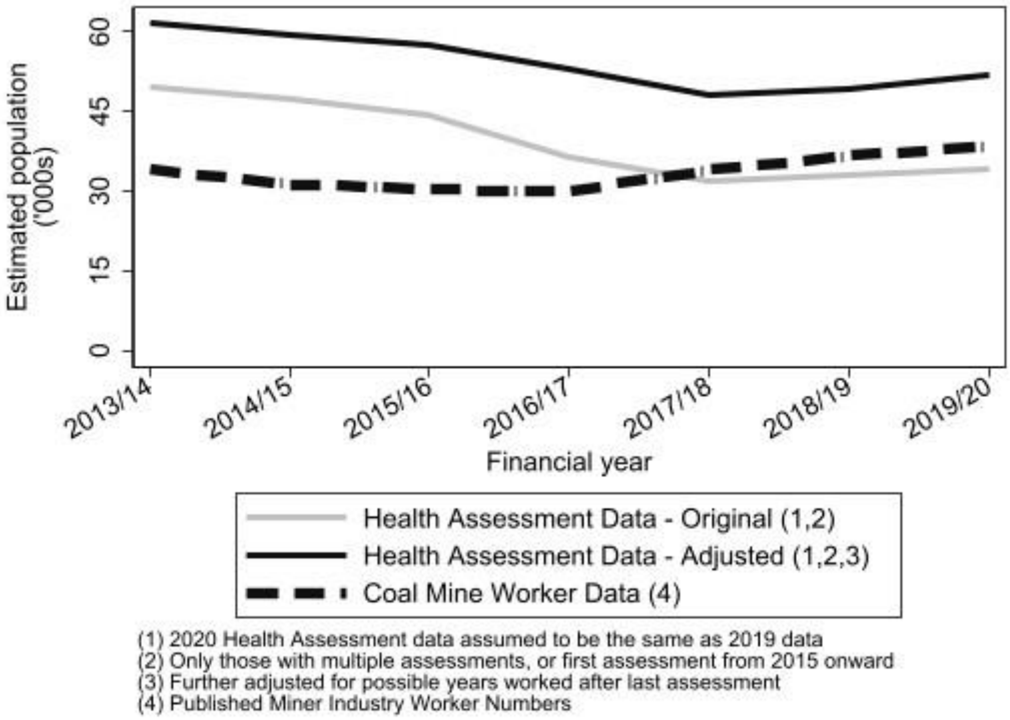


FIGURE 12 POPULATION OF FULL-TIME EQUIVALENT COAL MINERS BY COAL MINE TYPE, QUEENSLAND, 2013/14 TO 2019/20



For the 2013/14 to 2019/20 financial years, we were then able to compare the previously generated Health Assessment-based population estimates with corresponding estimates of full-time equivalent coal mine workers (henceforth referred to as Coal Mine Worker data).

FIGURE 13 ESTIMATED POPULATION OF COAL MINERS - COMPARING HEALTH ASSESSMENT DATA WITH COAL MINE WORKER DATA



As expected, the population estimates from the Coal Mine Worker dataset (50), which was based on the full-time equivalent data (2019/20 population=38,291), were lower than the adjusted population estimates using the Health Assessment data which was based on the number of individual workers (2019/20 population=51,644).

One possible explanation for this discrepancy is that it may reflect the number of mine workers who did not work full time for a specific year.

The information from the Coal Mine Worker dataset on numbers of Queensland mine workers was only available between the first quarter of 2014 and the first quarter of 2020. Hence to estimate these population numbers from 1983/84 to 2012/13, we used the ratio of the Health Assessment data and the Coal Mine Worker data for the observed years (2013/14 to 2019/20) and applied that to the Heath Assessment data for 1983/84 to 2012/13. The value of this ratio varied from a high of 1.90 in 2015/16 to 1.34 in 2018/19, with a mean value of 1.64. We used this mean value across all the financial years with missing population data. The estimated populations (full-time equivalent) of coal miners between 1983/84 and 2019/20 are shown in Figure 14 and Table 2 below.

FIGURE 14 ESTIMATED POPULATION OF COAL MINERS USING HEALTH ASSESSMENT AND COAL MINE WORKER DATA FROM RSHQ

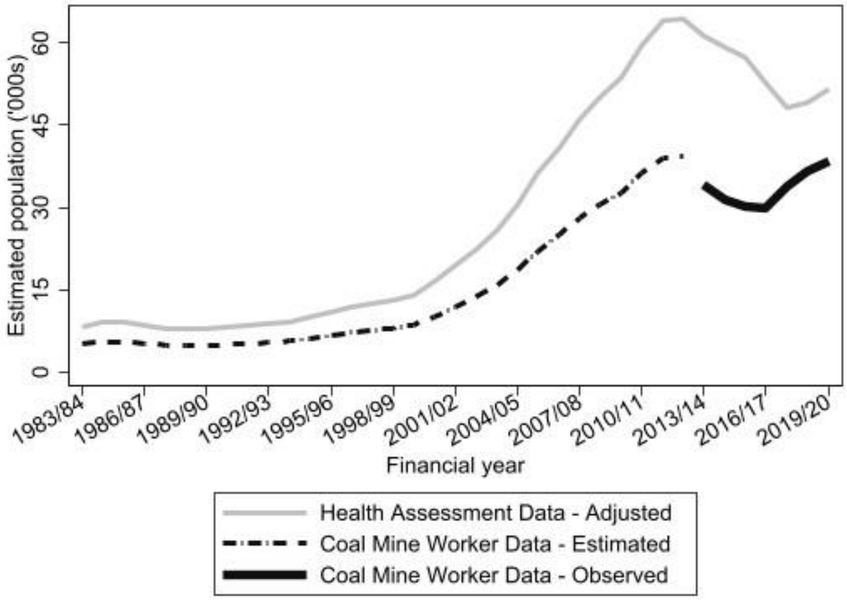


TABLE 2 ESTIMATED POPULATION OF COAL MINERS IN QUEENSLAND USING HEALTH ASSESSMENT AND COAL MINE WORKER DATA

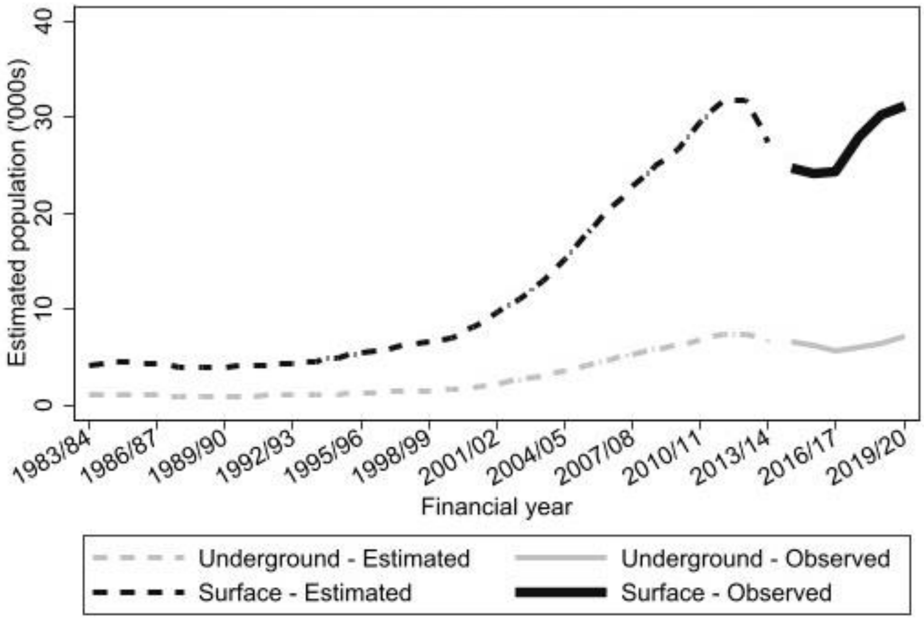
Year	Estimated Coal Mine Worker data [1]	Health Assessment data	Year	Estimated Coal Mine Worker data [1]	Health Assessment data
1983/84	5,104	8,364	2002/03	13,628	22,331
1984/85	5,529	9,060	2003/04	15,768	25,839
1985/86	5,490	8,996	2004/05	18,692	30,630
1986/87	5,242	8,590	2005/06	22,073	36,169
1987/88	4,862	7,968	2006/07	25,034	41,022
1988/89	4,733	7,755	2007/08	28,054	45,970
1989/90	4,880	7,996	2008/09	30,574	50,100
1990/91	5,020	8,226	2009/10	32,747	53,660
1991/92	5,166	8,466	2010/11	36,333	59,536
1992/93	5,350	8,767	2011/12	39,135	64,128
1993/94	5,652	9,262	2012/13	39,218	64,264
1994/95	6,107	10,008	2013/14	34,074	61,469
1995/96	6,661	10,916	2014/15	31,277	59,293
1996/97	7,195	11,790	2015/16	30,292	57,376
1997/98	7,612	12,473	2016/17	29,935	52,767
1998/99	8,027	13,154	2017/18	33,941	48,234
1999/00	8,631	14,143	2018/19	36,603	49,198
2000/01	10,025	16,428	2019/20	38,291	51,644
2001/02	11,919	19,532			

[1] Coal Mine Worker data estimated from 1983 to 2013 using the average ratio of Health Assessment data and Coal Mine Worker data from 2014 to 2020.

It was also assumed that the ratio of underground to surface coal mine workers between 2014 and 2020 remained the same as between 1983 and 2013, and this was applied to the population estimates described above. The validity of this assumption was not able to be assessed; if the proportion of coal miners who work in each type of mine had changed substantially over time, this would mean the estimated prevalence rates calculated in this report are higher or lower than the actual correct rates.

Between 2014 and 2020, the number of full-time equivalent surface mine workers was between 3.7 (2014/15) and 4.7 (2018/19) times higher than the corresponding values for full-time equivalent number of underground mine workers (See Figure 15 and Table 3 below), with an average value of 4.3.

FIGURE 15 ESTIMATED POPULATION (FULL TIME EQUIVALENT) OF COAL MINERS IN QUEENSLAND BY COAL MINE TYPE



For each year that a person was alive after being diagnosed with coal mine dust lung disease, we needed to estimate the combined cumulative exposure of coal miners up to and including that year. For example, if we were interested in the amount of previous exposure that coal miners in Queensland had up to 2015/16, we determined the number of workers involved in the Health Assessment dataset, reduced that by a factor of 1.6 to calculate the number of full-time equivalent workers and then for those workers, determined the total number of years those workers had worked in coal mines (starting from 1983/84) up to and including 2015/16.

TABLE 3 ESTIMATED POPULATION (FULL TIME EQUIVALENTS) OF COAL MINERS IN QUEENSLAND BY COAL MINE TYPE

Year	Estimated underground coal miners [1]	Estimated surface coal miners	Year	Estimated underground coal miners [1]	Estimated surface coal miners
1983/84	965	4,139	2002/03	2,576	11,052
1984/85	1,045	4,484	2003/04	2,981	12,788
1985/86	1,038	4,452	2004/05	3,533	15,159
1986/87	991	4,251	2005/06	4,172	17,900
1987/88	919	3,943	2006/07	4,732	20,302
1988/89	895	3,838	2007/08	5,303	22,751
1989/90	922	3,957	2008/09	5,779	24,795
1990/91	949	4,071	2009/10	6,190	26,557
1991/92	977	4,190	2010/11	6,868	29,465
1992/93	1,011	4,339	2011/12	7,397	31,738
1993/94	1,068	4,584	2012/13	7,413	31,805
1994/95	1,154	4,953	2013/14	6,644	27,430
1995/96	1,259	5,402	2014/15	6,595	24,682
1996/97	1,360	5,835	2015/16	6,187	24,105
1997/98	1,439	6,173	2016/17	5,568	24,367
1998/99	1,517	6,510	2017/18	5,956	27,985
1999/00	1,631	6,999	2018/19	6,317	30,286
2000/01	1,895	8,130	2019/20	7,096	31,195
2001/02	2,253	9,666			

[1]Coal Mine Worker data estimated from the data in Table 2 and applying the average ratio of surface mine and underground mine from 2013/14 to 2019/20.

Mortality data for the population of coal miners was not available, so to estimate the population of "ever" (since 1983/84) coal miners who were still alive in each prevalent year, we considered the population mortality rate over that period. Between 1983 and 2019, the crude population mortality rate for males and females combined was between 6.0 and 7.2 deaths per 1,000 population. (51) Allowing for a possible higher general mortality rate among coal miners than the general population, we assumed an annual mortality rate of 8 deaths per 1,000 population, or 0.1% per year, over the study period and applied that to the estimated population of "ever" workers.

Results in Figure 16 and Table 4 show, for example, that in 2019/20, there were an estimated 69,497 full-time equivalent coal miners who had "ever" (since 1983/84) previously worked in Queensland mines and were still alive in that year. These miners, in addition to those who were estimated to have died up to 2019/20, contributed an estimated total of 1,028,939 years of previous coal mine experience (or exposure) up to 2019/20 (Table 4).

FIGURE 16 ESTIMATED CUMULATIVE NUMBER OF FULL TIME EQUIVALENT COAL MINE WORKERS IN QUEENSLAND (FROM 1983/84) ALIVE EACH YEAR, AFTER ADJUSTING FOR ESTIMATED POPULATION MORTALITY

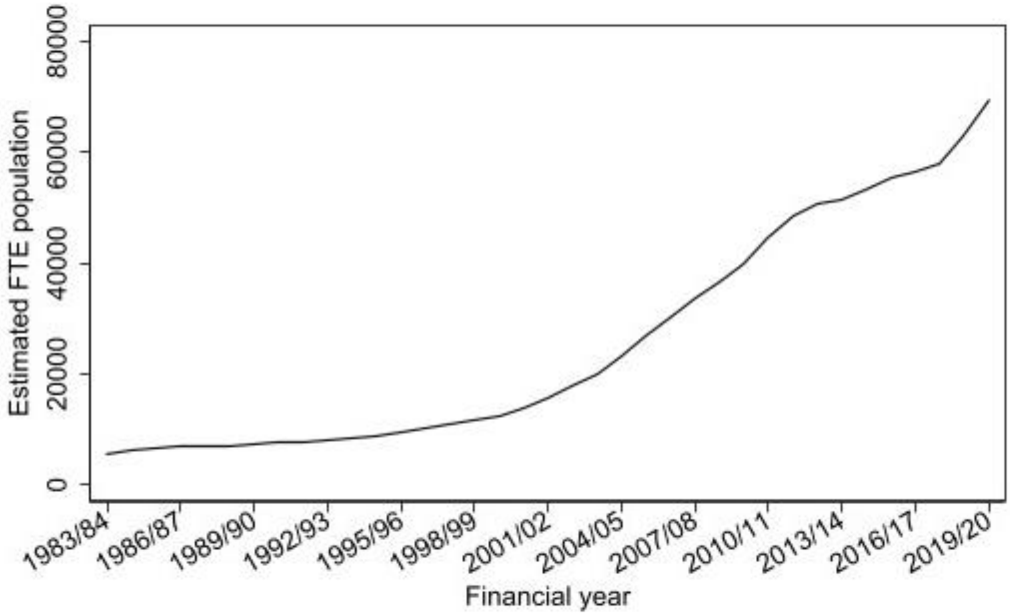


TABLE 4 ESTIMATED CUMULATIVE NUMBER OF COAL MINERS (N) IN QUEENSLAND ALIVE EACH YEAR, AND COMBINED PREVIOUS COAL MINE EXPOSURE (YEARS) FROM 1983/84

Year	Cumulative number of mine workers alive each year [1]	Number of previous years' exposure [1,2]	Year	Cumulative number of mine workers alive each year [1]	Number of previous years' exposure [1]
1983/84	5,424	7,838	2002/03	17,648	202,889
1984/85	6,243	14,125	2003/04	19,950	224,350
1985/86	6,630	20,848	2004/05	23,098	249,119
1986/87	6,834	27,829	2005/06	26,769	277,743
1987/88	6,927	34,957	2006/07	30,113	309,925
1988/89	7,104	42,317	2007/08	33,624	345,860
1989/90	7,347	49,977	2008/09	36,788	385,227
1990/91	7,538	57,887	2009/10	39,777	427,878
1991/92	7,724	66,043	2010/11	44,399	475,469
1992/93	7,959	74,497	2011/12	48,638	527,654
1993/94	8,331	83,385	2012/13	50,716	582,306
1994/95	8,898	92,908	2013/14	51,516	638,164
1995/96	9,611	103,214	2014/15	53,081	695,999
1996/97	10,322	114,309	2015/16	55,331	756,509
1997/98	10,935	126,099	2016/17	56,580	818,711
1998/99	11,522	138,564	2017/18	58,057	882,842
1999/00	12,271	151,870	2018/19	63,020	952,400
2000/01	13,804	166,807	2019/20	69,497	1,028,939
2001/02	15,821	183,872			

[1]Up to and including the specific financial year [2] Includes years worked by miners who might have died in previous years.

By applying the ratio (4.3:1) of the number of workers in surface mines to those working in underground mines, we could calculate the corresponding estimates from Table 4 of the cumulative number of former coal miners (Table 5) and cumulative years' experience by coal mine type (Table 6). Note that the average years of exposure per worker was assumed to remain the same for each coal mine type.

TABLE 5 ESTIMATED CUMULATIVE NUMBER OF COAL MINERS (N) IN QUEENSLAND BY MINE TYPE IN QUEENSLAND WHO WERE ALIVE IN THE RELEVANT YEAR

Year	Underground coal mines (years) [1]	Surface coal mines (years) [1]	Year	Underground coal mines (years) [1]	Surface coal mines (years) [1]
1983/84	1,023	4,401	2002/03	3,330	14,318
1984/85	1,178	5,065	2003/04	3,764	16,186
1985/86	1,251	5,379	2004/05	4,358	18,740
1986/87	1,289	5,545	2005/06	5,051	21,718
1987/88	1,307	5,620	2006/07	5,682	24,431
1988/89	1,340	5,764	2007/08	6,344	27,280
1989/90	1,386	5,961	2008/09	6,941	29,847
1990/91	1,422	6,115	2009/10	7,505	32,272
1991/92	1,457	6,267	2010/11	8,377	36,022
1992/93	1,502	6,458	2011/12	9,177	39,461
1993/94	1,572	6,759	2012/13	9,569	41,147
1994/95	1,679	7,219	2013/14	9,720	41,796
1995/96	1,813	7,797	2014/15	10,015	43,066
1996/97	1,948	8,375	2015/16	10,440	44,891
1997/98	2,063	8,872	2016/17	10,676	45,905
1998/99	2,174	9,348	2017/18	10,954	47,103
1999/00	2,315	9,955	2018/19	11,890	51,129
2000/01	2,605	11,200	2019/20	13,113	56,384
2001/02	2,985	12,836			

[1]Up to and including the specific financial year

TABLE 6 ESTIMATED CUMULATIVE NUMBER OF YEARS WORKED BY COAL MINERS (YEARS) IN QUEENSLAND BY MINE TYPE IN QUEENSLAND

Year	Underground coal mines (years) [1,2]	Surface coal mines (years) [1,2]	Year	Underground coal mines (years) [1,2]	Surface coal mines (years) [1,2]
1983/84	1,479	6,359	2002/03	38,281	164,608
1984/85	2,665	11,460	2003/04	42,330	182,020
1985/86	3,934	16,915	2004/05	47,004	202,115
1986/87	5,251	22,578	2005/06	52,404	225,339
1987/88	6,596	28,361	2006/07	58,476	251,449
1988/89	7,984	34,333	2007/08	65,257	280,603
1989/90	9,430	40,548	2008/09	72,684	312,543
1990/91	10,922	46,965	2009/10	80,732	347,146
1991/92	12,461	53,582	2010/11	89,711	385,758
1992/93	14,056	60,441	2011/12	99,557	428,097
1993/94	15,733	67,652	2012/13	109,869	472,437
1994/95	17,530	75,378	2013/14	120,408	517,756
1995/96	19,474	83,740	2014/15	131,321	564,678
1996/97	21,568	92,741	2015/16	142,738	613,772
1997/98	23,792	102,307	2016/17	154,474	664,237
1998/99	26,144	112,420	2017/18	166,574	716,268
1999/00	28,655	123,215	2018/19	179,698	772,702
2000/01	31,473	135,334	2019/20	194,140	834,800
2001/02	34,693	149,179			

[1]Up to and including the specific financial year [2] Includes years worked by miners who might have died in previous years.

