

Queensland Coal Mine Workers' Cancer and Mortality Study

Summary

Background

Following a health survey of coal mine workers in 1982, mandatory pre-employment and periodic medical assessments were incrementally introduced in the Queensland coal mining sector. Coal mine workers now have medicals at least 5-yearly and the data are reported to Resources Safety and Health Queensland (RSHQ).

The data collated by RSHQ were used to compile a cohort of Queensland coal mine workers with the aim of identifying whether mortality and cancer incidence among these workers is higher than that of the general population and whether mortality and cancer incidence rates varied by job.

Methods

The cohort data were linked to the Australian death and cancer registries to identify the fact and cause of death from 1980-2020 and the incidence cancers between 1982 and 2016. The cohort members were grouped by mine types (open cut vs underground vs CHPP), Work Category (Office unexposed, Non-office unexposed, Occasionally exposed, Production, Maintenance and Construction) and then into more specific Job Groups such as Dragline operators, Diesel fitters or Miners.

The cohort mortality and cancer incidence were compared (i) to age adjusted Australian general population rates, and (ii) within the cohort, (iii) to age adjusted Queensland population rates (for some outcomes). Separate risks were calculated for men and women. Smoking data, available for more than 99% of the cohort, together with age and era were adjusted for in the 'within cohort' comparisons.

RSHQ also provided data on respirable crystalline silica, total respirable dust and diesel engine particulate for a range of coal mine jobs collected between 1999 and 2022.

The research was granted ethics approval by Human Research Ethics Committees of Monash University, the Australian Institute of Health and Welfare (AIHW), and Australian State and Territory Cancer Registries.

Results

There were 164,622 men and 24,389 women in the cohort with 2,132,340 and 253,567 person-years of follow-up respectively. The linkage identified 4,957 deaths and 5,940 cancers among men and 211

deaths and 427 cancers among women. There were little differences in risks for most causes of death between Site Types. Table 1 to Table 4 summarise the mortality and cancer incidence for men and women.

Overall mortality was significantly reduced (19% reduction for men and 25% for women) and mortality from all malignancies was significantly reduced for men and women compared to the general population. Female maintenance workers had reduced overall mortality compared to the general population, as did men in jobs categorised as Administration, Occasionally exposed or Maintenance workers and when compared to the rest of the men in the cohort after adjusting for age and smoking. The mortality rate among men in Shutdown maintenance jobs was 21% higher than that observed among other maintenance workers.

Suicide was statistically significantly increased among men but not women when compared with the Australian general population and not when compared to the Queensland population. Increased suicides were seen in men <65 years, and within five years of their first assessment. Those whose first assessment was after 2010 appeared more at risk than those recruited in previous decades. Suicides were significantly increased for male and female Production workers, male Truck Drivers and Construction workers compared to the general population. When compared to Queensland rates, suicides were only elevated but not statistically significantly increased for male Construction workers and female Production workers. Significant excesses of suicide were also seen for men in several Job Groups including Shutdown Maintenance workers, Boilermakers, Tyre fitters, Operators and Truck Drivers (nec¹). Comparisons within the cohort showed that the suicide rate among male Shutdown Maintenance workers was higher than in other Maintenance workers. Female cohort members who ever worked as Production workers had an over three-fold higher risk of suicide compared to other female coal mine workers.

AIHW data show that suicide rates have been higher in Queensland than in the general Australian population over the past two decades. Suicide risk is higher for rural and remote areas, and these may underlie the difference in State rates and account for at least some of the increases observed in the cohort.

Accidental death rates were similar to those of the Australian general population although somewhat elevated in men. The increase is not seen when compared to the Queensland rates. The data do not identify whether the deaths were work-related but most (59%) were a result of transport accidents. Accidental deaths were increased for male and female Production workers and Cleaners, for male Truck Drivers (nec) and Labourers (nec) and elevated for Construction workers when compared to the general population. The risk was higher for men within 5 years of their first assessment but those with more than 15 years employment showed a lower accidental mortality than the general population. The decrease in risk with years of employment showed a statistically significant trend. Within cohort comparisons showed increased accidental deaths among men who had ever been Production Workers

¹ nec indicates that the job could not be classified into a specific Work Category e.g. Maintenance or Production.

or Truck Drivers compared to other men in the cohort. Women who worked as Cleaners (nec) were 3-times more likely than other women in the cohort to experience an accidental death.

