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Review Article

Prevalence of Respiratory Disorders and Associated Factors among Coal Mine Workers, Narrative Review

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Abstract

The potential of pneumoconiosis was only discussed in the pretext of coal mining, but there is a new spectrum of respiratory diseases affecting coal miners termed as coal mine dust lung disease. In this narrative review, an attempt has been made to understand the prevalence of respiratory disorders among coal miners. A narrative synthesis was undertaken, using thematic analysis to synthesize the findings of the studies included within the review. The final narrative synthesis contains 12 studies. The majority of the studies were conducted in the USA. Among the total sample of 35,480 from 4 articles, a cumulative prevalence of 4.5% was found for Coal workers' pneumoconiosis in the studies conducted in mines of USA. Whereas the study in South Africa revealed a prevalence of 2.59%. The review has found a strong association of years of coal dust exposure with the occurrence of respiratory disorders among coal mine workers. Smoking is also found to be strongly associated with increasing the risk of respiratory disorders. So the review recommends an appropriate workplace culture, including respiratory hygiene, protection and avoiding habits like smoking among coal mine workers. The occupational surveillance for respiratory disorders among the workers needs to be strengthened.

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Introduction

Coal resources are an important component of the world's energy supply, accounting for 27.62% of primary energy consumption worldwide. With the development and utilization of coal resources in the past and present, the legacy of health problems (lung diseases) is increasingly apparent. These health problems develop from creating dust particles in the coal production process and the reaction of the lung tissue to the dust. The potential of coal mine dust to cause disabling pneumoconiosis has long been recognized, but research now suggests that pneumoconiosis is not the only respiratory hazard of coal mining. There is a spectrum; these have recently been termed "coal mine dust lung disease" (CMDLD). These include Coal Workers' Pneumoconiosis, silicosis, mixed dust pneumoconiosis, dust-related diffuse fibrosis (which can be mistaken for idiopathic pulmonary fibrosis), and chronic obstructive pulmonary disease. [1-3]

Although prevention efforts have been taken for many decades, coal workers' pneumoconiosis is still a public health issue around the world. The Global Burden of Disease Study collected and analyzed the annual number of patients with different types of pneumoconiosis, which occurred in 195 countries and regions worldwide between 1990 and 2017, increasing by 66.0% from 36,186 in 1990 to 60,055 in 2017, wherein the proportion of coal workers' pneumoconiosis (CWP) was 27% and 25%, respectively Especially in developing countries where coal is the main energy source, millions of workers are exposed to coal dust during their professional activities. The United States Census industry code showed coal mining to be the highest risk industry for asthma and COPD-related deaths, and the results were independent of smoking as a risk factor. The published literature has reported that more than 20 million workers are exposed to coal dust in the workplace in China and India alone. By the end of 2021, 915,000 patients with occupational pneumoconiosis had been reported cumulatively in China. [4-6]

The respirable coal dust associated with coal mining, both surface and underground mining, contains quartz silica, phyllosilicates and sulphides, which can lead to respiratory cell damage.[4] In addition to the interstitial disease presentations classically associated with coal mining, coal miners are also at risk for dust-related diffuse fibrosis (DDF) and chronic airways diseases, including emphysema and chronic bronchitis. All of these fall within the spectrum of CMDLD. The DDF is a form of interstitial disease occurring in coal miners that has a radiographic appearance of irregular opacities and can be mistaken for idiopathic pulmonary fibrosis (IPF) if an exposure history is not obtained. The occurrence of irregular opacities in coal miners has long been recognized. A recent evaluation of 30 years' experience in the US Coal Workers' Health Surveillance Program (CWHSP) showed that about 38% of coal miners with radiographic findings of interstitial disease had primarily irregular opacities. These miners showed a lower zone predominance (upper 20.5%, middle 38.4%, and lower 41.1%).[2,7-8]

It has been recognized for decades that coal mine dust exposure can cause COPD. Several studies have shown that coal miners are at increased risk of developing COPD, including emphysema, relative to nonminers. .[9-12] For example, a study of 722 autopsied coal miners and non-miners in the United States showed that cumulative dust exposure was a significant predictor of pathological emphysema severity and had a similar additive effect on emphysema severity as smoking.[13]