3.4. Initial results

3.4.1. Characteristics of confirmed cases

The total number of coal miners with confirmed coal mine dust lung disease in Queensland up to 30 June 2020 was 166. Of these, 90 (54%) were based on CMWHS Health Assessment forms received from the RSHQ, 66 (40%) were based on notifications only from the OIR and a further 10 cases were from other unidentified sources (Table 7, Table 8). When reporting average estimates below, missing values are excluded from the calculations. All estimates given below are summarised in Table 7, Table 8, Figure 17, Figure 18 and Figure 19. Note that in Figure 17, the plots are designed to show the distribution of known values across all cases, even if those values include zero.

Note that an additional two cases were known to have been diagnosed between 1 July 2020 and 30 September 2020, but since this report presents data by financial year, these two cases were not included in any results for this report.

The characteristics of the cases (n=166) are summarised in Tables 7-8 and Figures 17-19. Overall, the average age at diagnosis for the cases was 56.8 years (Table 7). Their average

age at entry into the coal mining industry was 29.4 years with a mean tenure of 27.0 years in the mining industry and 24.0 years in the coal mining industry.

The average number of years worked in either surface or underground mines was around 12.1 years compared to around 3.3 years in other types of mines. On average, miners in the study cohort started smoking aged 18.7 years and had smoked for 27.9 years.

The average values of the individuals diagnosed with coal mine dust lung disease for lung function testing were 85.9%, 92.7% and 89.0% for forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and their ratio (FEV_1/FVC) respectively.

The values of all these variables (except age at entry into coal mining industry, number of years smoked and FVC) were lower for cases reported by RSHQ than those based on OIR notifications. In terms of missing information, cases notified through the OIR, or other unidentified sources had a consistently lower number of records with complete data for each of these characteristics than those in the RSHQ database. As an example, information on coal mining tenure was available for 94% (85 of 92) of the RSHQ cases, 38% (25 of 66) of OIR cases and 70% (7 of 10) of other unidentified source cases.

All cases were males, about a third of the cohort (34.3%) were aged between 50 and 59 years and lived in either inner regional (38.0%) or outer regional (27.1%) areas (Table 8). Only 7.2% were from the two least socio-economic disadvantaged quintiles, whereas around 48.0% lived in the two most disadvantaged quintiles. While about one fifth of the cohort (21.7%) were current smokers, 41.0% had smoked previously and 22.3% were never smokers.

Around three-quarters (78.3%) were employed in coal mines only and the majority worked solely in Queensland (45.2%). Around 15.1% had worked in both coal and mineral industries with a similar percentage (15.7%) having worked interstate. In terms of coal mining tenure, 4.8% had worked for 0-9 years (please note there were 3.6% cases with 0-9 years tenure across all mine types), 14.6% for 10-14 years, 9.0% for 15-19 years and 41.5% for 20 or more years. About 43.4% of the cohort were surface miners and 31.9% were underground miners, with about 5.0% having worked in both types of mines. In addition, the majority of the coal mine dust lung disease cohort were employed by mine operators during their entire occupational history (61.5%) with a quarter being mine contractors.

In terms of quantifying the presence of opacities sourced from the ILO report, 21.7% had normal chest radiographs (i.e. no evidence of opacities in the ILO report), 13.3% had radiographs with ILO profusion category 0 and 19.9% had radiographs with ILO profusion category 1 or greater. There was no information about ILO opacities for the remaining cases (45.2%).

The most diagnosed coal mine dust lung diseases were COPD (29.5%), CWP (22.3%), multiple coal mine dust lung diseases (16.9%), silicosis (13.3%), and mixed dust pneumoconiosis (9.6%).

Two methods were used to ascertain the financial year of diagnosis. The first method only used the date information from the Respiratory Physician report or the most recent record date. With this method, around 47 (28.3%) of cases had missing information about the date of diagnosis. When we included additional information about the X-ray reading date or the CT scan date, the number of records without a diagnosis date reduced to 29 (17.5%). This latter method was used for the year of diagnosis calculations throughout the report. About a quarter (25.9%) of the cases were diagnosed in the 2019/20 financial year, 17% in the 2018/19 financial year, and 6.6% in the 2017/18 financial year. A total of 20 cases (13%) were diagnosed up to and including the 2011/12 financial year.

3.4.2. Incomplete / missing data

Cases notified through the OIR, or other unidentified sources had a consistently lower number of records with complete data for each of the categorical characteristics than those in the RSHQ data extract (Table 8). For example, while five out of 90 (5.6%) records in the RSHQ database lacked information on years worked (tenure), the majority (n=42, 63.6%) of 66 notifications from the OIR and around a third (n=3, 30.0%) of 10 notifications from other unidentified sources did not have this information. The majority (n=57, 86.4%) of records from the OIR or other unidentified sources (n=7, 70.0%) also did not have information on the ILO classification of chest radiographs compared to n=11 (13.0%) of cases based on the RSHQ notifications.

Table 7 Characteristics of confirmed cases of coal mine dust lung disease in Queensland, 1983/84 to 2019/20 (Part A)

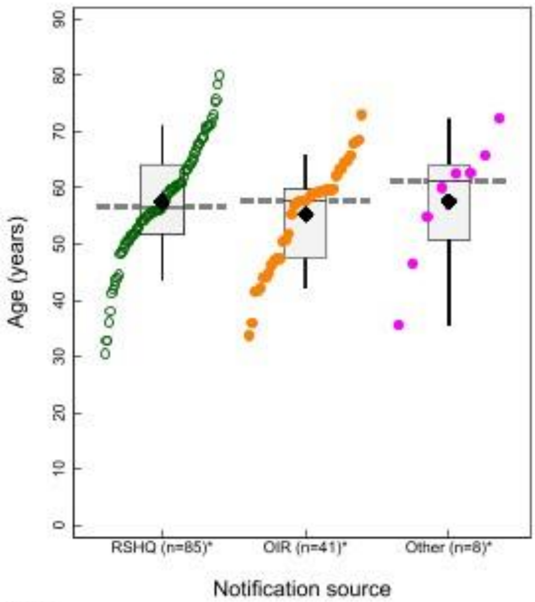
	RSHQ notified (n=90)		OIR (n=66)		Further cases (n=10)		Total (n=166)	
Characteristics	**Number (% of eligible cases)**	**Average**	**Number (% of eligible cases)**	**Average**	**Number (% of eligible cases)**	**Average**	**Number (% of eligible cases)**	**Average**
Age at diagnosis (years)	85 (94.4)	57.5	41 (62.1)	55.3	8 (80.0)	57.6	134 (80.7)	56.8
Mining tenure (years)	81 (90.0)	26.5	34 (51.5)	28.7	8 (80.0)	25.0	123 (74.1)	27.0
Coal mining tenure (years)	85 (94.4)	22.9	25 (37.9)	27.3	7 (70.0)	25.6	117 (70.5)	24.0
Age entry into coal mine industry (years)	85 (94.4)	30.2	50 (75.8)	28.5	8 (80.0)	27.0	143 (86.1)	29.4
Years worked in surface mines	82 (91.1)	11.3	13 (19.7)	17.8	3 (30.0)	8.0	98 (59.0)	12.1
Years worked in underground mines	80 (88.9)	11.5	17 (25.8)	15.5	4 (40.0)	22.0	101 (60.8)	12.6
Years worked in other mines	81 (90.0)	3.2	11 (16.7)	4.7	2 (20.0)	0.0	94 (56.6)	3.3
Age started smoking (years)	68 (75.6)	18.7	38 (57.6)	18.9	4 (40.0)	19.0	110 (66.3)	18.7
Number of years smoked	46 (51.1)	28.3	19 (28.8)	26.4	2 (20.0)	34.5	67 (40.4)	27.9
Forced expiratory volume (FEV_1) Observed/Predicted% [1]	86 (95.6)	84.6	44 (66.7)	87.3	8 (80.0)	92.1	138 (83.1)	85.9
Forced vital capacity (FVC) Observed/Predicted% [2]	86 (95.6)	93.7	44 (66.7)	90.7	8 (80.0)	92.7	138 (83.1)	92.7
FEV_1/FVC%	79 (87.8)	87.6	9 (13.6)	97.9	3 (30.0)	99.7	91 (54.8)	89.0

[1] Predicted Forced expiratory volume (FEV_1) is the volume of air that can be forcibly exhaled in the first second after a full in breath. In CMWHS Clinical Pathways Guideline (52), the threshold for FEV_1 and impairment is defined by the comparison of absolute measurements to reference values (e.g., less than the Lower Limit of Normal (LLN) or less than 70% predicted, from Global Lung function Initiative (GLI) reference values).

[2] Forced vital capacity (FVC) is the total amount of air exhaled during the FEV test.

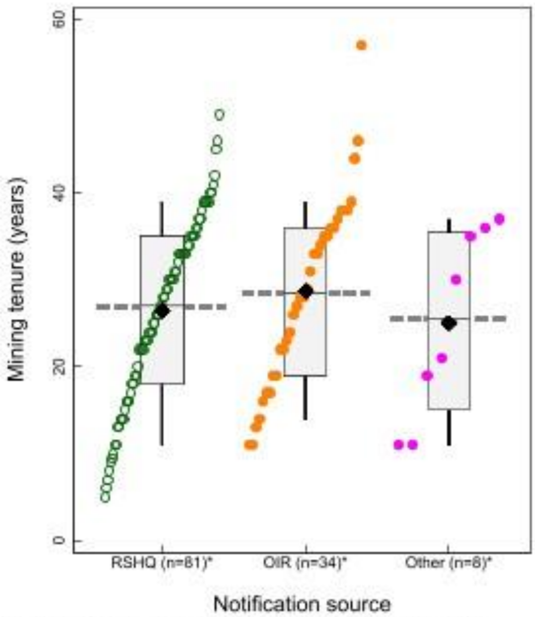
Figure 17 Characteristics of confirmed cases of coal mine dust lung disease in Queensland, 1983/84 – 2019/20 (Part A) – See also Table 7

Age at diagnosis (years)



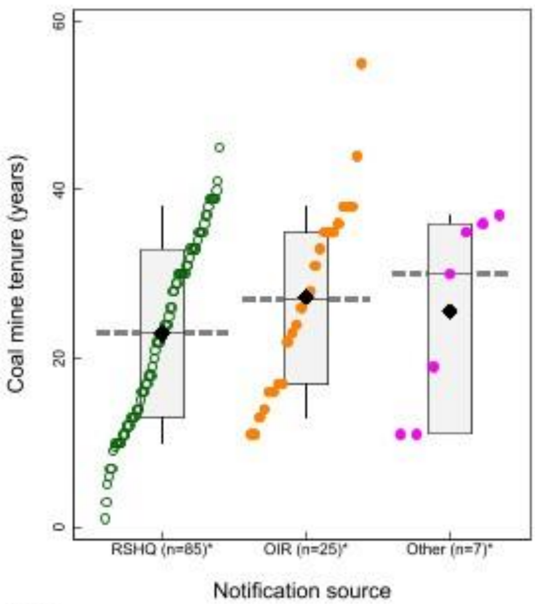
Notes:
*Excludes missing values for RSHQ notified (n=5), OIR (n=25) and Other sources (n=2)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: meidan value
Black diamond: mean value

Mining (all mining) tenure (years)



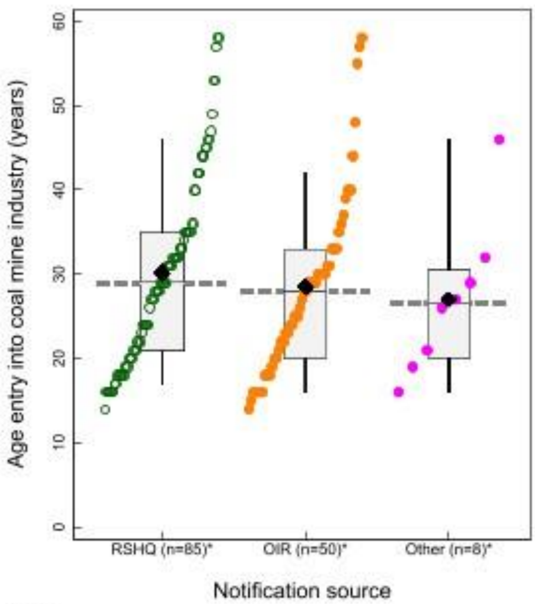
*Exclude missing values for RSHQ notified (n=9), OIR notified (n=32) and Other sources (n=2)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: meidan value
Black diamond: mean value

Coal mining tenure (years)



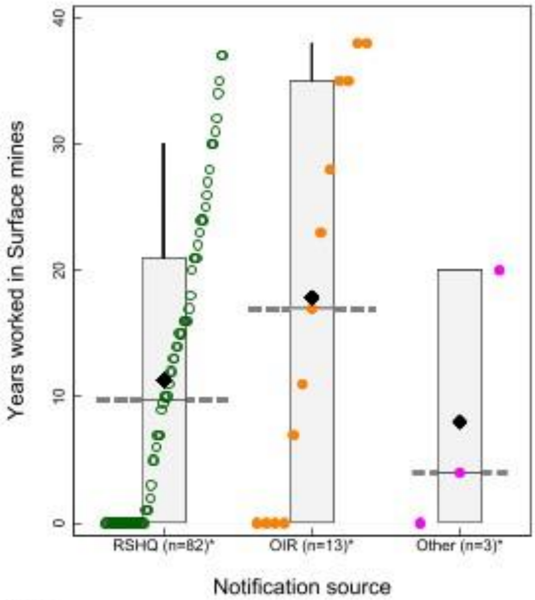
Notes:
*Excludes missing values for RSHQ notified (n=5), OIR notified (n=41) and Other sources (n=3)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Age entry into coal mine industry (years)



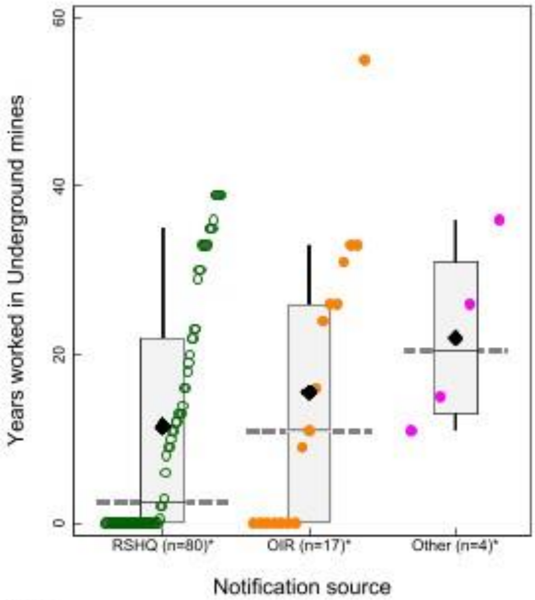
Notes:
*Excludes missing values for RSHQ notified (n=5), OIR notified (n=16) and Other sources (n=2)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Years worked in surface mines



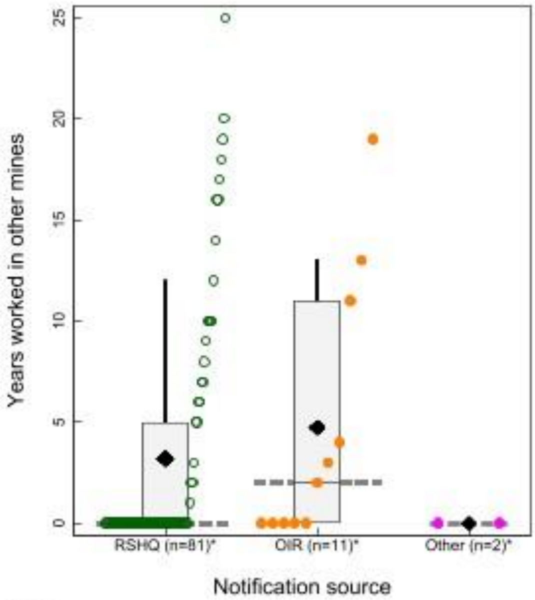
Notes:
*Excludes missing values for RSHQ notified (n=8), OIR notified (n=53) and Other sources (n=7)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Years worked in underground mines



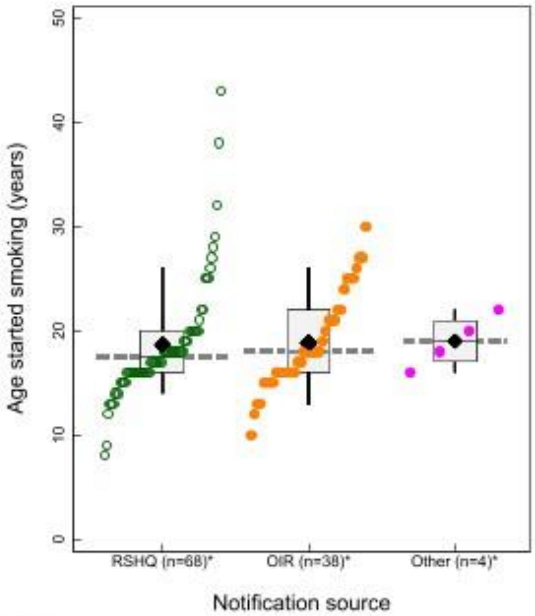
Notes:
*Excludes missing values for RSHQ notified (n=10), OIR notified (n=49) and Other sources (n=6)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Years worked in other mines



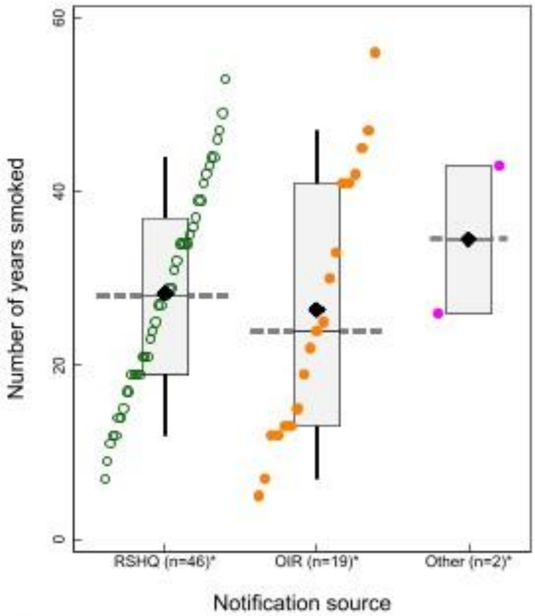
Notes:
*Excludes missing values for RSHQ notified (n=9), OIR notified (n=55) and Other sources (n=8)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Age started smoking (years)



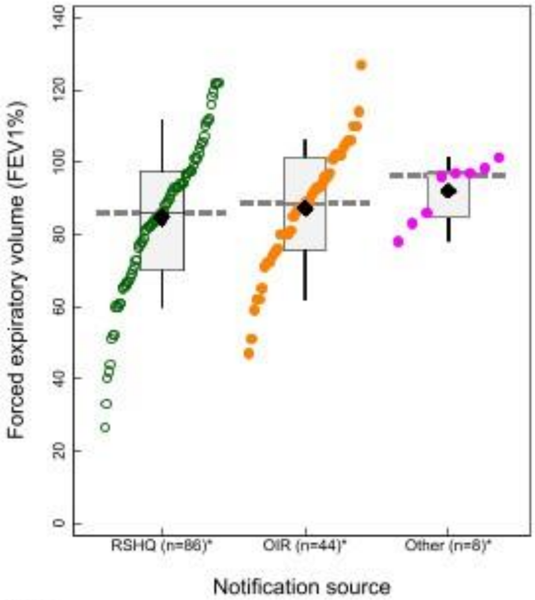
Notes:
*Excludes missing values for RSHQ notified (n=3), OIR notified (n=22)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Number of years smoked