Circulatory disease deaths were reduced for men and women in the cohort, significantly so for men, and particularly male Administration, Occasionally Exposed, Production and Maintenance workers. Compared to other cohort members, after adjusting for age and smoking, male Administration and Maintenance workers had reduced risks of circulatory disease but risk was higher for Production workers, Drillers (general), Unexposed Non-Office workers and Labourers (nec).

Respiratory disease mortality was reduced for men and women in the cohort, significantly so for men, particularly Production workers when compared to the general population. For male Maintenance and Production workers, the risk was higher for those employed for more than 10 years. Deaths from *Lung Diseases due to Dust*² were significantly higher under 65 years, but not in the older group but numbers were small (n=6).

Mortality and length of employment Deaths from accidents and suicides both show a monotonic decrease with increasing length of employment. However, many workers in the study had not worked for a long period, only 10% of maintenance workers had worked for more than 15 years. Monotonic increases with years since first employed were also seen for respiratory and digestive causes of death.

Overall cancer incidence was the same as that of the general Australian population for women but 7% higher for men. Men had significantly increased incidence of cancer of the lip, melanoma, prostate and lymphoid leukaemia, when compared to the general population. In women, melanoma and cancers of the bladder and gallbladder were significantly increased, although based on small numbers. After adjustment for smoking and age, male Production workers and female office workers had an increased risk of overall cancer compared with other male and female workers in the cohort, respectively.

Lung cancer incidence and mortality was significantly increased for male Construction and Production workers, compared to the general population, and in Construction workers compared with other men in the cohort after adjusting for smoking and age. Within Production, lung cancer mortality was higher for those who ever worked as Drillers (general) or Operators compared to the general population, and 74% higher among Drillers compared with other Production workers. When compared with all other maintenance workers, lung cancer incidence was significantly increased for Shutdown Maintenance. These job groups are among those with the highest dust exposure.

Lung cancer mortality, but not incidence, showed a significant trend, increasing with time since first assessment. When split by age, significantly increased lung cancer incidence was observed for men 65 years and above, but not for the younger men. No excess lung cancer incidence was observed among women.

Laryngeal cancers were significantly increased for male Production workers, specifically for underground Miners and Drillers (general) compared to the general population and elevated in Maintenance workers.

² This includes coal workers' pneumoconiosis, asbestosis, silicosis etc. The classification is drawn from the death certificate.

Melanoma incidence but not death, was significantly increased among men and women when compared to national rates but not when compared to Queensland rates. For both men and women, the risk was highest within five years of first employment and in Administration workers. Male electricians and Drillers (general) had an increased risk of melanoma compared to other Maintenance and Production workers respectively.

Lip cancer incidence was increased for both men and women. The increase was significant for men who were Maintenance and Production workers and Exploration drillers compared to the general population. Within cohort comparisons did not show different risks between Job Groups after adjustment for smoking and age although the risk for Production workers was increased even after adjusting for age and smoking

Mesothelioma incidence was raised for men in the cohort particularly when over 65 years compared to the general population. For Maintenance workers, both incidence and mortality were significantly raised above the general population. Coal mine workers in the Administration, and Occasionally exposed groups had higher mesothelioma incidence than the general population, with significantly higher mortality in technical and mining services group. Construction workers had a higher point estimate but the increase was not statistically significant reflecting a smaller population.