Researchers at the University of Illinois Chicago and NIOSH analyzed cause of death data from the National Death Index on 235,550 U.S. coal miners who died between 1979 and 2017, and found that coal miners have significantly increased odds of death from CWP, COPD, and lung cancer compared with their counterparts in the U.S. population. This higher mortality has also worsened over time, with modern miners facing greater risk than their predecessors.[14] As per a study, the prevalence of CWP in coal workers remains high in India; the overall prevalence was found to be 3.03%, ranging from 1.52% to 4.76% in different areas.[15] In China, the prevalence of CWP is 6.02% (95% CI 3.43%, 9.26%) according to published studies. [16] What is exciting is that several plans have been included in the Health China 2030 Action Plan to address occupational health issues, and a pneumoconiosis prevention and control action

requires that at least 95% of occupational dust-exposed workers must undergo health examinations, and 80% of coal industry workers should be covered by work-related injury insurance by 2020.[17]

The coal mine workers are also susceptible to other respiratory disorders like Chronic Obstructive Pulmonary Disease (COPD), especially among smokers, Tuberculosis and Lung Cancer. So we felt the need to review the prevalence of respiratory disorders among coal mine workers.

The aim of the current review is to address two important questions:

What are the respiratory disorders that are prevalent among coal mine workers?
What are the associated factors that pose a risk of developing respiratory disorders among coal mine workers?

Materials and Methods

Review Design and Reporting Framework

This study was conducted as a narrative review. A narrative approach was chosen because the available literature demonstrates substantial heterogeneity in study designs, outcome definitions, measurement methods, and populations. Such heterogeneity limits the feasibility of conducting a systematic meta-analysis. Therefore, a qualitative synthesis was considered the most appropriate method to summarize the available evidence. The review was reported in line with PRISMA 2020 guidance, where applicable to narrative syntheses, and informed by established methodological frameworks for narrative and qualitative reviews.10 A protocol was not prospectively registered, given the narrative and policy-oriented scope of the review

Search strategies

Literature search of articles published from 2000- 2023 in PubMed/Medline, Cochrane, ScienceDirect, Embase, CINAHL, and Google Scholar was conducted. The following medical subject headings were used in the search strategy:

Coal mine respiratory disorders
Prevalence
Coal miners
Coal mines
Pulmonary function
Coal mine dust lung diseases

The search strategy attempted to retrieve all relevant studies in a conventional review manner.

Eligibility criteria

The articles were included for evaluation if they were relevant to the aims that were to be addressed. All the articles were selected according to the following inclusion criteria:

Includes a study population of coal mine workers
Includes measurement of the prevalence of respiratory disorders among coal mine workers
Provides information on associated factors for developing respiratory disorders among coal mine workers

No restrictions concerning age, gender, race or socio-economic status of coal mine workers were considered. For the purpose of this review, only those articles (case control studies, cohort, cross-sectional studies) that were published in English were considered for the analysis. Letters to the editor, books and conference proceedings were not considered. The manuscripts that met the inclusion criteria were retrieved,

analyzed and interpreted, and those that did not meet the above-stated criteria were excluded from the analysis.

Data extraction

Two reviewers reviewed each article independently based on the inclusion criteria. The review team assessed articles on the prevalence of respiratory disorders among coal mine workers as well as those related to the factors associated with the occurrence of respiratory disorders among coal mine workers. After reaching an agreement by the review team over the inclusion criteria on the identified articles, full papers were obtained for the review. Any disagreement between the reviewers regarding the article's selection was resolved during a consensus meeting. If agreement could not be achieved during the meeting, a third reviewer was asked to provide necessary assistance.

Data Processing

Based on the literature search, a total of 1555 titles were identified. A number of titles were found to be duplicated in the database search. A total of 12 manuscripts were identified to be included in this review after examining the abstracts and excluding duplicates (Figure 1). The papers were primarily excluded on the basis that the study did not measure the prevalence or associated factors of respiratory disorders among coal mine workers.