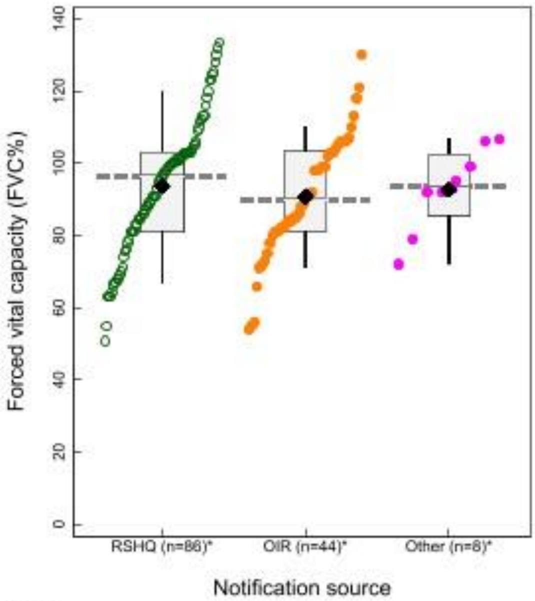
Notes:
*Excludes missing values for RSHQ notified (n=3), OIR notified (n=22)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Forced expiratory volume (FEV_1 Observed/Predicted%)



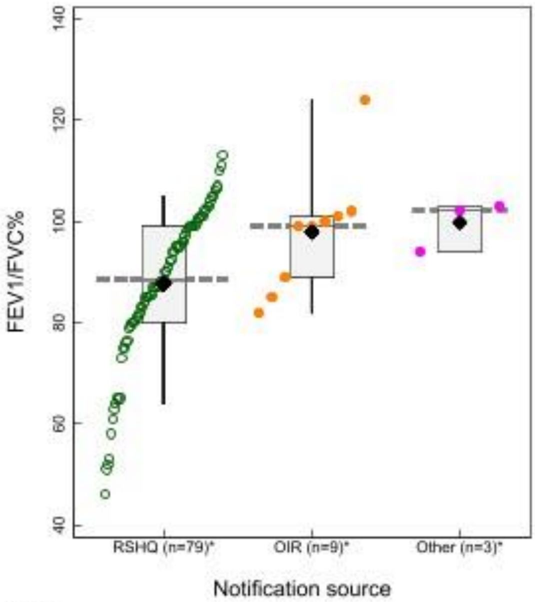
Notes:
*Excludes missing values for RSHQ notified (n=5), OIR notified (n=22) and Other sources (n=2)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

Forced vital capacity (FVC Observed/Predicted%)



Notes:
*Excludes missing values for RSHQ notified (n=5), OIR notified (n=22) and Other sources (n=2)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

FEV_1/FVC%



Notes:
*Excludes missing values for RSHQ notified (n=11), OIR notified (n=57) and Other sources (n=7)
Dots: Individual records
Rectangle box: Interquartile range
Thick dashed line: median value
Black diamond: mean value

TABLE 8 CHARACTERISTICS OF CONFIRMED CASES OF COAL MINE DUST LUNG DISEASE IN QUEENSLAND, 1983/84 – 2019/20 (PART B) (SEE FIGURE 18)

	RSHQ notified (n=90)	OIR (n=66)	Further cases (n=10)	Total (n=166)
Characteristics	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**
Mining sector				
Coal only	65 (72.2)	55 (83.3)	10 (100)	130 (78.3)
Coal & Minerals	14 (15.6)	11 (16.7)	0 (0.0)	25 (15.1)
Coal & Quarries	5 (5.6)	0 (0.0)	0 (0.0)	5 (3.0)
Coal, Minerals & Quarries	6 (6.7)	0 (0.0)	0 (0.0)	6 (3.6)
Sex				
Male	90 (100)	66 (100)	10 (100)	166 (100)
Female	0 (0)	0 (0)	0 (0)	0 (0)
Locality of Mine				
QLD only	60 (66.7)	10 (15.2)	5 (50.0)	75 (45.2)
QLD & Interstate	17 (18.9)	8 (12.1)	1 (10.0)	26 (15.7)
QLD & International	8 (8.9)	2 (3.0)	2 (20.0)	12 (7.2)
QLD & Interstate & International	2 (2.2)	3 (4.6)	0 (0.0)	5 (3.0)
QLD & Unknown	3 (3.3)	43 (65.2)	2 (20.0)	48 (28.9)
Age group at diagnosis				
30 to 39	5 (5.6)	2 (3.0)	1 (10.0)	8 (4.8)
40 to 49	10 (11.1)	10 (15.2)	1 (10.0)	21 (12.7)
50 to 59	37 (41.1)	19 (28.8)	1 (10.0)	57 (34.3)
60 and above	33 (36.7)	10 (15.2)	5 (50.0)	48 (28.9)
Unknown	5 (5.6)	25 (37.9)	2 (20.0)	32 (19.3)
Geographical remoteness				
Major city	7 (7.8)	8 (12.1)	1 (10.0)	16 (9.6)
Inner regional	44 (48.9)	16 (24.2)	3 (30.0)	63 (38.0)
Outer reginal	26 (28.9)	17 (25.8)	2 (20.0)	45 (27.1)
Remote	3 (3.3)	5 (7.6)	1 (10.0)	9 (5.4)
Very remote	1 (1.1)	0 (0.0)	0 (0.0)	1 (0.6)
Unknown	9 (10.0)	20 (30.3)	3 (30.0)	32 (19.3)
Area-level socio-economic status				
Quintile 5 (least disadvantaged)	2 (2.2)	2 (3.0)	0 (0.0)	4 (2.4)
Quintile 4	6 (6.7)	2 (3.0)	0 (0.0)	8 (4.8)
Quintile 3 (Medium SES)	32 (35.6)	17 (25.8)	3 (30.0)	52 (31.3)

	RSHQ notified (n=90)	OIR (n=66)	Further cases (n=10)	Total (n=166)
Characteristics	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**
Quintile 2	24 (26.7)	13 (19.7)	2 (20.0)	39 (23.5)
Quintile 1(most disadvantaged)	17 (18.9)	11 (16.7)	2 (20.0)	30 (18.1)
Unknown	9 (10.0)	21 (31.8)	3 (30.0)	33 (19.9)
All mining tenure (years)				
0-9	6 (6.7)	0 (0.0)	0 (0.0)	6 (3.6)
10-14	8 (8.9)	4 (6.1)	2 (20.0)	14 (8.4)
15-19	9 (10.0)	5 (7.6)	1 (10.0)	15 (9.0)
20-24	11 (12.2)	4 (6.1)	1 (10.0)	16 (9.6)
>=25	47 (52.2)	20 (30.2)	4 (40.0)	71 (42.8)
Unknown	9 (10.0)	33 (50.0)	2 (20.0)	44 (26.6)
Coal mining tenure (years)				
0-9	8 (8.9)	0 (0.0)	0 (0.0)	8 (4.8)
10-14	18 (20.0)	4 (6.1)	2 (20.0)	24 (14.6)
15-19	10 (11.1)	4 (6.1)	1 (10.0)	15 (9.0)
20-24	11 (12.2)	3 (4.6)	0 (0.0)	14 (8.4)
>=25	38 (42.2)	13 (19.7)	4 (40.0)	55 (33.1)
Unknown	5 (5.6)	42 (63.6)	3 (30.0)	50 (30.1)
Type of coal mine				
Surface	44 (48.9)	28 (42.4)	0 (0.0)	72 (43.4)
Underground	32 (35.6)	14 (21.2)	7 (70.0)	53 (31.9)
Surface and Underground	7 (7.8)	1 (1.5)	1 (10.0)	9 (5.4)
Unknown	7 (7.8)	23 (34.9)	2 (20.0)	32 (19.3)
Employer type				
Mine operator	65 (72.2)	30 (45.5)	7 (70.0)	102 (61.5)
Contractor to mine(s)	22 (24.4)	16 (24.2)	3 (30.0)	41 (24.7)
Unknown	3 (3.3)	20 (30.3)	0 (0.0)	23 (13.9)
Smoker status				
Current smoker	24 (26.7)	10 (15.2)	2 (20.0)	36 (21.7)
Ex-smoker	47 (52.2)	19 (28.8)	2 (20.0)	68 (41.0)
Never smoker	16 (17.8)	15 (22.7)	6 (60.0)	37 (22.3)
Unknown	3 (3.3)	22 (33.3)	0 (0.0)	25 (15.1)
ILO classification				

	RSHQ notified (n=90)	OIR (n=66)	Further cases (n=10)	Total (n=166)
Characteristics	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**	**Number (% of eligible cases)**
Normal radiograph	32 (35.6)	4 (6.1)	0 (0.0)	36 (21.7)
Category 0	20 (22.2)	1 (1.5)	1 (10.0)	22 (13.3)
Category 1	22 (24.4)	2 (3.0)	2 (20.0)	26 (15.7)
Category 2	3 (3.3)	1 (1.5)	0 (0.0)	4 (2.4)
Category 3	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
A, or B, or C	2 (2.2)	1 (1.5)	0 (0.0)	3 (1.8)
Unknown	11 (12.2)	57 (86.4)	7 (70.0)	75 (45.2)
Type of coal mine dust lung disease				
CWP	22 (24.4)	8 (12.1)	7 (70.0)	37 (22.3)
Silicosis	11 (12.2)	11 (16.7)	0 (0.0)	22 (13.3)
Mixed Dust Pneumoconiosis	8 (8.9)	7 (10.6)	1 (10.0)	16 (9.6)
COPD	30 (33.3)	18 (27.3)	1 (10.0)	49 (29.5)
Multiple CMDLD	15 (16.7)	12 (18.2)	1 (10.0)	28 (16.9)
Other CMDLD	4 (4.4)	8 (12.1)	0 (0.0)	12 (7.2)
Asbestosis	0 (0.0)	2 (3.0)	0 (0.0)	2 (1.2)
Year of diagnosis				
Method 1[1]				
2002/03	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2003/04	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2007/08	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2008/09	0 (0.0)	3 (4.6)	0 (0.0)	3 (1.8)
2009/10	2 (2.2)	3 (4.6)	0 (0.0)	5 (3.0)
2010/11	0 (0.0)	3 (4.6)	1 (10.0)	4 (2.4)
2011/12	0 (0.0)	4 (6.1)	1 (10.0)	5 (3.0)
2012/13	0 (0.0)	4 (6.1)	1 (10.0)	5 (3.0)
2013/14	0 (0.0)	2 (3.0)	0 (0.0)	2 (1.2)
2014/15	0 (0.0)	4 (6.1)	0 (0.0)	4 (2.4)
2015/16	1 (1.1)	5 (7.6)	0 (00.0)	6 (3.6)
2016/17	12 (13.3)	1 (1.5)	2 (20.0)	15 (9.0)
2017/18	7 (7.8)	1 (1.5)	0 (0.0)	8 (4.8)
2018/19	22 (24.4)	2 (3.0)	0 (0.0)	24 (14.5)
2019/20	33 (36.7)	1 (1.5)	1 (10.0)	35 (21.7)

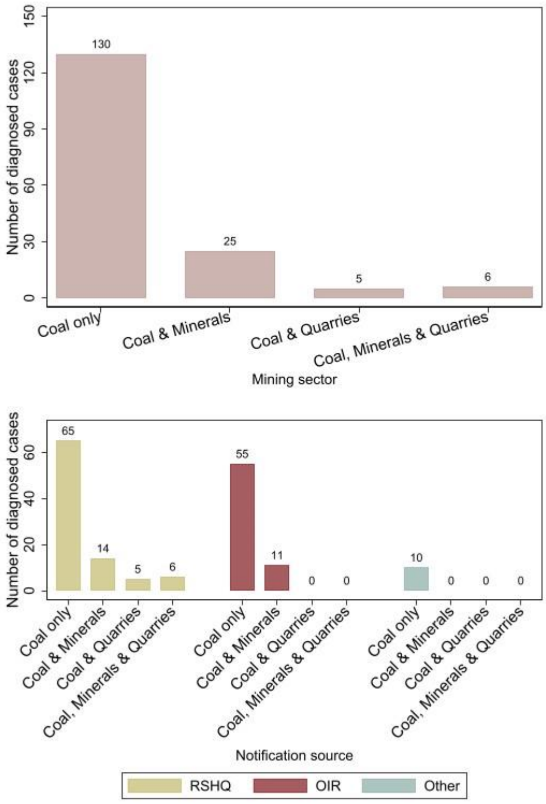
Characteristics	RSHQ notified (n=90) Number (% of eligible cases)	OIR (n=66) Number (% of eligible cases)	Further cases (n=10) Number (% of eligible cases)	Total (n=166) Number (% of eligible cases)
Unknown	13 (14.4)	30 (45.5)	4 (40.0)	47 (28.3)
Method 2[2]				
2002/03	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2003/04	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2007/08	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.6)
2008/09	0 (0.0)	3 (4.6)	0 (0.0)	3 (1.8)
2009/10	2 (2.2)	3 (4.6)	0 (0.0)	5 (3.0)
2010/11	0 (0.0)	3 (4.6)	1 (10.0)	4 (2.4)
2011/12	0 (0.0)	4 (6.1)	1 (10.0)	5 (3.0)
2012/13	0 (0.0)	4 (6.1)	1 (10.0)	5 (3.0)
2013/14	0 (0.0)	2 (3.0)	0 (0.0)	2 (1.2)
2014/15	0 (0.0)	4 (6.1)	0 (0.0)	4 (2.4)
2015/16	1 (1.1)	5 (7.6)	1 (10.0)	7 (4.2)
2016/17	13 (14.4)	1 (1.5)	3 (30.0)	17 (10.2)
2017/18	8 (8.9)	2 (3.0)	1 (10.0)	11 (6.6)
2018/19	22 (24.4)	6 (9.1)	0 (0.0)	28 (16.9)
2019/20	41 (45.6)	1 (1.5)	1 (10.0)	43 (25.9)
Unknown	3 (3.3)	25 (37.9)	1 (10.0)	29 (17.5)

[1] Method 1 was using the RSHQ provided "Date of Respiratory Physician report" where available to assign the date of diagnosis for coal mine dust lung disease for our data set. If this information was missing, the "most recent record date" was used if the "most recent record type" was CMWHS Section 4.

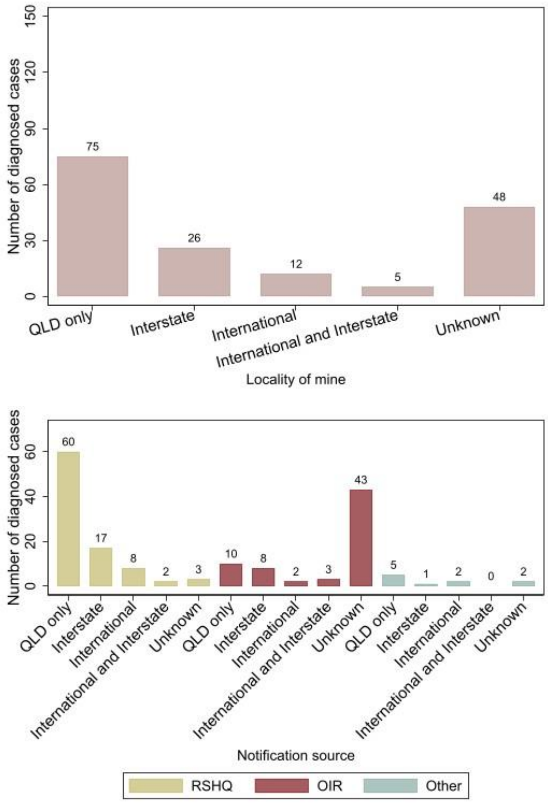
[2] Method 2 also considered the date of diagnosis to be the "Date of reading" (of the X-ray by B-reader) where available, or the "Date of CT scan" This assumption was made because X-ray dual reading and medical review (may include HRCT) is an essential process during a CMDLD diagnosis.

FIGURE 18 CHARACTERISTICS OF CONFIRMED CASES OF COAL MINE DUST LUNG DISEASE IN QUEENSLAND, 1983/84 – 2019/20, TOTALS AND BY NOTIFICATION SOURCE (SEE ALSO TABLE 8)