Prostate cancer incidence was increased for men in the cohort compared to the general population, but mortality was not. The increase was significant for Production workers particularly underground Miners, Operators and Dragline operators, and elevated but not statistically significant for Maintenance workers. There was a statistically significant trend in prostate cancer with increasing years of employment as measured by time between first and last assessment. Prostate cancer mortality however was elevated above population levels among fitters (nec). Production workers showed an increased risk of prostate cancer for compared to the rest of the cohort even after age and smoking adjustment

Other cancer incidence and mortality: Cancers of the digestive tract were significantly increased in some Work Categories and Job Groups when compared to the general population and also in internal analyses adjusted for age and smoking. Male Boilermakers had 3-times higher risk of oesophageal cancer compared to other Maintenance workers. There was a significant excess of lymphoid leukaemia for men but not women in the cohort when compared to the general population. The increase was seen in the Maintenance and Production Work Categories, specifically in Labourers, Supervisors and Truck drivers. Recently employed men, women and men in the Maintenance Work Category had a significant increase in gallbladder cancer.

Exposure to respirable dust, respirable crystalline silica and diesel engine particulate showed that mean yearly average exposures have usually been below the relevant Workplace Exposure Standards for most jobs. Exposure data were not available before 1999 but trend lines suggest that exposure would have been higher for Underground workers, Exploration drillers and some Maintenance workers.

Discussion

The number of calculated risk estimates was large in this study so the overall patterns of results is important. There were several cancers showing increased risk in only one group of workers. This could be a result of the large number of comparisons resulting in some chance findings or there could be unexplained risk factors.

The cohort was relatively young, with an average age of less than 60 years in 2020, so relatively few cancers and deaths have occurred. Also, there was a short follow-up period for many individuals with 81% of men and 93% of women having their first assessment in or after 2003. Consequently, the power of this study to determine risk associated with cancer or specific causes of death was limited for some outcomes, for women and for smaller work groups.

Some groups probably had reduced risk of mortality and perhaps cancer incidence, when compared to the general Australian population as a result of the well-established “healthy worker effect”. The short follow-up for many workers means that this bias could not be ruled out.

Prostate cancer and melanoma incidence were increased, but mortality was not increased. This could be a diagnostic bias following increased screening in the working population or this could be a result of increased survival because of, for example, better general health or better, earlier access to treatment.

Important strengths of this study are that the cohort is a near complete record of all Queensland coal mine workers employed after 1982 and that smoking data were available for over 99% of participants, which was used to adjust internal analyses to remove its possible confounding effect. Cancer and death registration is mandatory in all Australia and is virtually complete.

Limitations include that the length of employment was approximated from the dates of first and last assessments which may not reflect the full employment history. Job titles were only collected after 1993 which meant that pre-1993 data could not be used in the job specific analyses. As Site Type (i.e. either open cut or underground) was largely determined using mine names, and these were recorded as “Unknown” or “Various” for around 55% of the health assessments some of the worker/jobs could not be assigned to a Site Type.

Conclusions

Overall mortality and cancer incidence varied substantially across job groups, with excess mortality and cancer incidence observed particularly in Production and Construction work categories among men and in Cleaners among women.

As the cohort ages there will be increased numbers of cancer and death events so rematching the cohort in five years would be informative. The investigation of other important health outcomes, such as reduced lung function or mental health outcomes, which would need a different research methodology, may further the understanding of the health of this cohort.