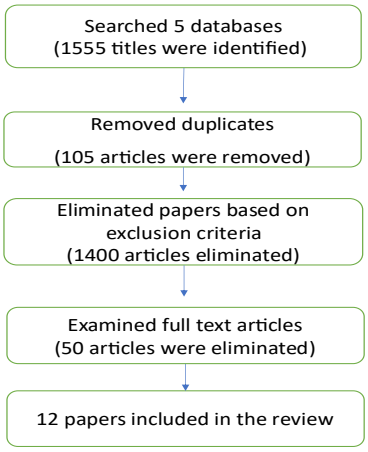


Fig 1: Selection process of articles for review

Results

Data Analysis

Due to the methodological diversity of the included studies, a descriptive synthesis was deemed the most appropriate analytical method. A table was prepared with a summary of findings (Table 1)

Table 1: Study Characteristics

Author, Study Design, Place, Year	Sample size Characteristics	Data Collection	Results
Reynolds L E (et al) Cross-sectional design USA 2017[18]	5605 active coal miners with at least 10 years of tenure	Demographic, occupational history, smoking status, chest radiograph according to ILO classification, Spirometry classified into 4 patterns: normal, obstructive, restrictive and mixed	A total of 103 (2.1%) miners had radiographic evidence of Coal workers' pneumoconiosis. 524 miners (9.3%) had abnormal spirometry results. An obstructive pattern was more common (3.6%). Study found that miners with at least 10 years of tenure and evidence of CWP had twice the prevalence of lung function impairment, compared to miners of the same tenure and normal radiographs.
Mamuya SHD (et al) Cross-sectional design Tanzania 2007[19]	250 workers of the coal mine	Interview using a respiratory health questionnaire having 3 parts: personal and work characteristics, smoking habits and respiratory health symptoms (modified version of British Medical Research Council questionnaire)	High prevalence of dry cough(45.7%), breathlessness(34.8%0 and blocked nose(23.9%). High cumulative coal dust exposure was significantly associated with cough(OR=2.91, 95% CI 1.06, 7.97)
Hall NB (et al) Cross-sectional design USA 2020[20]	4742 surface coal miners with 10 years or more tenure	A questionnaire of demographic, working tenure, job held, and Chest radiograph classified according to the ILO classification	Pneumoconiosis was present in 109(1.6%) surface coal miners, including 12 with Progressive massive fibrosis. Among the surface mining workers, those involved in drilling or blasting operation 4.1% (17 workers) had evidence of pneumoconiosis, and 6 (1.4%) had evidence of Progressive massive fibrosis.
Prasad S K (et al) Cross-sectional design West Bengal India	230 underground coal miners and 130 age-matched workers of coal mines	Structured questionnaire and spirometry	Lung function indices were significantly impaired($p<0.050$) between the exposed(43.91%) and non-exposed(23.85%) groups. Positive relationship between exposure time and lung function deterioration.

2021[21]			
Go LHT(etal) Cross-sectional design USA 2022[22]	2568 former coal miners	Spirometry and Chest radiograph	56.6% had abnormal spirometry. Age-standardized prevalence of air-flow obstruction among miners aged ≥ 45 years was 18.9% and 12.2% among never smokers.
Graber J M Survey USA 2017[23]	24,686 coal miners	Questionnaire Chest X-ray	8.5% had advanced Coal workers' pneumoconiosis. Prevalence was highest among younger individuals (less than or equal to 56 years, 10.86%).
Wang ML Prospective study China 2005[24]	445 coal miners	Questionnaire and spirometry tests	New miners experience an initial rapid FEV1 decline, primarily during the first year of mining, little change during the second year, and partial recovery during the third year. Smoking miners lost more FEV1 than non-smokers.
Gonzalez N Cross-sectional design Paipa, Spain 2017[25]	226 coal mining workers	Occupational disease questionnaire of the American Thoracic Society and Spirometry	Twenty-eight subjects (12.3%) showed patterns of obstructive and restrictive respiratory disease with mild degrees of severity. Eighty subjects (35%) showed a decrease in the forced vital capacity ratio/expiratory volume in one second (FVC/FEV1). A statistically significant association between age range (p=0.002) and years of mining work (p=0.34) with the development of restrictive and obstructive disorders was found.
Torres Rey CH Cross-sectional design USA 2015[26]	447 coal miners	Survey for evaluating the work environment, Demographic details, Occupational Medical History Spirometry, chest X-ray	35.9% prevalence of pneumoconiosis in the study group (42.3% in region 1 and 29.9% in region 2). An association was found between a radiologic diagnosis of pneumoconiosis and a medium risk level of exposure to carbon dust (OR: 2.901, 95% CI: 0.937, 8.982), medium size companies (OR: 2.301, 95% CI: 1.260–4.201), length of mining work greater than 25 years (OR: 3.222, 95% CI: 1.806–5.748), and a history of smoking for more than one year (OR: 1.479, 95% CI: 0.938–2.334).