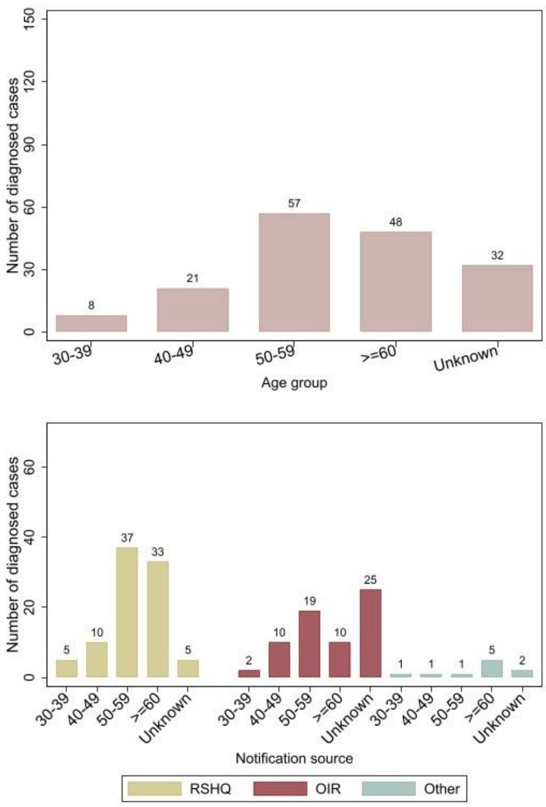
Mining sector



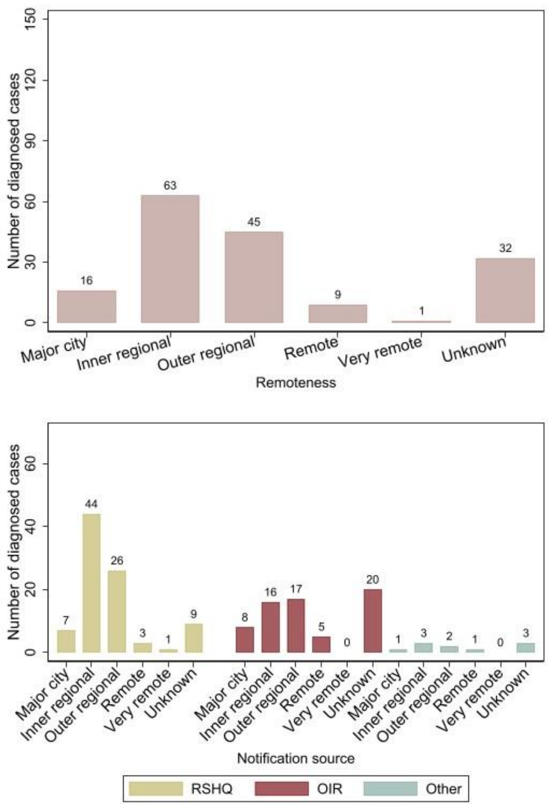
Locality of mine



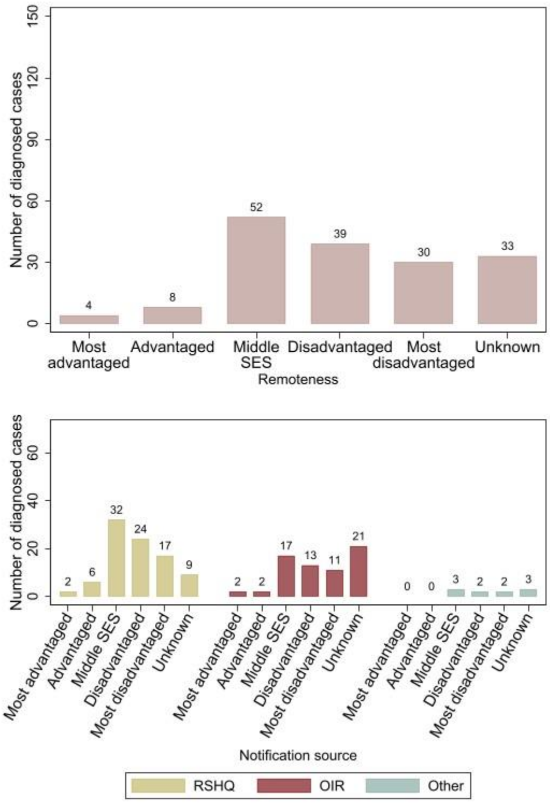
Age group at diagnosis



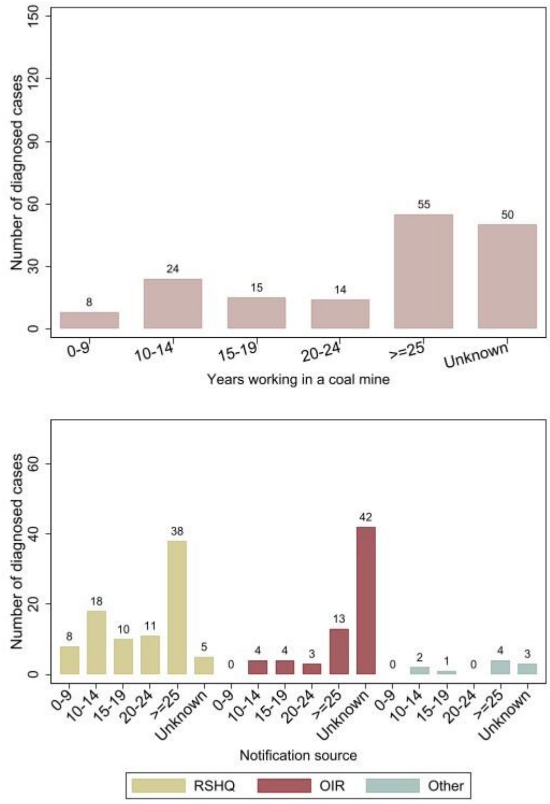
Geographical remoteness



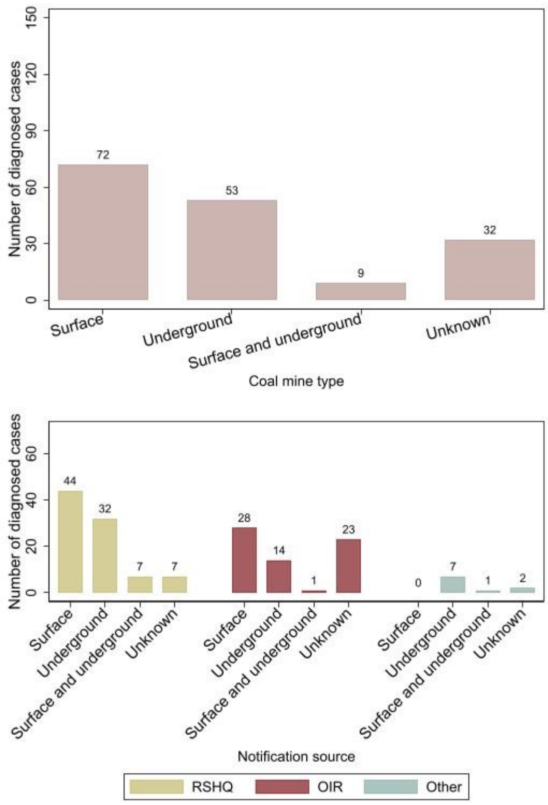
Area-level socio-economic status



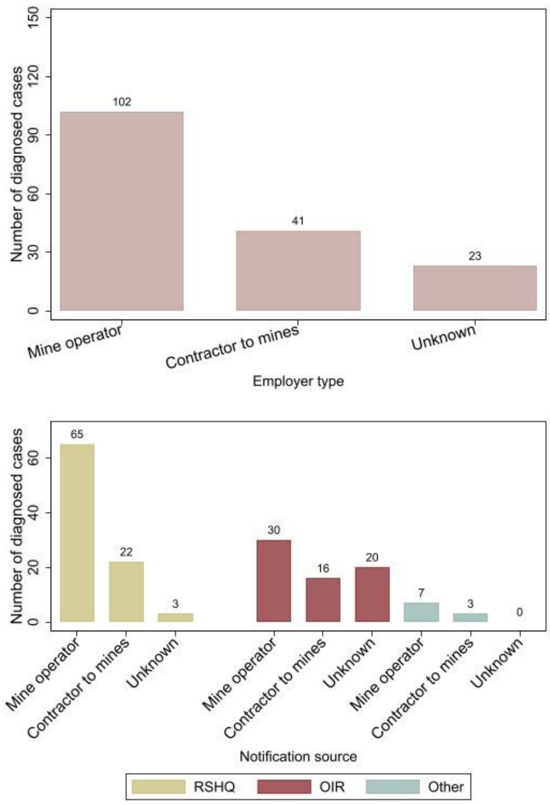
Coal mining tenure group



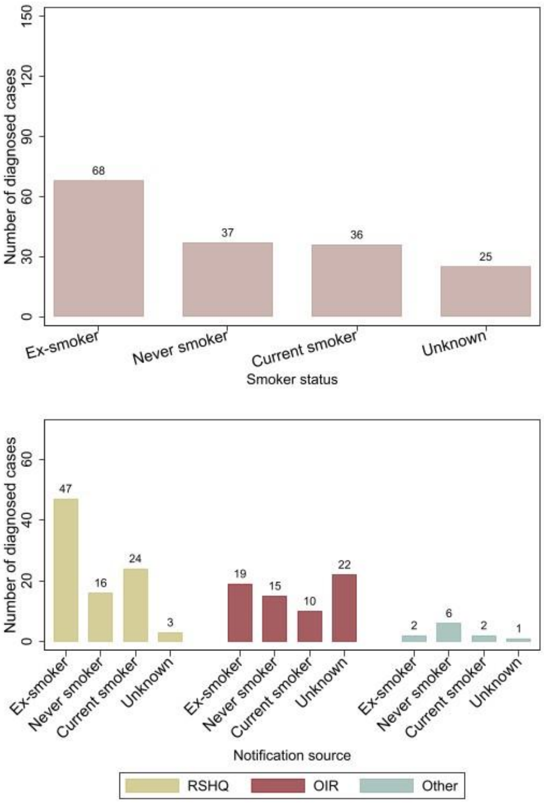
Type of coal mine



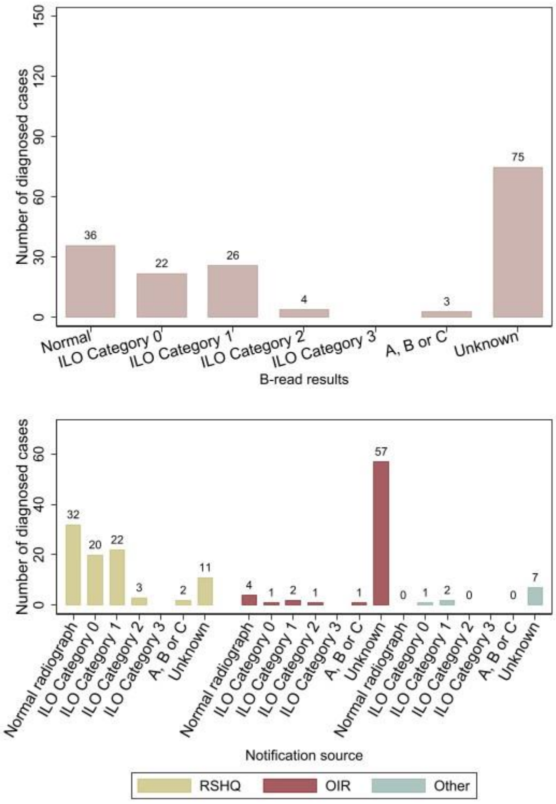
Employer type



Smoker status



B-reader results



Type of coal mine dust lung disease

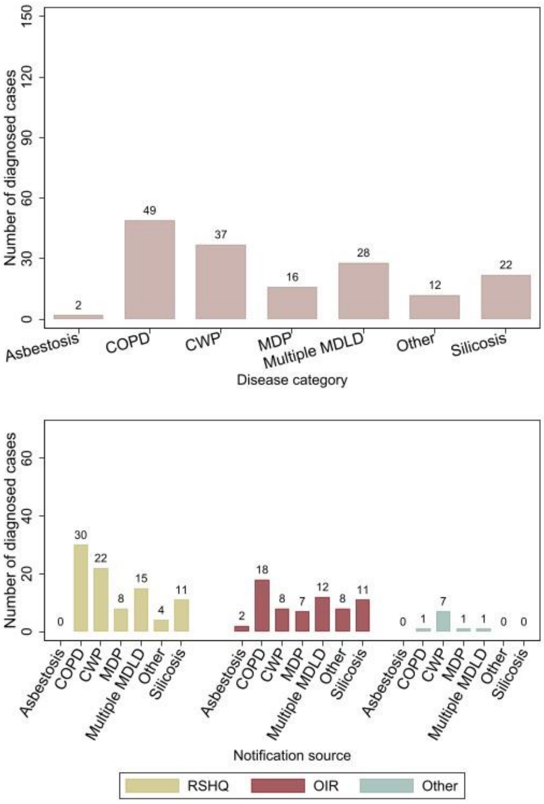
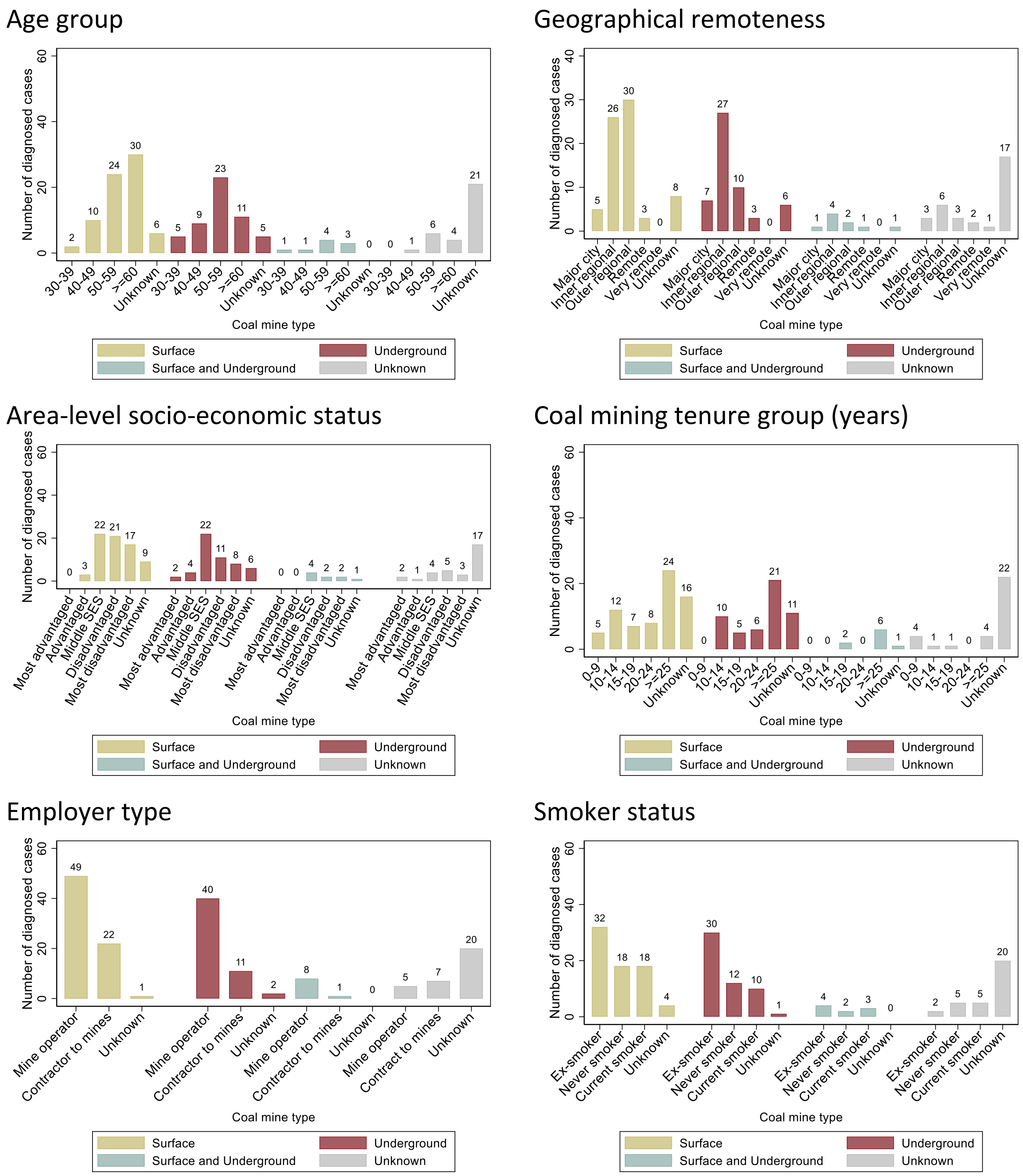
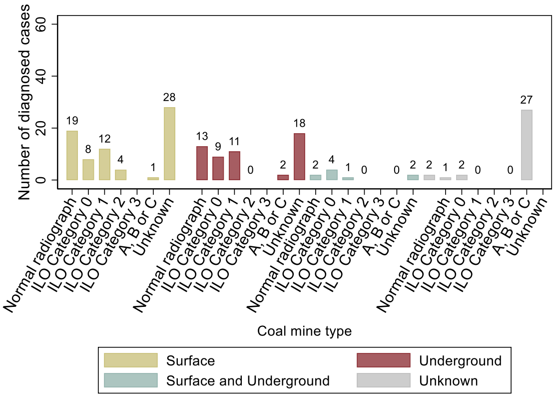


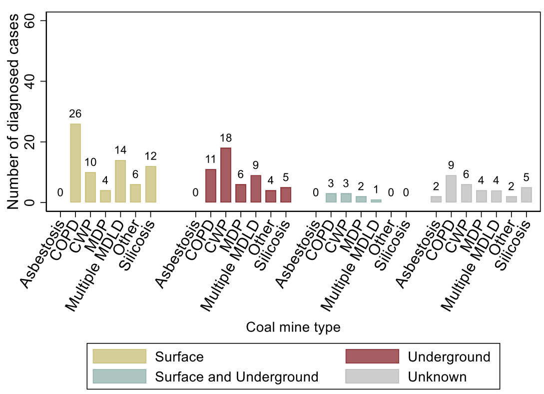
Figure 19 Characteristics of confirmed cases of coal mine dust lung disease in Queensland, 1983/84 – 2019/20, by coal mine type (See Table 8)



B-reader results



Type of coal mine dust lung disease



The number of cases of coal mine dust lung disease in Queensland by financial year of diagnosis and tenure is shown below (Table 9).

TABLE 9 NUMBER OF CASES OF COAL MINE DUST LUNG DISEASE IN QUEENSLAND BY FINANCIAL YEAR OF DIAGNOSIS AND TENURE IN COAL MINING, 1983/84 TO 2019/20

Financial Year of Diagnosis	Coal Mine Tenure (years) n (%)						
	0-9	10-14	15-19	20-24	>=25	Unknown	Total
2002/03	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.8)	0 (0.0)	1 (0.6)
2003/04	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.0)	1 (0.6)
2007/08	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.8)	0 (0.0)	1 (0.6)
2008/09	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (6.0)	3 (1.8)
2009/10	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.6)	3 (6.0)	5 (3.0)
2010/11	0 (0.0)	0 (0.0)	1 (6.7)	0 (0.0)	1 (1.8)	2 (4.0)	4 (2.4)
2011/12	0 (0.0)	2 (8.7)	0 (0.0)	0 (0.0)	0 (0.0)	3 (6.0)	5 (3.0)
2012/13	0 (0.0)	0 (0.0)	1 (6.7)	0 (0.0)	3 (5.5)	1 (2.0)	5 (3.0)
2013/14	0 (0.0)	0 (0.0)	1 (6.7)	0 (0.0)	0 (0.0)	1 (2.0)	2 (1.2)
2014/15	0 (0.0)	1 (4.2)	0 (0.0)	1 (7.1)	0 (0.0)	2 (4.0)	4 (2.4)
2015/16	0 (0.0)	2 (8.3)	1 (6.7)	0 (0.0)	1 (1.8)	3 (6.0)	7 (4.2)
2016/17	1 (12.5)	2 (8.3)	1 (6.7)	2 (14.3)	9 (16.4)	2 (4.0)	17 (10.2)
2017/18	0 (0.0)	3 (12.5)	0 (0.0)	3 (21.4)	5 (9.1)	0 (0.0)	11 (6.6)
2018/19	2 (25.0)	5 (20.8)	3 (20.0)	3 (21.4)	11 (20.0)	4 (8.0)	28 (16.9)
2019/20	5 (62.5)	6 (25.0)	6 (40.0)	4 (28.6)	19 (34.6)	3 (6.0)	43 (25.9)
Unknown	0 (0.0)	3 (12.5)	1 (6.7)	1 (7.1)	2 (3.6)	22 (44.0)	29 (17.5)
Total	8 (100.0)	24 (100.0)	15 (100.0)	14 (100.0)	55 (100.0)	50 (100.0)	166 (100.0)

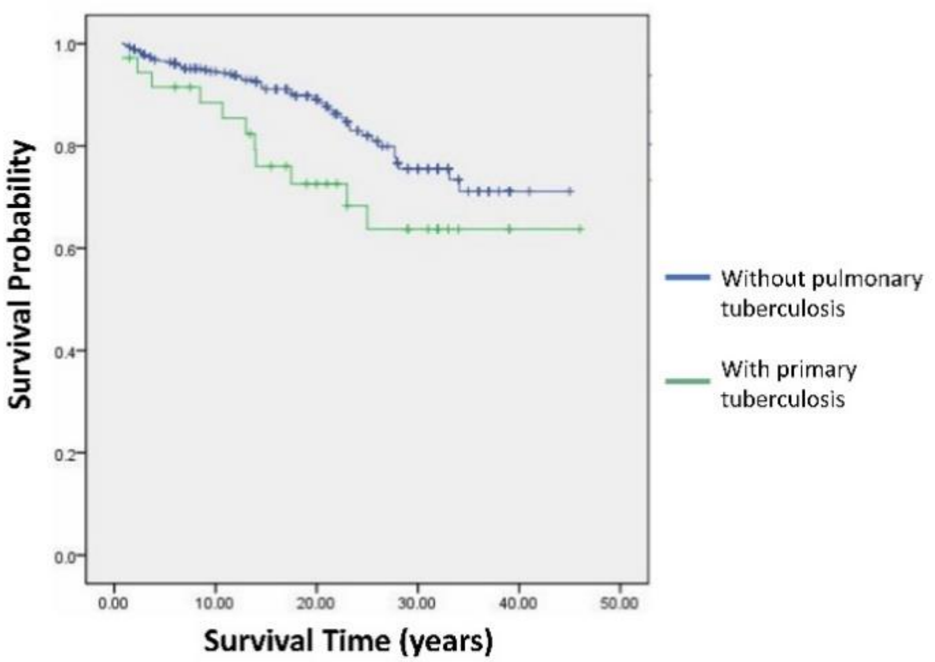
3.4.3. Estimated survival of people diagnosed with coal mine dust lung disease

The data on Queensland coal miners who had been diagnosed with coal mine dust lung disease contained no information about mortality status. Thus, it was not possible to ascertain whether coal miners who were diagnosed with coal mine dust lung disease were still alive as of 30 June 2020. Since this information was necessary for estimating prevalence rates, some approximation of the survival experience was required.

Ideally, we would base these approximations on published survival estimates. However, in our systematic literature review of the international literature (including from Australia), we found only one study from China (38) that reported on cause-specific survival outcomes for miners diagnosed with CWP. However, the presentation of the results in that paper made it impossible to determine an estimate for five-year survival. We tried contacting the corresponding author of the paper twice to obtain further information, but to date have not received a response. Based on their published graph (Figure 20), an estimate of 95% five-year survival, and 90% 10-year survival, would appear reasonable.

It is not known to what extent the survival experience of coal miners in China who were diagnosed with CWP is consistent with the survival experience of coal miners in Queensland who were diagnosed with CWP.