Table 1: Mortality for men by Work Category*

Cause of Death	Administration	Unexposed non-Office	Occasionally exposed	Maintenance	Production	Exploration Driller**	Construct'n	Truck Driver (nec)	Labourer (nec)	Cleaner (nec) **	All Men
All Causes of Death	↓↓ (↓↓) [↓↓]	= (↑) [=]	↓↓ (↓↓) [↓↓]	↓↓ (↓↓) [↓↓]	↓↓ [↓↓]	= [=]	= (↑) [=]	↓ [↓]	↑ [=]	= [=]	↓↓ [↓↓]
Malignancies	↓↓ (↓) [↓↓]	= [=]	↓ [↓↓]	↓↓ [↓↓]	↓ [↓↓]	= [=]	= [=]	= [=]	= [=]	= [=]	↓↓ [↓↓]
Metabolic	↓↓	=	↓↓	↓↓	↓↓	=	=	=	=	=	↓↓
Mental & Behavioural	↓↓	0	=	↓↓	↓↓	0	=	0	0	0	↓↓
Nervous system	↓↓	=	=	↓↓	↓↓	0	=	↓	=	0	↓↓
Circulatory	↓↓ (↓↓)	= (↑↑)	↓↓	↓↓ (↓↓)	↓↓ (↑↑)	=	=	= (↑)	= (↑↑)	=	↓↓
Respiratory	↓	=	↓↓	↓ (↑)	↓↓	=	=	=	=	=	↓↓
Digestive	↓↓	=	↓↓	↓↓	↓↓	0	= (↑↑)	↓↓	=	=	↓↓
Urinary	=	0	0	↓↓	↓↓	0	=	=	0	=	↓↓
Injury & Trauma	↓↓ (↓↓) [↓↓]	= [=]	↓↓ (↓↓) [↓↓]	= (↓↓) [↓↓]	↑↑ (↑↑) [=]	↑↑ [=]	↑↑ [↑]	↑↑ (↑↑) [↑↑]	↑↑ [↑]	=	↑↑ [↓]
All Accidents	↓↓ (↓↓) [↓↓]	= [=]	↓↓ (↓↓) [↓↓]	↓ (↓↓) [↓↓]	↑↑ (↑↑) [=]	↑ [=]	↑ [=]	↑↑ (↑↑) [↑↑]	↑ [↑]	↑↑ [↑↑]	↑ [=]
Suicide	= (↓) [↓↓]	= [=]	= [↓]	↑ [=]	↑↑ [=]	= [=]	↑↑ [=]	↑↑ [=]	= [=]	= [=]	↑↑ [=]
Other Causes	↓↓	=	↓↓	↓↓	↓↓	=	↓	↓↓	= (↑)	↑	↓↓

* Data shows findings from external analyses compared to the Australian population, and square brackets show comparisons with the Queensland population, where available. Statistically significant within cohort comparisons (internal analyses), after adjusting for age and smoking, have been added in round brackets.

** No internal analyses due to small numbers.

Key

↓↓

Statistically significant decrease

↓

Non-statistically significant decrease (*estimate <95 & CI upper limit ≤ 105*)

↑

Non-statistically significant increase (*estimate ≥110 & CI lower limit > 90*)

↑↑

Statistically significant increase

=

No difference

na

Not applicable, not analysed by job due to few cases overall

0

No cases

Table 2: Cancer risk for men in the cohort by Work Category*

Type of Cancer	Administration	Unexposed non-Office	Occasionally exposed**	Maintenance	Production	Exploration Driller**	Construction	Truck Driver (nec)	Labourer (nec)	All Men
All Malignancies	= (↓↓)	↑	=	= (↓↓)	↑↑ (↑↑)	=	=	↑	↑	↑↑
Lip, Oral Cavity etc.	=	=	=	↑	↑	↑↑	=	=	=	↑
Lip	=	=	=	↑↑	↑↑	↑↑	=	↑	=	↑↑
Pharynx	=	=	=	=	=	=	↑↑ (↑↑)	=	=	=
Digestive Organs	=	↑↑ (↑)	=	=	=	↓↓	=	=	=	↑
Colorectal	=	↑↑	=	=	↑↑ (↑)	0	=	=	=	=
Gallbladder	=	=	=	↑↑	=	0	=	=	=	↑
Respiratory	=	=	=	=	↑↑ (↑)	=	↑↑ (↑↑)	=	=	↑
Larynx	=	=	=	↑	↑↑	0	=	=	0	↑
Lung	=	=	=	=	↑↑ (↑)	=	↑↑ (↑↑)	=	=	=
Melanoma	↑↑	=	↑↑	↑↑ (↓↓)	↑↑	↑↑	=	↑↑	=	↑↑ [=]
Mesothelioma	↑↑	0	↑↑	↑↑	= (↓↓)	0	=	0	=	↑
Male Reproductive	=	=	=	↑ (↓)	↑↑ (↑↑)	=	=	↑	=	↑↑
Prostate	=	=	=	↑	↑↑ (↑↑)	=	=	↑ (↑)	↑	↑↑
Testis	=	↑ (↑↑)	=	↓↓	=	=	=	=	=	=
Urinary Tract	=	=	=	=	↑↑ (↑)	=	=	=	=	↑
Kidney	=	=	=	=	↑ (↑)	=	=	=	=	=
Brain & CNS	=	=	=	=	=	=	=	=	=	↑
Brain	=	=	=	=	↑	=	=	=	=	↑
Thyroid & Endocrine	=	=	=	=	=	=	=	=	=	=
Lymphoid, Haema-topoietic + Related Tissue	= (↓)	=	=	=	↓	=	↓↓ (↓↓)	=	=	↓↓
NHL	= (↓)	=	=	=	=	=	↓↓	=	=	↓↓
Leukaemia	=	=	=	=	=	0	=	↑↑ (↑)	=	↑
Lymphoid leukaemia	=	=	=	↑	↑↑	0	=	↑↑	↑↑	↑↑
Myeloid leukaemia	=	=	=	=	↓↓	0	0	=	0	=
Other Cancers	=	=	=	=	↑ (↑↑)	=	=	=	=	=