Blackley L(etal) Longitudinal survey USA 2014[27]	3771 coal miners	spirometry and chest radiography	One in four miners had evidence of CWP, abnormal lung function or both. In regression analysis, working in a small mine was associated with 37% higher prevalence of abnormal spirometry (PR 1.37, 95% CI 1.16 to 1.61) and 2.1 times higher prevalence of CWP (95% CI 1.68 to 2.70)
Mahadevari S Cross-sectional survey Iran 2016[28]	556 coal miners	Demographic details, British Medical Research Council Questionnaire Spirometry	Shortness of breath (72.3%) was the main health problem prevalent among coal miners. Non-linear decline in FEV_1 over the first five years of employment, with a sharp decrease in the first year of employment. Face miners were found to have a higher risk of respiratory problems.
Naidoo RN Cross-sectional survey South Africa 2006 [29]	896 coal miners	Work histories, interviews, spirometry, chest X-ray, cumulative dust exposure	Prevalence of CWP was 2.59%, 11.30% of the population had symptoms of chronic bronchitis. An association was found between long term of cumulative dust exposure and bronchitis.

A narrative synthesis was undertaken, using thematic analysis to synthesize the findings of the studies included within the review. The final narrative synthesis contains 12 studies. The studies took place across several countries, including the USA (n = 6), Tanzania (n=1), China (n = 1), Spain (n = 1), Iran(n=1) and India (n = 1). Sample sizes ranged from a minimum of 226 coal miners to a maximum of 24,686. Overall, the studies processed in the narrative synthesis included 43,866 participants. All referenced studies were observational and quantitative.

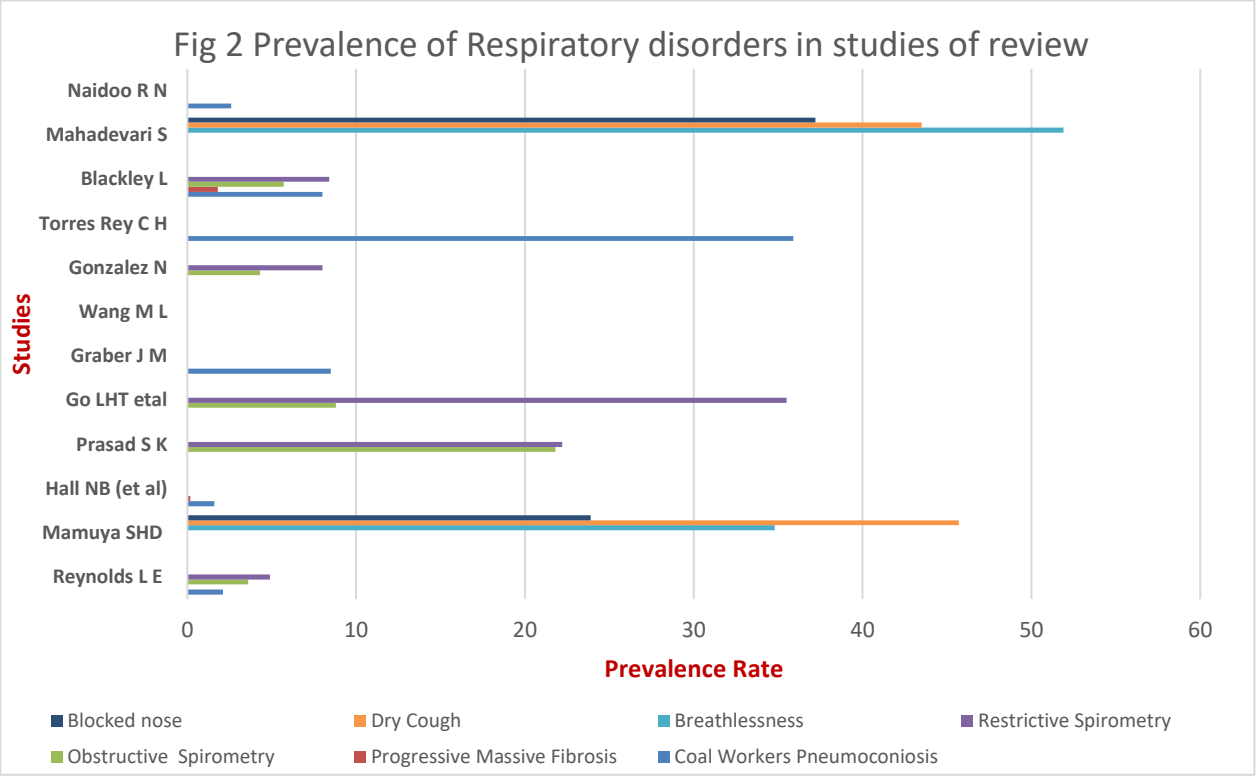
Prevalence of respiratory disorders in coal miners