FIGURE 20 PUBLISHED SURVIVAL CURVES OF COAL WORKERS' PNEUMOCONIOSIS (CWP) PATIENTS WITH OR WITHOUT PULMONARY TUBERCULOSIS



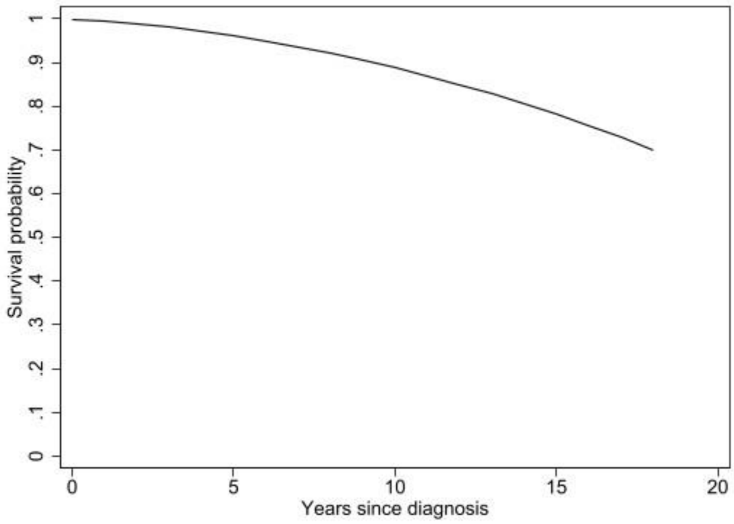
Sourced from Han et al 2017 "Survival Analysis of Coal Workers' Pneumoconiosis (CWP) Patients in a State-Owned Mine in the East of China from 1963 to 2014", International Journal of Environmental Research and Public Health; 14:489.

To determine the percentage of people who had died from the disease, we subtracted the survival percentage from 100%.

This meant that if we were estimating the prevalence of coal mine dust lung disease as of 30 June 2020, then about 5% of cases diagnosed in 2015 would be expected to have died before 30 June 2020, thus no longer being counted as prevalent cases. Similarly, about 10% of the cases diagnosed in 2009/10 would be expected to have died before 30 June 2020.

We generated a simulated survival curve that was similar to these specifications (Figure 21). This was generated using the formula $-0.0007*yearssince^2 - 0.004*yearssince + 0.9984$, where the variable yearssince was the number of years since diagnosis.

FIGURE 21 ESTIMATED SURVIVAL CURVE FOR COAL MINE DUST LUNG DISEASE PATIENTS



From this curve, we could estimate the probability that a coal miner diagnosed with coal mine dust lung disease died in any specific year since diagnosis (Table 10). That meant that if a coal miner was diagnosed with coal mine dust lung disease in 2015/16, and had survived to 2017/18, then in 2018/19 (i.e. 3 years since diagnosis) they would have a 0.008 probability of dying in that year.

TABLE 10 ESTIMATED PROBABILITY OF DYING FROM COAL MINE DUST LUNG DISEASE BY YEARS SINCE DIAGNOSIS OF COAL MINE DUST LUNG DISEASE

Year since diagnosis	Conditional probability of dying[1]	Year since diagnosis	Conditional probability of dying[1]
1	0.005	10	0.019
2	0.006	11	0.021
3	0.008	12	0.023
4	0.009	13	0.025
5	0.011	14	0.028
6	0.012	15	0.030
7	0.014	16	0.033
8	0.015	17	0.036
9	0.017	18	0.039

[1]Based on the survival curve in Figure 21. Conditional probability of dying in the ith year since diagnosis assuming they have survived up to the (i-1) year since diagnosis

The estimated probabilities in Table 10 only considered deaths due to coal mine dust lung disease, that is, they did not include the risk of dying from other causes. This is known as general population mortality, which is reported by the Australian Bureau of Statistics in their population life tables. (53) These are currently available for Queensland by calendar year from 1982 to 2017. Given that there was no equivalent data for 2018/2020, we have assumed that the population mortality for those years was the same as for 2017. These data are provided by five-year age groups, so we assumed the probability for each single year within each five-year age group was the same. In practice, this assumption was only violated for those aged 0-4 years, with higher mortality among younger (≤ 1 year) than older children (1-4 years). However, this would not impact current results due to the age distribution of cases. The probabilities of death were not adjusted for smoking status.

These population life tables gave, for each calendar year, age and sex combination, the probability of surviving for another 12 months. Given that all the coal mine dust lung disease cases in our study were males, Figure 22 shows the estimated population survival curve by age for Queensland in the 2017 calendar year.

We assumed that the population mortality for each calendar year was the same as for the future overlapping financial year. That is, the population mortality for 2016 was the same as for 2016/17.

FIGURE 22 POPULATION SURVIVAL PROBABILITY FOR MALES IN QUEENSLAND, 2017.

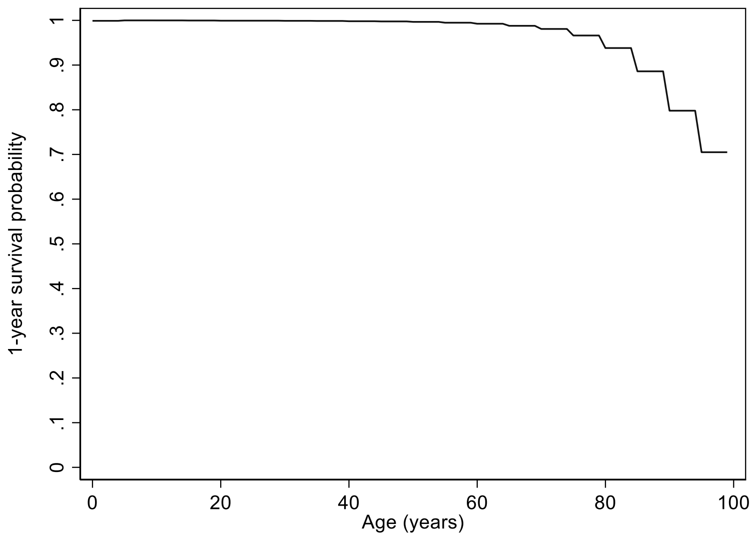


Table 11 Estimated population probability of dying from any cause in Queensland, Males, 2017

Age (years)	Probability of dying in next year[1]	Age (years)	Probability of dying in next year[1]
10	0.000	55	0.005
15	0.000	60	0.008
20	0.001	65	0.012
25	0.001	70	0.019
30	0.001	75	0.034
35	0.001	80	0.062
40	0.002	85	0.114
45	0.002	90	0.202
50	0.003	95	0.295

[1]Based on the population survival curve in Figure 22

3.4.4. Prevalence counts of coal mine dust lung disease in Queensland by coal mine type

The study cohort included 74 surface miners, 53 underground miners and nine miners who had worked in both types of mines. Information on mine type was missing for 32 miners. We imputed the value of mine type for these missing records by first applying the ratio of surface to underground mine workers among the population of coal miners of 4.3:1, and then randomly allocating records with unknown coal mine type to surface mines with probability of 0.81 (i.e. if a randomly generated number was ≤ 0.81) and underground mines with probability of 0.19 (i.e. if the random number was between 0.81 and 1.00).
When reporting the prevalence counts by mine type, we included miners from the combined group in both the surface and underground categories during their estimation. This meant that the subgroup-specific prevalence counts were more than the total counts.

The age that each coal miner would have been on 30 June 2020 was estimated using the information about the date of birth. There were three coal miners for which this information was missing. For two of these coal miners, we used the available information about the year they first started work in the coal mines and assumed they were aged 20 when they started. For the third case, we used the information about the year they first started smoking and assumed this was at age 18 years.

Assumption #1: There were no deaths among coal miners diagnosed with coal mine dust lung disease, and only those cases with known date of diagnosis were included.

Note, as per the assumption above, the 29 (17%) coal miners who did not have complete information about date of diagnosis were excluded from the prevalence count estimates for this calculation (Table 12).

TABLE 12 ESTIMATED PREVALENCE COUNT FOR COAL MINE DUST LUNG DISEASE – ASSUMPTION #1

Year	Prevalence count			Year	Prevalence count		
	Total[1]	Underground mines[2,3]	Surface mines[2,3]		Total[1]	Underground mines[2,3]	Surface mines[2,3]
2002/03	1	0	1	2012/13	25	9	17
2003/04	2	0	2	2013/14	27	9	19
2004/05	2	0	2	2014/15	31	10	22
2005/06	2	0	2	2015/16	38	16	23
2006/07	2	0	2	2016/17	55	26	32
2007/08	3	0	3	2017/18	66	31	40
2008/09	6	1	5	2018/19	94	44	58
2009/10	11	3	8	2019/20	137	61	85
2010/11	15	5	10				

1. N=29 cases were not included in prevalence counts due to missing date of diagnosis
2. Some miners were included in both categories: surface mines and underground mines, so subtotals will not add up to the total
3. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

Assumption #2: There were no deaths among coal miners diagnosed with coal mine dust lung disease, and records with missing dates of diagnosis (n=29) were approximated based on the distribution of known cases.

For the 29 records that had missing data on the year of diagnosis, we imputed their year of diagnosis according to the distribution of cases across the known years of diagnosis. This calculation assumed that the cases with unknown year of diagnosis were not diagnosed earlier and may not be valid if the reason for the missing data was poorer data quality in earlier years.

To impute the year of diagnosis for these cases, we used the reverse gamma (1,4) distribution. The comparisons between the distributions for the cases with known year of diagnosis and unknown year of diagnosis can be seen in Figure 23. For example, in 2019/20, rather than the 43 observed new cases diagnosed, we imputed that an additional three cases (out of the 29 cases with missing data) were also diagnosed in 2019/20.

The estimated prevalence counts were then re-calculated using this updated diagnosis information (Table 13).

FIGURE 23 DISTRIBUTION OF COUNTS BY YEAR OF DIAGNOSIS FOR KNOWN VALUES (N=121) AND SIMULATED COUNTS FOR MISSING (N=29) VALUES OF YEAR OF DIAGNOSIS VARIABLE

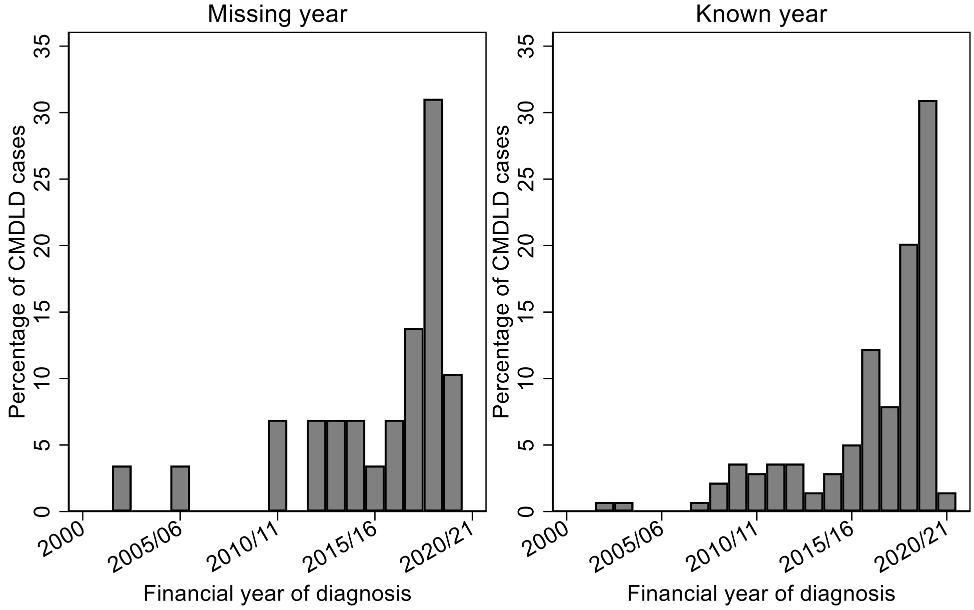


TABLE 13 ESTIMATED PREVALENCE COUNT FOR COAL MINE DUST LUNG DISEASE– ASSUMPTION #2

Year[1]	Prevalence count: Total	Prevalence count: Underground mines[2,3]	Prevalence count: Surface mines[2,3]	Year[1]	Prevalence count: Total	Prevalence count: Underground mines[2,3]	Prevalence count: Surface mines[2,3]
2002/03	2	0	2	2011/12	24	7	17
2003/04	3	0	3	2012/13	31	9	23
2004/05	3	0	3	2013/14	35	9	27
2005/06	4	0	4	2014/15	41	11	31
2006/07	4	0	4	2015/16	49	17	33
2007/08	5	0	5	2016/17	68	27	44
2008/09	8	1	7	2017/18	83	32	56
2009/10	13	3	10	2018/19	120	48	80
2010/11	19	5	14	2019/20	166	66	109

1. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
2. Some miners were included in both categories: surface and underground mines, so subtotals will not add up to the total
3. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

Assumption #3: There were coal mine dust lung disease-related deaths among coal miners diagnosed with coal mine dust lung disease, and missing dates of diagnosis (n=29) were imputed based on the distribution of known cases.

The estimated, cause-specific survival curve (Figure 21) was used to estimate the number of coal miners who would have died in the years following diagnosis from coal mine dust lung disease. For example, if a coal miner with coal mine dust lung disease had survived four years, they would have a 0.011 probability of dying from the disease in that fifth year.

Random numbers were used (values between zero and one sampled from the uniform distribution) to simulate whether a coal miner died from the disease in a specific year (conditional on having survived up to the previous year).

After running this simulation, due to the projected low probability of coal mine dust lung disease patients dying from the disease, and the (relatively) low number of coal miners diagnosed with the disease, the simulations estimated that nine coal mine dust lung disease patients died of the disease, one in 2005/06, one in 2007/08, one in 2014/15, three in 2017/18, one in 2018/19, and two in 2019/20. Thus, the estimated prevalence counts (Table 14) were reduced in those and subsequent years compared with the estimates under Assumption 2.

According to Assumption 3, there would be 157 coal miners in Queensland alive on 30 June 2020 after being formerly diagnosed with coal mine dust lung disease.

It is important to note that these counts were based on simulations only, and hence may be very different to the actual counts based on record linkage of the cases with death registry mortality information. While there were no data to validate these estimates, RSHQ had some incomplete information about coal mine dust lung disease cases who had died, however this was for all causes of death, not just deaths due to coal mine dust lung disease. This showed that at least eight of the 166 coal mine dust lung disease cases were known to have died from any condition, which was consistent with our simulations.

TABLE 14 ESTIMATED PREVALENCE COUNT FOR COAL MINE DUST LUNG DISEASE– ASSUMPTION #3

	Prevalence count[1]				Prevalence count[1]		
Year[2]	Total	Underground mines[3,4]	Surface mines[3,4]	Year[2]	Total	Underground mines[3,4]	Surface mines[3,4]
2002/03	2	0	2	2011/12	22	7	15
2003/04	3	0	3	2012/13	29	9	21
2004/05	3	0	3	2013/14	33	9	25
2005/06	3	0	3	2014/15	38	10	29
2006/07	3	0	3	2015/16	46	16	31
2007/08	3	0	3	2016/17	65	26	42
2008/09	6	1	5	2017/18	77	30	52
2009/10	11	3	8	2018/19	113	45	76
2010/11	17	5	12	2019/20	157	62	103

1. Includes adjustment for the probability of people dying from coal mine dust lung disease
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Some miners were included in both surface mines and underground mines, so subtotals will not add up to the total
4. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

Assumption #4: There were coal mine dust lung disease-related deaths and deaths due to other causes among coal miners diagnosed with coal mine dust lung disease, and records with missing dates of diagnosis (n=29) were approximated based on the distribution of known cases.

This assumption builds on the previous three assumptions, in that missing diagnosis years for cases were imputed, and adjustments made for the possibility of dying from coal mine dust lung disease based on the years since diagnosis (Table 10) and also the general population mortality based on the age in the specific (prevalent) year (Table 11).

The age in the specific prevalent year was estimated based on the reported year of birth and the estimated age each person would have been on the date of diagnosis.

In addition, to account for the greater uncertainty associated with estimating mortality based on random numbers, we ran the simulations 1,000 times, and thus estimated the range of values for the estimated prevalence that might be expected under this assumption. This means, for each simulation, we generated a random number between zero and one, compared that with the age-specific probability of dying within the next year, and thus estimated whether a person remained a prevalent case or not.

From these analyses, we estimated that in 2019/20, there were between 135 and 149 prevalent cases of coal mine dust lung disease in Queensland (Figure 24, Table 15), with an average value across the 1,000 simulations of 142.8 prevalent cases. Compared to the results based on Assumption 2, this suggested that between 17 and 31 people formerly diagnosed with coal mine dust lung disease in Queensland died from coal mine dust lung disease or from other causes by 30 June 2020.

As with Assumption #3, it is important to note that these counts were based on simulations only and hence may be very different to the actual counts of deaths among individual cases based on record linkage between the coal mine dust lung disease cases and the death registry mortality information.

As noted above, while there was no data to validate these estimates, RSHQ had some incomplete information about coal mine dust lung disease cases who had died. This showed that at least eight of the 166 coal mine dust lung disease cases were known to have died, which was consistent with the estimates in this simulation study. There was no information about the cause of death for these eight cases.

When splitting by type of coal mine (Figure 25, Table 15), we estimated that in 2019/20 there were between 56 and 65 prevalent cases among coal miners who had worked in underground coal mines, and between 82 and 95 prevalent cases who had worked in surface mines.

The additional assumptions made for these estimates increase their face validity; that is the extent to which the calculation of the prevalence rates appear to reflect its intent. For this reason, the calculation of the prevalence rates in the next section will use the prevalence count estimates generated under Assumption #4.

Figure 24 Estimated range of prevalence counts of coal mine dust lung disease annually in Queensland: results of 1,000 simulations based on Assumption #4

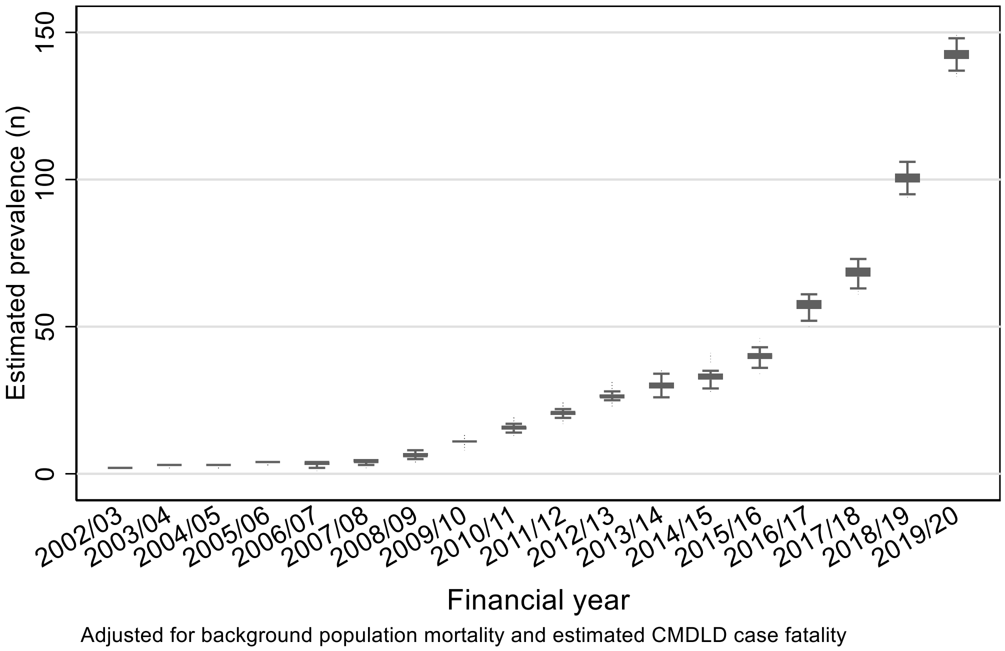


Figure 25 Estimated range of prevalence counts of coal mine dust lung disease annually in Queensland by mine type: results of 1,000 simulations based on Assumption #4