* Data shows findings from external analyses compared to the Australian population, and square brackets show comparisons with the Queensland population, where available. Statistically significant within cohort comparisons (internal analyses), after adjusting for age and smoking, have been added in round brackets.

** No internal analyses due to small numbers.

Table 3: Mortality for women by Work Category*

Cause of Death	Administration	Unexposed non-Office**	Occasionally exposed**	Maintenance**	Production	Cleaner	All Women
All Causes of Death	↓↓	=	=	↓↓	=	=	↓↓ [↓]
Malignancies	=	=	=	=	=	=	↓↓ [↓]
Metabolic	na	na	na	na	na	na	↓
Mental and Behavioural	na	na	na	na	na	na	↓
Nervous system	na	na	na	na	na	na	↓
Circulatory	=	=	=	=	=	=	↓
Respiratory	=	=	=	0	0	=	↓
Digestive	na	na	na	na	na	na	↓
Urinary	na	na	na	na	na	na	↓
Injury & Trauma	↓↓ (↓↓)	= [=]	=	= [=]	= [=]	↑↑ (↑↑) [↑↑]	= [=]
All Accidents	↓↓ (↓↓) [↓↓]	= [=]	=	= [=]	= [=]	↑↑ (↑↑) [↑↑]	= [=]
Suicide	0	= [=]	=	0	↑↑ (↑↑) [↑]	= [=]	= [=]
Other Causes	na	na	na	na	na	na	↓↓

* Data shows findings from external analyses compared to the Australian population, and square brackets show comparisons with the Queensland population, where available. Statistically significant within cohort comparisons (internal analyses), after adjusting for age and smoking, have been added in round brackets.

** No internal analyses due to small numbers.

Table 4: Cancer risk for women in the cohort by Work Category*

Type of Cancer	Administration	Unexposed non-Office**	Occasionally exposed**	Maintenance**	Production	Cleaner**	All Women
All Malignancies	↑	=	=	=	=	=	=
Lip	na	na	na	na	na	na	=
Digestive Organs	=	=	0	=	=	=	=
Gallbladder	na	na	0	na	na	na	↑↑
Respiratory and Intrathoracic Organs	↑	=	=	↓	↓	=	=
Melanoma	↑↑	=	=	=	=	=	↑↑ [=]
Breast	↑	=	=	=	↓↓	=	=
Female Reproductive	=	=	=	=	=	=	↓↓

* Data shows findings from external analyses compared to the Australian population, and square brackets show comparisons with the Queensland population, where available. Statistically significant within cohort comparisons (internal analyses), after adjusting for age and smoking, have been added in round brackets.

** No internal analyses due to small numbers.