The studies which used chest X-rays as the tool found a high prevalence of Coal workers' pneumoconiosis among the workers of coal mines. All studies have used respiratory questionnaires, including occupational history, for data collection. Some studies have combined spirometry and Chest x-ray also. In most of the studies, an obstructive pattern was shown in the spirometry.

The majority of the studies conducted in the USA have revealed a high prevalence of Coal workers' pneumoconiosis. [18,20,23,26], whereas the study in South Africa revealed a prevalence of 2.59%.[29]

In a cross-sectional survey conducted in India, lung function indices were significantly impaired among coal miners(43.91%) as compared to age-matched unexposed workers(23.85%).[21] A study conducted in Spain has found that 35% of subjects had a decrease in the forced vital capacity ratio/expiratory volume in one second (FVC/FEV1). The study also revealed 12.3% prevalence of obstructive patterns in spirometry. [25] Meanwhile, a study conducted in Tanzania showed a High prevalence of dry cough(45.7%), breathlessness(34.8%0 and blocked nose(23.9%). [19] In addition, a cross-sectional survey from the USA also found an abnormal spirometry pattern among 9.3 % of coal miners, with an obstructive pattern being

more common among them (4.2%). Another longitudinal survey from the USA had revealed that one in four miners had evidence of CWP, abnormal lung function or both



Associated factors contributing to respiratory diseases

A number of associated factors were identified in the review. The period of tenure in coal mines or the years of coal dust exposure were significantly associated with respiratory disorders in the majority of the studies.[18,19,21,25,26,29] The habit of smoking was found to have an association with the development of respiratory disorders among coal miners.[17,19] In two studies, a strong association with the size of mine (small mines) and the occurrence of respiratory disorders was found.[19,20] In addition to these factors, a few studies have shown a strong association of face mining or surface mining with the occurrence of respiratory disorders among coal mine workers.[20,28]

Discussion

The review was conducted with the objective of identifying the prevalence of respiratory disorders among coal mine workers and the associated factors that increase the risk for respiratory disorders among coal mine workers.

The review identified a high prevalence rate of respiratory disorders among coal mine workers. The previous literature highlighted the high prevalence of coal workers' pneumoconiosis. Through this narrative review, we have highlighted the prevalence of abnormal lung function, with a high prevalence of abnormal spirometry with an obstructive pattern. These findings were supported by a systematic review.

The review has found a strong association of years of coal dust exposure with the occurrence of respiratory disorders among coal mine workers. Smoking is also found to be strongly associated with increasing the risk of respiratory disorders. So the review recommends an appropriate workplace culture, including

respiratory hygiene, protection and avoiding habits like smoking among coal mine workers. The occupational surveillance for respiratory disorders among the workers needs to be strengthened.

We acknowledge that the current review identified only a handful of studies focusing on the coal mine workers. Therefore, it may be argued that very limited research exists on this occupational group all over the world, which may be one of the reasons why other factors, such as psychological risk factors and individual risk factors, were not studied extensively. In our opinion, such factors need to be studied in future studies in order to develop a holistic health approach targeted at the coal mine workers.

This review must be interpreted in the context of several limitations. All reviews are potentially open to publication bias, as other relevant studies with negative results may have been withheld. Lastly, the review only included those studies published in English, and this may have excluded other relevant studies.

Conclusion

Overall, the review identified a high prevalence rate of respiratory disorders among coal miners. This constitutes a significant concern for the occupational health sector. Hence, more research should be conducted to prevent or reduce respiratory disorders among coal miners. Future studies need to focus more on prevention strategies to develop good job practices.

The various associated factors of respiratory disorders, like coal dust exposure for long-term, smoking, and the size of a coal mine, were identified in this review. Proper implementation of a respiratory surveillance program in the occupational health service sector of the coal mining industry can reduce the burden of occupational respiratory disorders in coal mines.

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Nil

Conflicts of Interest

There are no conflicts of interest.

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