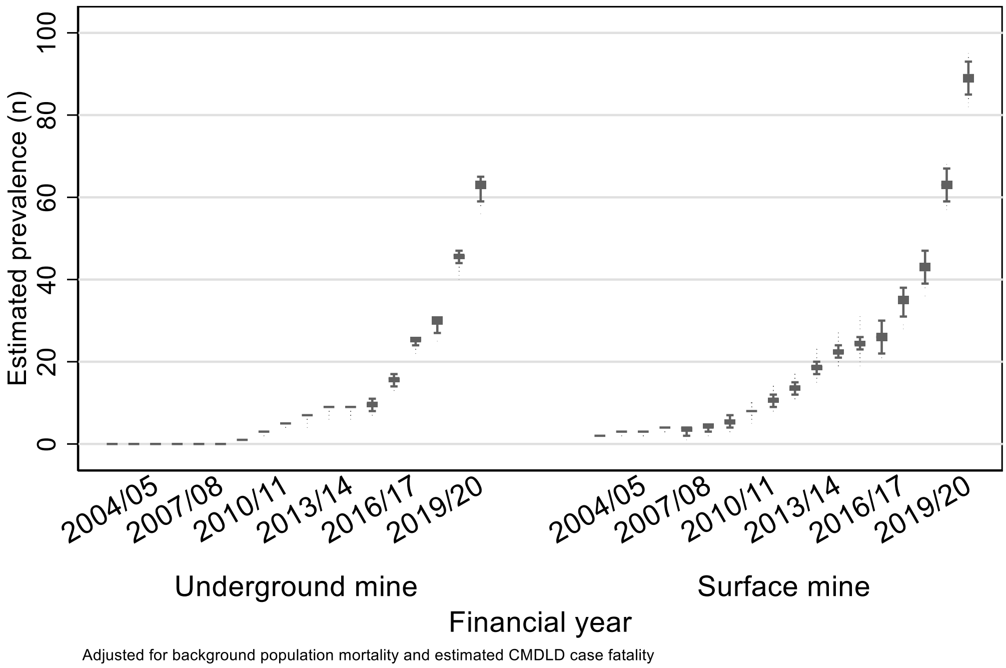


TABLE 15 ESTIMATED AVERAGE PREVALENCE COUNT FOR COAL MINE DUST LUNG DISEASE BASED ON 1,000 SIMULATIONS – ASSUMPTION #4

	Prevalence count[1]				Prevalence count[1]		
Year[2]	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**	**Year[2]**	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**
2002/03	2.0 [2-2]	0.0 [0-0]	2.0 [2-2]	2011/12	20.7 [17-24]	6.9 [4-7]	13.8 [11-17]
2003/04	3.0 [2-3]	0.0 [0-0]	3.0 [2-3]	2012/13	26.5 [23-31]	8.9 [6-9]	18.6 [15-23]
2004/05	3.0 [2-3]	0.0 [0-0]	3.0 [2-3]	2013/14	29.9 [26-35]	8.8 [6-9]	22.2 [19-27]
2005/06	3.9 [3-4]	0.0 [0-0]	3.9 [3-4]	2014/15	33.1 [28-41]	9.7 [7-11]	24.4 [19-31]
2006/07	3.6 [1-4]	0.0 [0-0]	3.6 [1-4]	2015/16	40.3 [34-46]	15.5 [13-17]	25.7 [21-30]
2007/08	4.3 [2-5]	0.0 [0-0]	4.3 [2-5]	2016/17	57.5 [50-61]	25.3 [22-26]	35.1 [28-38]
2008/09	6.4 [4-8]	1.0 [1-1]	5.4 [3-7]	2017/18	68.4 [61-73]	30.0 [25-31]	43.4 [36-47]
2009/10	11.2 [8-13]	3.0 [2-3]	8.2 [5-10]	2018/19	100.9 [94-106]	45.5 [40-47]	63.2 [57-68]
2010/11	16.1 [13-19]	5.0 [4-5]	11.1 [8-14]	2019/20	142.8 [135-149]	62.6 [56-65]	89.0 [82-95]

1. Includes adjustment for the probability of people dying from coal mine dust lung disease and from all other causes
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Includes mean value over 1,000 iterations and the range (minimum-maximum)
4. Some miners were included in both surface mines and underground mines, and values reflect averages and ranges of individual simulations, so subtotals will not add up to the total
5. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

3.4.5. Prevalence counts for current miners at time of diagnosis

For most of the 166 coal miners diagnosed with coal mine dust lung disease, we had information about when they commenced coal mining, and the number of years that they had worked in coal mines.

We assumed that the number of years worked in a coal mine were continuous and without breaks. That is, miners did not work for five years in coal mines, then have four years in another occupation, and then work for another six years in coal mines. We had no information to assess the validity of this assumption.

Some cases lacked information on the year they started being a coal miner and/or the number of years worked in coal mines (Table 16).

TABLE 16 MISSING VALUES FOR MINE EXPERIENCE VARIABLES (N=166)

Coal mine tenure	Start of employment in coal mining		
	Valid	Missing	Total
Valid	113	3	116
Missing	32	18	50
Total	145	21	166

For the diagnosed cases with a valid start date but missing coal mine tenure (n=32), we needed to estimate whether they were current miners at the time of diagnosis. If the age at diagnosis was more than 65 years, we assumed they were not current miners at the time of diagnosis. Thus, we set the coal mine tenure variable to be the year of diagnosis - start year – 2, with the value of "-2" chosen arbitrarily to ensure they were not counted in the group of current miners. Conversely, if the age at diagnosis was ≤65 years then we assumed that they were coal miners at the time of diagnosis, so we set the coal mine tenure variable to be the year of diagnosis - start year + 2, with the '"+2" chosen to ensure they were included in the group of current miners.

Similar changes based on the age at diagnosis were made for the 21 coal miners with missing information about when they began work. That is, if the age at diagnosis was more than 65 years then data was imputed so that the combination of start time and coal mine tenure meant they were not current coal miners at the time of diagnosis.

These calculations were made on the basis of calendar year, and then applied to the financial year data.

The results of this simulation are shown in Table 17.

TABLE 17 DISTRIBUTION OF COAL MINE DUST LUNG DISEASE CASES BASED ON WHETHER THEY WERE A CURRENT COAL MINER AT DIAGNOSIS

Status at diagnosis	Original data	Imputed data[1]
Current miners	44 (27%)	73 (44%)
Previous miners	70 (42%)	93 (56%)
Missing	52 (31%)	0 (0%)

1. See text for imputation details

After applying the same assumptions as Assumption #4 to these current miners, the estimates of coal mine dust lung disease prevalence counts are shown in Figure 26 and Figure 27, and Table 18.

Note that these prevalence counts refer to the number of people who were alive in the relevant year and had been diagnosed with coal mine dust lung disease while they were employed in coal mines. Therefore, if a coal miner was diagnosed with coal mine dust lung disease in the 2012/2013 financial year, and was alive on 30 June 2020, then that coal miner would be included in the prevalence counts for each financial year between 2012/13 and 2019/20. If, however, the coal miner died (of any cause) in 2017/18, then they would only be included in the prevalence counts between 2012/13 and 2017/18.

FIGURE 26 ESTIMATED RANGE OF PREVALENCE COUNTS OF COAL MINE DUST LUNG DISEASE AMONG MINERS WHEN EMPLOYED AT COAL MINES IN QUEENSLAND: RESULTS OF 1,000 SIMULATIONS BASED ON ASSUMPTION #4

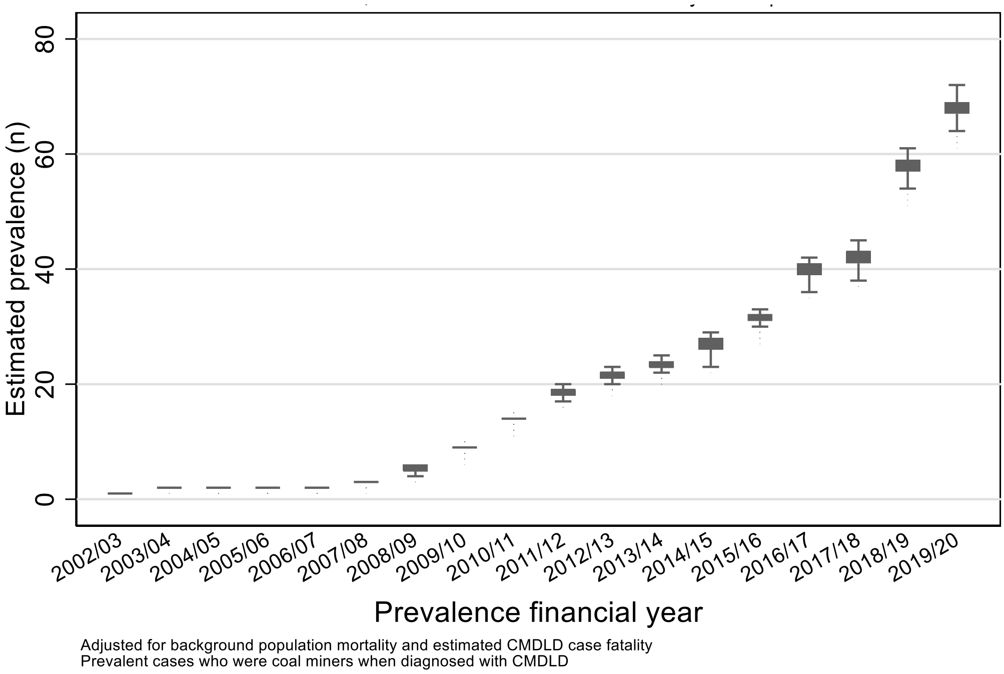


FIGURE 27 ESTIMATED RANGE OF PREVALENCE COUNTS OF COAL MINE DUST LUNG DISEASE AMONG MINERS WHEN EMPLOYED AT COAL MINES IN QUEENSLAND BY MINE TYPE: RESULTS OF 1,000 SIMULATIONS BASED ON ASSUMPTION #4

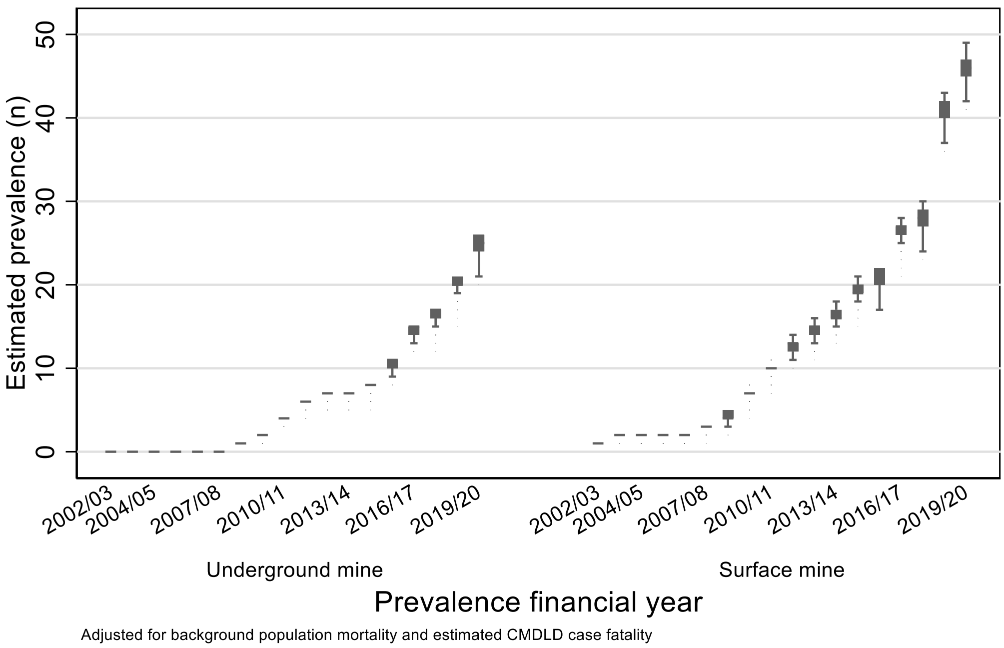


TABLE 18 ESTIMATED PREVALENCE COUNT FOR COAL MINE DUST LUNG DISEASE – ONLY CASES DIAGNOSED WHILE WORKING AS COAL MINERS ONLY (ASSUMPTION #4)

	Prevalence count[1]				Prevalence count[1]		
Year[2]	Total[3]	Underground mines[3,4,5]	Surface mines[3,4,5]	Year[2]	Total[3]	Underground mines[3,4,5]	Surface mines[3,4,5]
2002/03	1.0 [1-1]	0.0 [0-0]	1.0 [1-1]	2011/12	18.7 [16-20]	5.9 [4-6]	12.7 [10-14]
2003/04	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2012/13	21.5 [18-23]	6.9 [5-7]	14.6 [11-16]
2004/05	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2013/14	23.1 [20-25]	6.8 [5-7]	16.3 [13-18]
2005/06	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2014/15	26.8 [22-29]	7.7 [5-8]	19.1 [15-21]
2006/07	1.9 [1-2]	0.0 [0-0]	1.9 [1-2]	2015/16	31.4 [27-33]	10.6 [8-11]	20.8 [17-22]
2007/08	2.9 [1-3]	0.0 [0-0]	2.9 [1-3]	2016/17	40.0 [35-42]	14.5 [12-15]	26.5 [21-28]
2008/09	5.2 [3-6]	1.0 [1-1]	4.2 [2-5]	2017/18	42.4 [37-45]	16.3 [12-17]	28.0 [23-30]
2009/10	9.0 [6-10]	2.0 [1-2]	7.0 [4-8]	2018/19	57.8 [51-61]	20.1 [15-21]	40.6 [36-43]
2010/11	13.9 [11-15]	4.0 [3-4]	9.9 [7-11]	2019/20	67.9 [61-72]	24.9 [20-26]	46.0 [41-49]

1. Includes adjustment for the probability of people dying from coal mine dust lung disease and from all other causes
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Includes mean value over 1,000 iterations and the range (minimum-maximum)
4. Some miners were included in both surface mines and underground mines, and values reflect averages and ranges of individual simulations, so subtotals will not add up to the total
5. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

3.4.6. Number of prevalent cases diagnosed within 15 years of working in a coal mine in a specific year

A limitation of only considering cases of coal mine dust lung disease in current workers is that it ignored the possibility that people who had worked in coal mines may be diagnosed with coal mine dust lung disease after they had stopped working on coal mines. This is a similar effect to other diseases such as lung cancer, where population trends in lung cancer incidence rates generally followed population trends in smoking rates 20-30 years earlier.

For this reason, we recalculated the prevalence counts by including any cases of coal mine dust lung disease that were diagnosed within 15 years of the specific financial year. For example, the prevalence count for 2019/20 included all cases of coal mine dust lung disease diagnosed up to 2019/20 among coal miners who were working in a coal mine 15 years earlier in 2004/05 and were alive on 30 June 2020.

Since this definition required at least 15 years of follow-up, this prevalence measure could only be calculated for those coal miners who had worked in 2004/05 and earlier. That is, it was not possible to calculate 15-year prevalence for coal miners who were working in 2010/11.

To calculate this measure, we considered the number of prevalent cases of coal mine dust lung disease based on the year when miners were working. For example, of coal miners working in 1987/88, there were two prevalent cases of coal mine dust lung disease 15 years later in 2002/03 (Table 19). Similarly, of all coal miners working in Queensland in 2004/05, the simulations estimated that there were between 89 and 102 prevalent cases of coal mine dust lung disease 15years later in 2019/20, (Figure 28) of which between 40-46 were working in underground coal mines and between 52-64 were working in surface coal mines

(Figure 29). Note that some of these cases were diagnosed while they were working in coal mines, and some were diagnosed within 15 years.

TABLE 19 ESTIMATED 15-YEAR PREVALENCE COUNTS ACCORDING TO PREVALENT YEAR – RESULTS OF 1,000 SIMULATIONS (DIAGNOSED UP TO 15 YEARS EARLIER, COAL MINE WORKER 15 YEARS AGO)

	Prevalence count[1]				Prevalence count[1]		
Prevalent Year[2]	Total[3]	Underground mines[3,4,5]	Surface mines[3,4,5]	Prevalent Year[2]	Total[3]	Underground mines[3,4,5]	Surface mines[3,4,5]
2002/03	2.0 [2-2]	0.0 [0-0]	2.0 [2-2]	2011/12	11.8 [9-14]	3.0 [1-3]	8.9 [6-11]
2003/04	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2012/13	16.6 [14-19]	3.9 [2-4]	12.7 [10-15]
2004/05	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2013/14	19.3 [16-22]	3.9 [2-4]	15.4 [12-18]
2005/06	2.0 [1-2]	0.0 [0-0]	2.0 [1-2]	2014/15	19.7 [15-24]	3.8 [1-4]	15.8 [11-20]
2006/07	1.9 [1-2]	0.0 [0-0]	1.9 [1-2]	2015/16	25.0 [20-28]	6.8 [4-7]	18.3 [13-21]
2007/08	2.9 [2-3]	0.0 [0-0]	2.9 [2-3]	2016/17	39.4 [34-42]	14.7 [12-15]	26.7 [22-29]
2008/09	4.2 [2-5]	0.0 [0-0]	4.2 [2-5]	2017/18	49.5 [44-53]	20.3 [16-21]	32.1 [27-35]
2009/10	6.1 [4-7]	2.0 [2-2]	4.1 [2-5]	2018/19	69.3 [62-74]	29.1 [24-30]	46.2 [40-50]
2010/11	9.0 [6-11]	2.0 [1-2]	7.1 [4-9]	2019/20	97.3 [89-102]	44.7 [40-46]	59.5 [52-64]

1. Includes adjustment for the probability of people dying from coal mine dust lung disease and from all other causes
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Includes mean value over 1,000 iterations and the range (minimum-maximum)
4. Some miners were included in both surface mines and underground mines, and values reflect averages and ranges of individual simulations, so subtotals will not add up to the total
5. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

FIGURE 28 ESTIMATED 15-YEAR PREVALENCE COUNTS ACCORDING TO PREVALENT YEAR – RESULTS OF 1,000 SIMULATIONS (DIAGNOSED UP TO 15 YEARS EARLIER, COAL MINE WORKER 15 YEARS AGO)

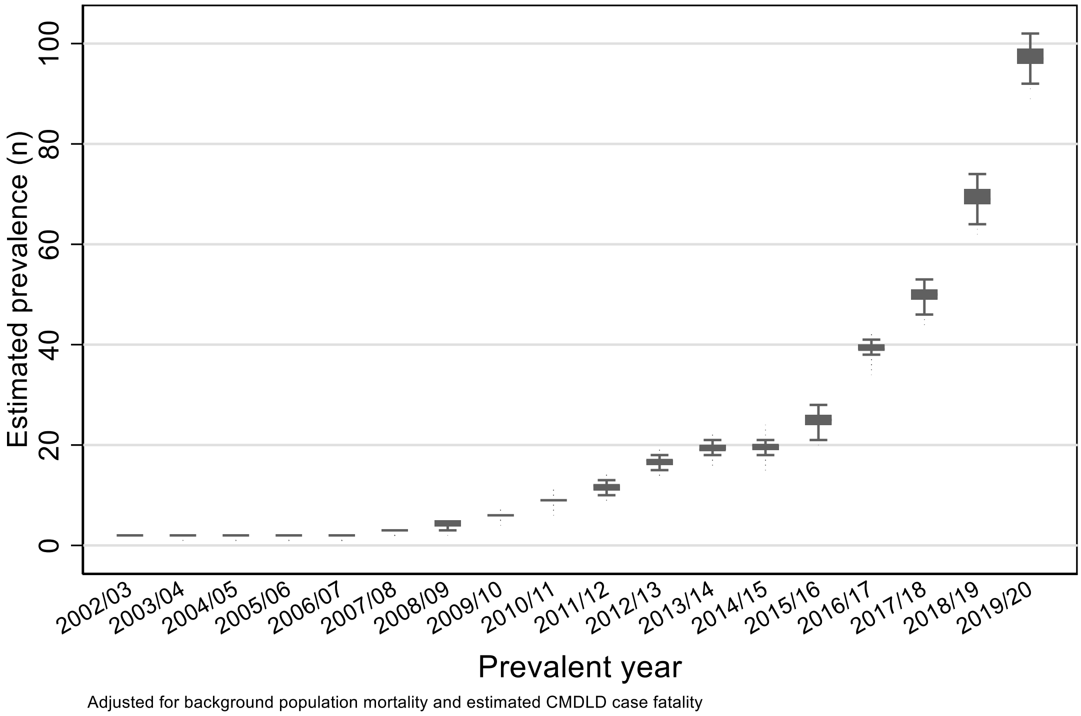
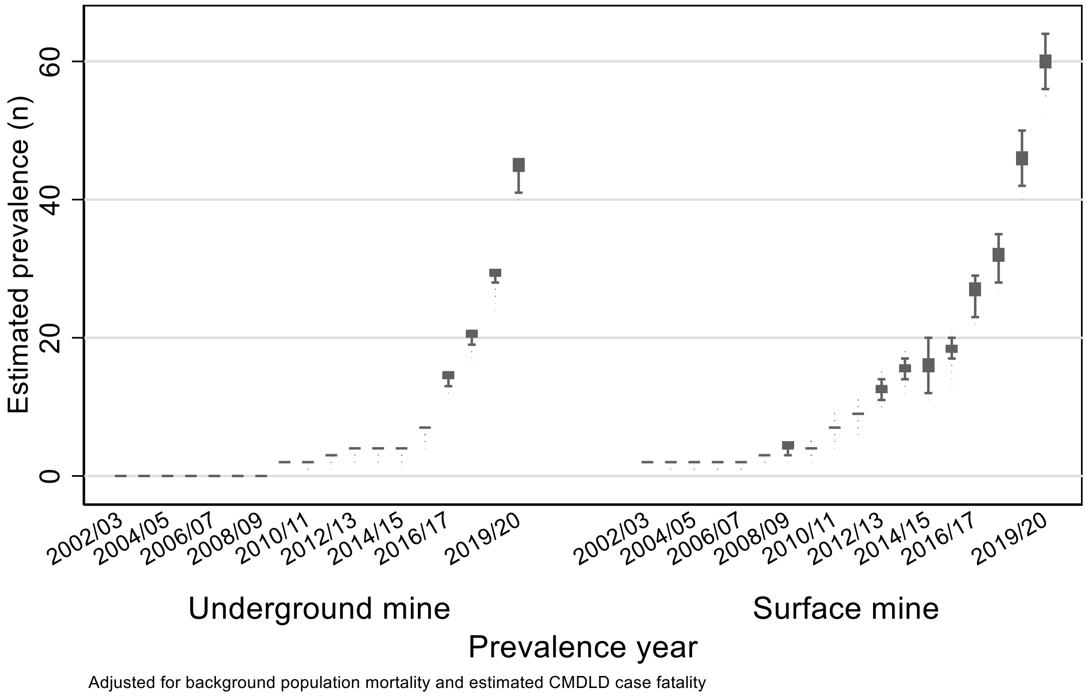


FIGURE 29 ESTIMATED 15-YEAR PREVALENCE COUNTS ACCORDING TO PREVALENT YEAR BY MINE TYPE – RESULTS OF 1,000 SIMULATIONS (DIAGNOSED UP TO 15 YEARS EARLIER, COAL MINE WORKER 15 YEARS EARLIER)



3.5. Prevalence rates of coal mine dust lung disease in Queensland

The calculation of prevalence rates involved dividing the number of prevalent cases (the numerator) by the population at risk (the denominator).

A key consideration was that the numerator needed to be a subset of the denominator. Therefore, simply dividing the estimated number of prevalent cases in 2019/20 by the number of coal mine workers in 2019/20 would not be valid, because many of the prevalent cases in 2019/20 were not working in coal mines in that financial year.

Ideally, the prevalence rate of a condition would be calculated by identifying a population at risk, such as coal miners, and then, determining at a single point in time, the number of people with the condition among the population at risk.

This was not feasible with coal mine dust lung disease, because the majority of cases (56%; Table 17) diagnosed in this study were among people who had formerly worked in coal mines, rather than current miners. In addition, the population of coal miners is continually changing.

We have identified at least two methods to calculate prevalence rates that provide different perspectives. Both methods included coal miners who were diagnosed while they were working in a coal mine, as well as people who were diagnosed after they had stopped working in a coal mine.

The difference between the two methods was the denominator. Method 1 was based on the number of full-time equivalent miners who had worked in a Queensland mine up to the prevalent year (starting from 1983/84). This reflected the scenario that coal miners were potentially at risk of being diagnosed with coal mine dust lung disease once they had worked in a coal mine, irrespective of whether they had since stopped working. This scenario was also consistent with what was observed in this study (Table 17).

Method 2 incorporated the time worked in a coal mine. This was on the basis that the more years worked in a coal mine, the higher the exposure to risk factors for coal mine dust lung disease.

Each of these methods is described in more detail below.

3.5.1. Prevalence rate (per 1,000 coal miners) of coal mine dust lung disease among current and former coal miners in Queensland (Method 1)

Numerator: Coal miners who had worked in a coal mine at some point prior to their diagnosis of coal mine dust lung disease and who were alive in the prevalent year (Table 15). Individual coal miners were counted in the prevalence count each year from their year of diagnosis until the prevalent year, as long as they remained alive. Hence a coal miner diagnosed with coal mine dust lung disease in the 2012/2013 financial year who was alive on 30 June 2020, was included in the prevalence counts for each financial year between 2012/13 and 2019/20.

Denominator: Cumulative number of full-time equivalent coal miners who had worked in Queensland coal mines up to and including the prevalent year and were still alive in that year (Table 4 and Table 5).

Prevalent year: The year that previously diagnosed cases are alive.

When considering all cases of coal mine dust lung disease, including those diagnosed when current miners and those diagnosed after they had stopped coal mining (Table 18, Figures 24-25), the estimated prevalence rate of coal mine dust lung disease in 2019/20 was 2.05 cases per 1,000 coal miners with a simulated range of 1.94-2.14 prevalent cases per 1,000 coal miners. This estimated prevalence rate (Table 20, Figure 30) was higher among underground miners (4.3-5.0 cases per 1,000 coal miners) than surface miners (1.5-1.7 cases per 1,000 coal miners) (Figure 31).

TABLE 20 ESTIMATED PREVALENCE RATE FOR COAL MINE DUST LUNG DISEASE – CURRENT AND FORMER COAL MINERS SINCE 1983/84 – RESULTS OF 1,000 SIMULATIONS

	Prevalence rate (/1,000 coal miners)[1]				Prevalence rate (/1,000 coal miners)[1]		
Year[2]	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**	**Year[2]**	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**
2002/03	0.1 [0.1-0.1]	0.0 [0.0-0.0]	0.1 [0.1-0.1]	2011/12	0.4 [0.3-0.5]	0.8 [0.4-0.8]	0.4 [0.3-0.4]
2003/04	0.1 [0.1-0.2]	0.0 [0.0-0.0]	0.2 [0.1-0.2]	2012/13	0.5 [0.5-0.6]	0.9 [0.6-0.9]	0.5 [0.4-0.6]
2004/05	0.1 [0.1-0.1]	0.0 [0.0-0.0]	0.2 [0.1-0.2]	2013/14	0.6 [0.5-0.7]	0.9 [0.6-0.9]	0.5 [0.5-0.6]
2005/06	0.1 [0.1-0.1]	0.0 [0.0-0.0]	0.2 [0.1-0.2]	2014/15	0.6 [0.5-0.8]	1.0 [0.7-1.1]	0.6 [0.4-0.7]
2006/07	0.1 [0.0-0.1]	0.0 [0.0-0.0]	0.1 [0.0-0.2]	2015/16	0.7 [0.6-0.8]	1.5 [1.2-1.6]	0.6 [0.5-0.7]
2007/08	0.1 [0.1-0.1]	0.0 [0.0-0.0]	0.2 [0.1-0.2]	2016/17	1.0 [0.9-1.1]	2.4 [2.1-2.4]	0.8 [0.6-0.8]
2008/09	0.2 [0.1-0.2]	0.1 [0.1-0.1]	0.2 [0.1-0.2]	2017/18	1.2 [1.1-1.3]	2.7 [2.3-2.8]	0.9 [0.8-1.0]
2009/10	0.3 [0.2-0.3]	0.4 [0.3-0.4]	0.3 [0.2-0.3]	2018/19	1.6 [1.5-1.7]	3.8 [3.4-4.0]	1.2 [1.1-1.3]
2010/11	0.4 [0.3-0.4]	0.6 [0.5-0.6]	0.3 [0.2-0.4]	2019/20	2.1 [1.9-2.1]	4.8 [4.3-5.0]	1.6 [1.5-1.7]

1. Includes adjustment for the probability of people dying from coal mine dust lung disease and from all other causes (among numerator and denominator)
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Includes mean value over 1,000 iterations and the range (minimum-maximum)
4. Some miners were included in both surface mines and underground mines, and values reflect averages and ranges of individual simulations, so subtotals will not add up to the total
5. Where information about mine type was missing (n=32), records were randomly allocated records to surface or underground by a ratio of 4.3:1

FIGURE 30 ESTIMATED PREVALENCE RATES (PER 1,000 COAL MINERS) OF COAL MINE DUST LUNG DISEASE AMONG MINERS EMPLOYED AT A COAL MINE AT TIME OF DIAGNOSIS, METHOD 1 RESULTS OF 1,000 SIMULATIONS

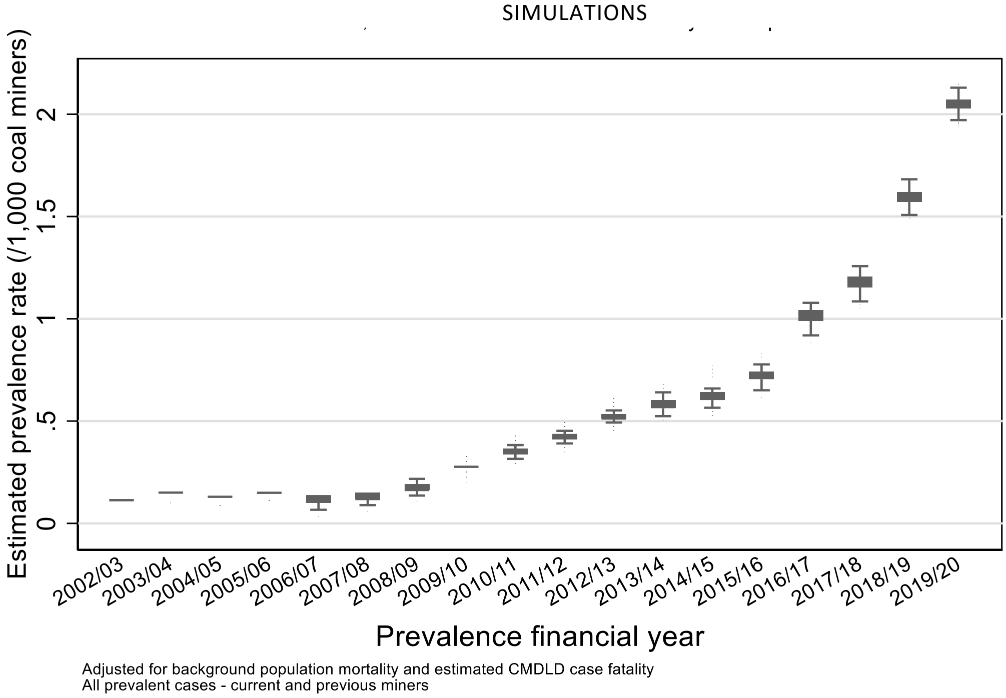
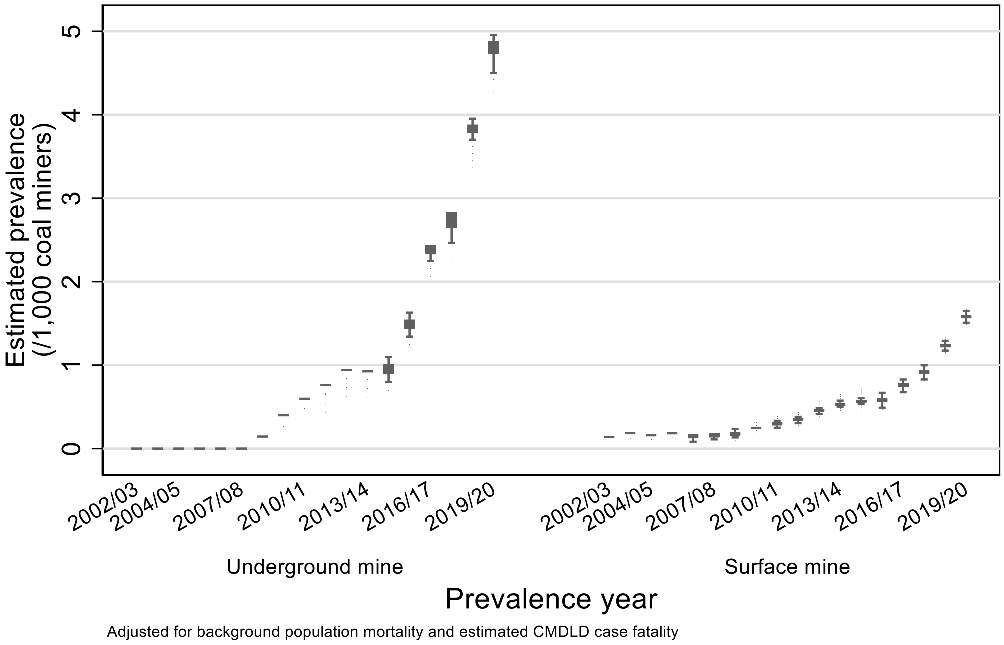


FIGURE 31 ESTIMATED PREVALENCE RATES (PER 1,000 COAL MINERS) OF COAL MINE DUST LUNG DISEASE AMONG MINERS EMPLOYED AT A COAL MINE AT TIME OF DIAGNOSIS BY MINE TYPE, METHOD 1 RESULTS OF 1,000 SIMULATIONS



3.5.2. Prevalence rate (per 100,000 person years of previous coal mine exposure) of coal mine dust lung disease (Method 2)

Theoretically, the use of the combined number of persons years at risk provides a more interpretable denominator than the use of a single fixed population. This is because it appropriately accounts for the impact of the number of years worked in a coal mine (higher years implies greater exposure to risk) in the denominator rather than the population at a fixed point in time (which would be the same regardless of whether miners had worked in coal mines for one year on average or 20 years on average).

Note that for these calculations, the number of years was calculated since 1983/84, and so for the purposes of these calculations, excluded coal mine exposure prior to 1983/84.

Numerator: Cases who were alive in the prevalent year (Table 15).

Denominator: Cumulative number of person years of work at coal mines between 1983/84 up to the prevalent year (Table 4 and Table 6).

This prevalence rate calculation was based on the total number of prevalent cases of coal mine dust lung disease (Table 15) divided by the estimated total number of person years of risk from the first year available (1983/84) up to and including the prevalent year (Table 6).

These simulations (Table 21, Figure 32) found that on 30 June 2020, there were about 14 prevalent cases of coal mine dust lung disease for every 100,000 coal mine person years worked up to that point.

This prevalence rate was higher among underground miners (29-33 cases per 100,000 person years) than surface miners (10-11 cases per 100,000 person years) (Table 21, Figure 33).

TABLE 21 ESTIMATED PREVALENCE RATE PER 100,000 PERSON YEARS FOR COAL MINE DUST LUNG DISEASE – METHOD 2 ALL PREVALENT CASES PER PERSON YEARS AT RISK – RESULTS OF 1,000 SIMULATIONS

	Prevalence rate (/1,000 person years) [1]				Prevalence rate (/1,000 person years)[1]		
Year[2]	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**	**Year[2]**	**Total[3]**	**Underground mines[3,4,5]**	**Surface mines[3,4,5]**
2002/03	1 [1-1]	0 [0-0]	1 [1-1]	2011/12	4 [3-5]	7 [4-7]	3 [3-4]
2003/04	1 [1-1]	0 [0-0]	2 [1-2]	2012/13	5 [4-5]	8 [5-8]	4 [3-5]
2004/05	1 [1-1]	0 [0-0]	1 [1-1]	2013/14	5 [4-5]	7 [5-7]	4 [4-5]
2005/06	1 [1-1]	0 [0-0]	2 [1-2]	2014/15	5 [4-6]	7 [5-8]	4 [3-5]
2006/07	1 [0-1]	0 [0-0]	1 [0-2]	2015/16	5 [4-6]	11 [9-12]	4 [3-5]
2007/08	1 [1-1]	0 [0-0]	2 [1-2]	2016/17	7 [6-7]	16 [14-17]	5 [4-6]
2008/09	2 [1-2]	1 [1-1]	2 [1-2]	2017/18	8 [7-8]	18 [15-19]	6 [5-7]
2009/10	3 [2-3]	4 [2-4]	2 [1-3]	2018/19	11 [10-11]	25 [22-26]	8 [7-9]
2010/11	3 [3-4]	6 [4-6]	3 [2-4]	2019/20	14 [13-14]	32 [29-33]	11 [10-11]

1. Includes adjustment for the probability of people dying from coal mine dust lung disease and from all other causes
2. Year of diagnosis was imputed for n=29 cases based on the distribution of known years of diagnosis
3. Includes mean value over 1,000 iterations and the range (minimum-maximum)
4. Some miners were included in both surface mines and underground mines, and values reflect averages and ranges of individual simulations, so subtotals will not add up to the total
5. Where information about mine type was missing (n=32), we randomly allocated records to surface or underground by a ratio of 4.3:1

FIGURE 32 PREVALENCE RATE OF COAL MINE DUST LUNG DISEASE ACCORDING TO THE CUMULATIVE NUMBER OF PERSON YEARS AT RISK UP TO AND INCLUDING THAT PREVALENT YEAR, METHOD 2

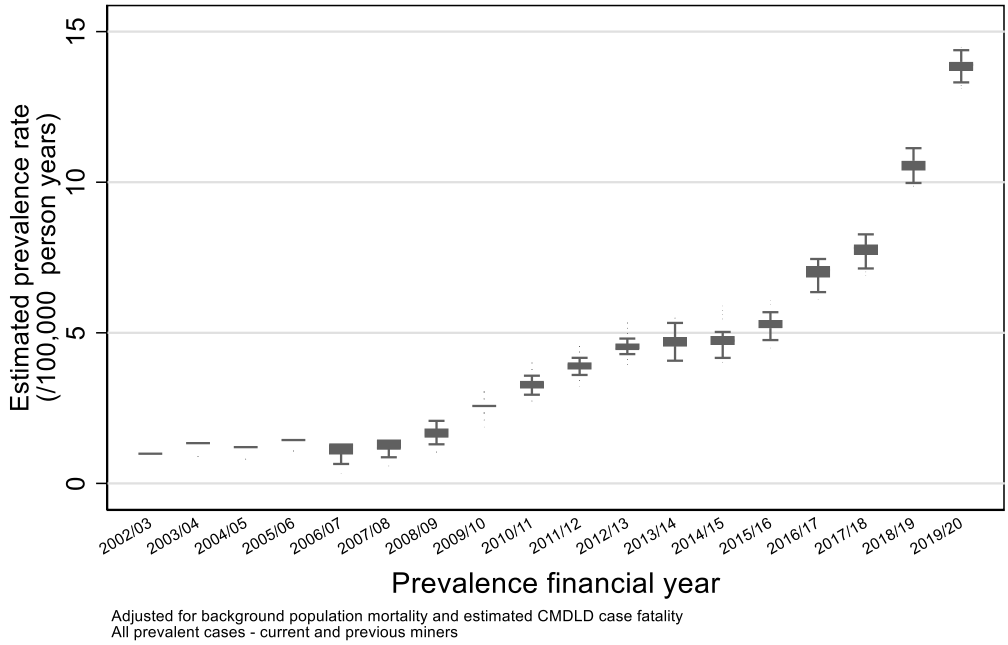
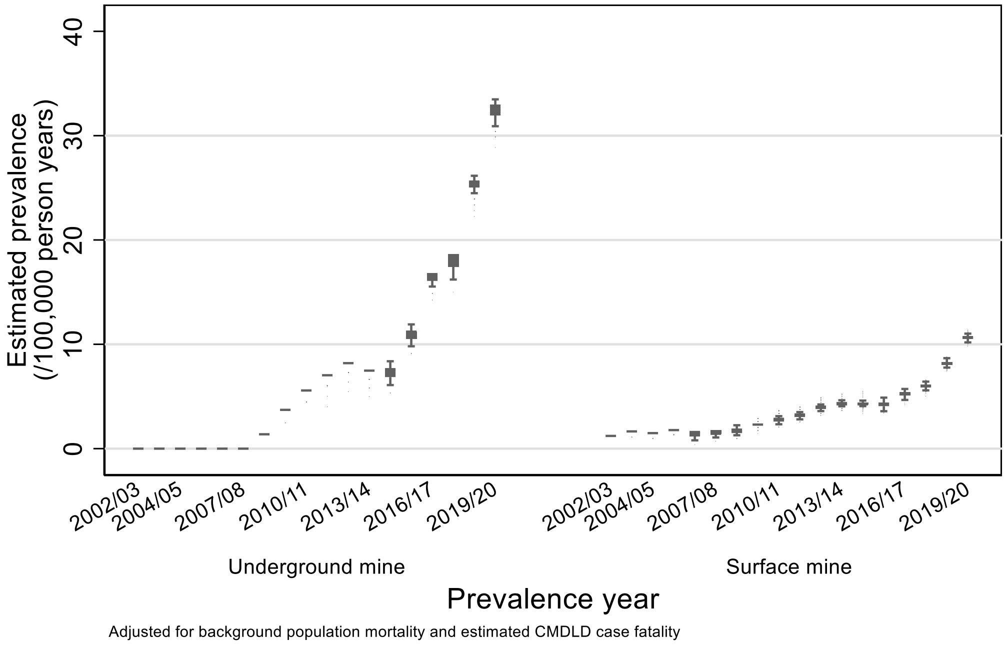


FIGURE 33 PREVALENCE RATE OF COAL MINE DUST LUNG DISEASE ACCORDING TO THE CUMULATIVE NUMBER OF PERSON YEARS AT RISK UP TO AND INCLUDING THAT PREVALENT YEAR, BY COAL MINE TYPE, METHOD 2



3.5.3. Changes in prevalence over time

The prevalence rate of coal mine dust lung disease in Queensland has clearly increased over time. For example, the prevalence rate per 1,000 coal miners (former or current) increased from 0.1 cases per 1,000 coal miners in 2006/07 to 2.1 cases per 1,000 coal miners in 2019/20 (Table 20). Increases were also observed for the prevalence among those who had worked in underground coal mines, from <0.1 cases per 1,000 miners in 2002/03 to 4.8 cases per 1,000 miners in 2019/20. Corresponding increases for those who had worked in surface mines were 0.1 in 2002/03 and 1.6 in 2019/20. This increase was due primarily to a general increase in the number of cases of coal mine dust lung disease diagnosed, particularly since the early 2000s, and the high proportion of people diagnosed with the disease who remained prevalent cases for a number of years after diagnosis.

3.6. Comparison of published estimates for occupation-related conditions in Australia

A search of the published literature was carried out to determine the reported prevalence rates of other occupation-related conditions both in Australia and internationally (Table 22 and Figure 34).

3.6.1. Australia

Only four studies on prevalence of occupation-related conditions in Australia were found with most of the available estimates being based on claims data, which was more a reflection of the incidence (number of new cases diagnosed) rather than prevalence (number of people alive who have been diagnosed previously). One study found that the prevalence of lung cancer on routine screening of asbestos-exposed workers in Western Australia was 8 cases per 1,000 workers, and mesothelioma was 4 cases per 1,000 workers. (54) Among the same cohort, the prevalence of indeterminate lung nodules was 85 cases per 1,000 workers. (55) The number of claims made for occupation-related conditions varied from 0.01 cases per 1,000 workers (56) for asbestosis up to 10 cases per 1,000 workers for musculoskeletal disorders. (56, 57)

3.6.2. International

International studies were primarily on the estimated prevalence of asthma, other occupation related respiratory conditions and/or respiratory symptoms. One study reported prevalence rates for current asthma (defined as a self-reported physician diagnosis of asthma which was ongoing) in the USA ranged from 26 to 124 cases per 1,000 workers in specific industries, with the highest rates being found among health care support workers and lowest among those working in farming, fishing or forestry. (58) Studies from the USA were mostly based on national cross-sectional surveys with large sample sizes, (58-62), thereby leading to representative and robust prevalence rates.

In many countries outside the USA, including Australia, there was a lack of reliable robust prevalence rates for any occupation-related condition. (63) Although in some countries there are surveillance schemes for occupation-related conditions, such as the Surveillance of Australian workplace Based Respiratory Events (SABRE) in the Australian states of New South Wales, Victoria and Tasmania, (64) and Surveillance of Work-related and Occupational Respiratory Disease (SWORD) in the United Kingdom, (65) the primary aims of these data collections are to accurately estimate work-related and occupation-related conditions incidence and to monitor trends. We found no studies reporting prevalence rates based on these data collections.

Table 22 Summary of published prevalence rates for occupational conditions in Australia and other countries

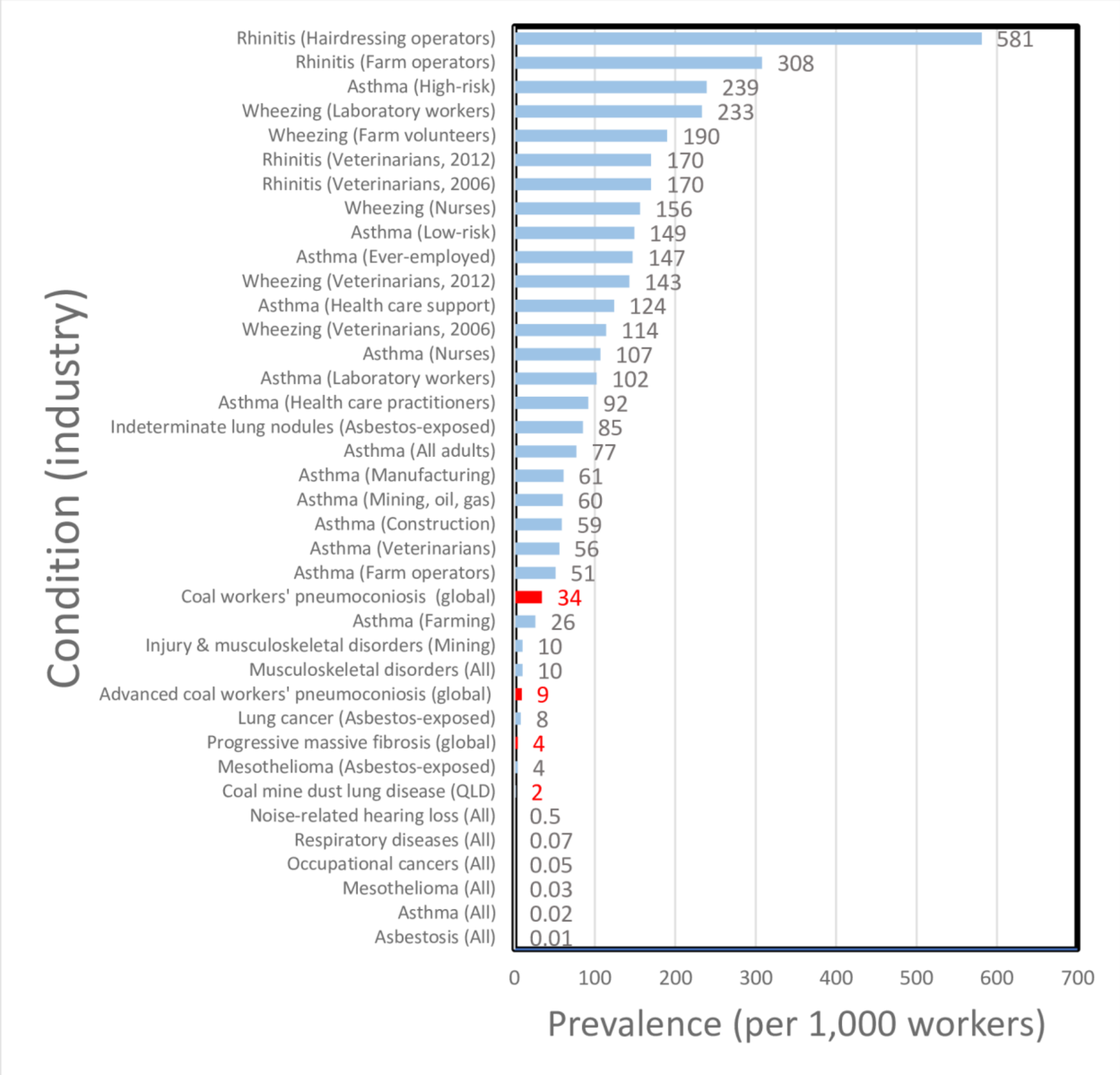
Condition	Industry/ population	Prevalence (per 1,000 workers)	Location (time period)	Design	First author, year	Population
Asthma	All	0.02	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Asthma[2]	Laboratory animal workers	102	Brazil (2012)	Cross-sectional[3]	Freitas et al. 2016 (66)	412
Asthma[4]	Veterinarians	51-56	BAV, Germany (2006, 2012)	Cross-sectional[3]	Schelkle et al. 2017 (67)	512 (2006), 596 (2012)
Asthma[5]	All employed adults	77	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Health care support	124	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Health care practitioners	92	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Manufacturing	61	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Mining, oil, and gas	60	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Construction	59	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[5]	Farming, fishing and forestry	26	USA (2013)	Cross-sectional[6]	Dodd et al. 2016 (58)	107,327
Asthma[7]	Farm operators	51	USA (2011)	Cross-sectional[6]	Patel et al. 2018 (62)	2,181,000
Asthma[8]	Nurses	107	Western Japan (2013)	Cross-sectional[6]	Watanabe et al. 2016 (68)	4,634
Asthma[5]	Ever-employed adults (with current asthma)[7]	147	USA (2012/13)	Cross-sectional[6]	Dodd et al. 2018 (59)	14,915
Asthma[9]	Low risk occupations[10]	149	USA (1999-2015)	Cross-sectional[6]	Laditka et al. 2020 (60)	NS
Asthma	High risk occupations[11]	239	USA (1999-2015)	Cross-sectional[6]	Laditka et al. 2020 (60)	NS
Mesothelioma	All	0.03	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Mesothelioma[12]	Asbestos-exposed population	4	WA (2012/13)	Surveillance[13]	Brims et al. 2015 (54)	906
Lung cancer[12]	Asbestos-exposed population	8	WA (2012/13)	Surveillance[13]	Brims et al. 2015 (54)	906
Indeterminate lung nodules[12]	Asbestos-exposed population	85	WA (2012/13)	Surveillance[13]	Murray et al. 2016 (55)	906
Asbestosis	All	0.01	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Respiratory diseases	All	0.07	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Occupational cancers[14]	All	0.05	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Wheezing[15]	Farm volunteers	190	Ireland (2013)	Cross-sectional[3]	Cushen et al. 2016 (69)	372
Wheezing[15]	Nurses	156	Western Japan (2013)	Cross-sectional[3]	Kurai et al. 2015 (70)	4,634
Wheezing[16]	Veterinarians	114-143	BAV, Germany (2006-2012)	Cross-sectional[3]	Schelkle et al. 2017 (67)	512 (2006), 596 (2012)
Wheezing[16]	Laboratory animal workers	233	Brazil (2012)	Cross-sectional[3]	Freitas et al 2016 (66)	412

Condition	Industry/ population	Prevalence (per 1,000 workers)	Location (time period)	Design	First author, year	Population
Rhinitis[15]	Hairdressing apprentices	581	Denmark (2013)	Cross-sectional[3]	Foss-Skiftesvik et al. 2017 (71)	504
Rhinitis[16]	Veterinarians	170-202	BAV, Germany (2006-2012)	Cross-sectional[3]	Schelkle et al. 2017 (67)	512 (2006), 596 (2012)
Rhinitis[15]	Farm operators	308	USA (2011)	Cross-sectional[3]	Mazurek et al. 2017 (61)	2,181,000
Noise-related hearing loss	All	0.5	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Musculoskeletal disorders	All	10	Australia (2010/11)	Compensation data[1]	Safe Work Australia 2014 (56)	NS
Injury and musculoskeletal disorders	Mining	10	Australia (2018/19)	Compensation data[1]	Safe work Australia 2020 (57)	247,000

WA Western Australia: NS Not stated, BAV Bavaria

[1] National Data Set for Compensation-based Statistics
[2] Clinical symptoms and positive lung-function abnormality tests
[3] Workplace based survey
[4] Having had an asthma attack in the last 12 months or/and taking anti-asthmatic drugs currently.
[5] Work related asthma defined as self-reported physician diagnosis of asthma related to occupational exposure
[6] Population based survey
[7] Self-reported physician diagnosis and having asthma at time of the survey.
[8] Self-reported physician diagnosis and positive asthma symptoms in the past 12 months.
[9] Self-reported physician diagnosis
[10] Professionals, managers, and clerical workers
[11] Industries include agriculture, cleaning, entertainment, health care, mining, manufacturing, construction, wood working, service, protective services
[12] Detected by low-radiation-dose computed topography
[13] The Asbestos Review Program
[14] Includes mesothelioma, skin cancers, blood cancers
[15] Self-reported symptoms
[16] Self-reported symptoms in the past 12 months

FIGURE 34 PREVALENCE RATES (PER 1,000 WORKERS) BY OCCUPATIONAL CONDITIONS (TABLE 22, BLUE) AND COAL MINE DUST LUNG DISEASE FROM THIS REPORT (RED) FROM THE META- ANALYSIS OF INTERNATIONAL PUBLISHED STUDIES AND THOSE BASED ON QUEENSLAND DATA [1-4]



[1]More details about the Condition (industry) are provided in Table 22.

[2]Injuries-is not stated in report whether means any injury or just related to musculoskeletal

[3]Low risk industries include professionals, managers, and clerical workers

[4]High risk industries include agriculture, cleaning, entertainment, health care, mining, manufacturing, construction, wood working, service, protective services

3.7. Summary

3.7.1. Main Findings

After making various assumptions about missing information for mortality and other information including dates of diagnosis, it was estimated that in the 2019/20 financial year there were between 135 and 149 prevalent cases of coal mine dust lung disease among current or former Queensland coal miners.

Just over half (56%) of coal mine dust lung disease cases were diagnosed among former coal miners, that is, after they had stopped working in Queensland coal mines.

The estimated prevalence rate of coal mine dust lung disease in the 2019/20 financial year among current or former coal miners in Queensland was 2.1 cases per 1,000 coal miners, (range 1.9 to 2.1 cases per 1,000 coal miners).

When considering the prevalence rate as a function of the length of exposure at coal mines, there were 14 prevalent cases of coal mine dust lung disease for every 100,000 person years worked in Queensland coal mines (range 13-14).

Prevalence rates were consistently higher among underground coal miners than surface coal miners and increased over time. This increase over time was due primarily to a general increase in the number of cases of coal mine dust lung disease since 1983/84, and the number of people diagnosed with the disease who remained prevalent cases for multiple years.

3.7.2. Rationale for using different methods to calculate prevalence rates

Prevalence or prevalence rate is defined as the proportion of people in a population who have a particular disease at a specified point in time (Point prevalence) or over a specified period (Period prevalence) of time.

The two methods used in this report to calculate prevalence rates of coal mine dust lung disease in Queensland are period estimates. However, by using different definitions of the denominator, they capture different aspects of the underlying disease progression and characteristics that are likely to impact results.

The first method considers the rate per 1,000 full time equivalent workers who had worked in Queensland coal mines since 1983/84. However, it makes no allowance for the length of time each worker had worked. It is likely that longer lengths of time worked in a coal mine increases the chance of excessive dust exposure, the primary cause of coal mine dust lung disease. For this reason, the second method is expressed per 100,000 person years at risk, thus noting the cumulative number of person years worked in Queensland coal mines since 1983/84.

3.7.3. Comparison with methods used for calculating prevalence rates in the literature

These methods vary from those reported in the published literature and described in the systematic review. These published prevalence rates were only based on the proportion (that is, the number of cases divided by the number of coal mine workers) at a specified point in time.

To our knowledge, the published papers did not include people who had formerly worked in relevant coal mines before the study, nor people diagnosed with coal mine dust lung disease after they had stopped working in coal mines. It was not possible to directly replicate these published estimates due to the different characteristics of data sources available.

For that reason, along with the different methodologies, numerators and denominators, direct comparison between the results of this study and those in the published literature should be made with caution.

However, it is noted that the prevalence rates for Queensland were substantially lower than the published rates. Given that most of the published rates were from studies in the United States, a previous study (72) has highlighted the lower burden due to coal mine dust lung disease in Australia compared to the United States. Our results were consistent with this. However, that comparison was made nearly a decade ago, and it is not known whether there have been any changes in the underlying factors in Australia or the United States during that time.

Despite this, the findings from this Queensland study of the increasing prevalence rates of coal mine dust lung disease over time, and that prevalence rates were higher among underground coal miners compared with surface coal miners, was consistent with published differences in rates by mine type.

3.7.4. Recommended methods for future calculations of prevalence rates

The methods used in this study were defined based on accepted guidelines for specifying the numerator and denominator in period prevalence calculations.

There were many assumptions made throughout these calculations, with each assumption increasing the level of uncertainty around the final rates. Access to better quality data on the characteristics of both those diagnosed with coal mine dust lung disease, and the population who have ever worked in Queensland coal mines, would increase the robustness of the final estimates.

In particular, ascertaining how long people diagnosed with coal mine dust lung disease survive after their diagnosis was an important gap in the currently available data, because prevalence rates require information about the number of formerly diagnosed workers who are still alive at the relevant point in time.

3.8. Limitations and recommendations

There are several limitations and caveats that need to be kept in mind when interpreting the results presented in this report:

- It was difficult to establish a definitive date of diagnosis for all cases in our study. The lack of a consistent systematic reporting process for key variables such as date of diagnosis was one factor contributing to the substantial amount of incomplete or missing data.

- The medical information provided for this study did not always provide a clear, definitive diagnosis of coal mine dust lung disease, leaving some uncertainty about the final cases based on the medical information alone. There were inconsistencies between the physicians' final diagnosis and the information on the Health Assessment form. We were reliant on advice from RSHQ regarding the specific case definition.

- Medical information was provided from various sources, with the completeness and readability of the data varying for different sources. It is not known to what extent this introduced a bias in the results. For example, if one source was more likely to register the diagnosis for a certain type of coal miner, and that source had a higher proportion of missing data, then the reporting of those specific characteristics would be biased.

- While the RSHQ did have some information about some deaths among coal miners diagnosed with coal mine dust lung disease, this was incomplete. Hence a range of probability-based assumptions needed to be made to estimate the final prevalence of coal mine dust lung disease. A systematic process to regularly determine whether coal miners diagnosed with coal mine dust lung disease have died from that or other causes would greatly increase the capacity to calculate meaningful and robust estimates of prevalence of coal mine dust lung disease among the Queensland coal mining community, as well as understand the loss of life expectancy associated with coal mine dust lung disease. With appropriate ethics and data custodian approvals, this could be done regularly using linked data.

- Along with information about mortality among the coal miners diagnosed with coal mine dust lung disease, it would be useful to better document the morbidity associated with a diagnosis of coal mine dust lung disease. This would require ongoing follow-up of coal miners after they have a definitive diagnosis. This could be carried out using prospective surveys, or else through ongoing data linkage with hospital, cancer registry and other relevant datasets. Of note, RSHQ has partnered with the Monash Centre for Occupational and Environmental Health to undertake a longer-term study to look at the cancer incidence and mortality of Queensland coal miners.(73)

- There was a lack of published information about the survival experience of coal miners who have been diagnosed with coal mine dust lung disease, with the only estimate being a single published study of CWP in China. These survival data would be more readily available should a system of regular follow up of diagnosed coal mine dust lung disease cases be implemented.

- The limited information on the historical populations of surface and underground coal mine workers in Queensland prior to 2014 meant that the ratio of surface and underground coal mine worker populations between 1983/84 to 2012/13 was assumed to be the same as the average ratio between 2014 to 2020.

- Due to the lack of information on age-specific populations of coal miners, the prevalence rates estimated in this report have not been age-standardised, so some of the changes over time might be due to changes in the age distribution of the population.

- While the simulation study provided an indication of the range of possible prevalence rate estimates, there are no confidence intervals around these rates. Given the number of assumptions made through these calculations, each with an unknown measure of uncertainty, providing a data-driven statistical measure of uncertainty such as a 95% confidence interval would be misleading as it would greatly underestimate the true uncertainty associated with these estimates. However, we have provided details about the range of estimates over 1,000 simulations to give a measure of uncertainty around the estimates.

4. References

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