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Review Article

Black Lung Disease Among Coal Miners in Asia: A Systematic Review

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ABSTRACT

Background: Coal miners are highly prone to occupational health risks, such as black lung disease. This study aims to assess the prevalence of black lung disease and the factors associated with black lung disease among coal miners in Asia.

Method: This systematic review, conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines, searched through the scientific literature of the following databases: EBSCO, ScienceDirect, PubMed, and Scopus. We selected articles that studied black lung disease among coal miners from 48 countries in Asia and were published between 2014 and 2023. Article quality was evaluated using the Critical Appraisal Skills Program.

Result: The seven articles that we review studied a total of 653,635 coal miners from various types of coal mines from three countries in Asia. Of these miners, 59,998 experienced black lung disease. Black lung disease is prevalent among 9.18% of coal miners in Asia, which is approximately four times higher than the worldwide prevalence. Common factors that influence black lung disease in Asia include age, years of dust exposure, smoking, drinking, working types, and sizes of mines, type of mines, respiratory functions, spirometry parameters, tenure, lack of attention to occupational health, inefficient surveillance, and weak occupational health service.

Conclusion: Although the prevalence of black lung disease among coal miners in Asia is considerably high, it can be addressed through effective prevention measures, monitoring, control, and case reporting.

1. Introduction

World coal consumption in 2022 increased by 1.2% from the previous year, reaching a record worldwide consumption of 8 billion tons. The three major coal-consuming countries in 2022 were China, India, and the USA. Massive consumption requires increased coal production in coal-producing countries, and of the 8 billion tons of coal used in 2022, 5.75 billion tons (71.9%) were produced by three coal-producing countries in Asia, namely, China, India, and Indonesia. Therefore, Asia plays important roles in both the supply and demand of coal worldwide [1].

High levels of coal production in Asia result in high occupational health risks in the coal mining industry, especially among coal miners. An occupational disease that is specific to coal miners is black lung disease or coal workers' pneumoconiosis. This lung disease is caused specifically by the continuous inhalation of coal dust by coal miners, resulting in damage to the lungs [2,3]. Coal consumption is positively correlated to coal production and the occurrence of new cases of black lung disease; specifically, a twofold increase in coal consumption and coal production will result in a similar twofold increase in new cases of black lung disease [4].

Coal miners face many dangers in the workplace, especially in relation to black lung disease. In the 1970s, coal constituted the backbone of the energy sector in the USA, resulting in nearly 30,000 cases of black lung disease every year. To address this issue, the National Institute for Occupational Safety and Health published various guidelines for black lung disease, and currently, black lung disease cases are decreasing, despite the increase of black lung disease cases in the last 10 years [5,6]. In Asian countries, the

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concern for coal miners is not as high as that of the USA; thus, these countries and their respective coal industries pay little attention to black lung disease [7]. Thus, there is little accurate data related to black lung disease in Asian countries, such as China, India, and Indonesia, which are the world's largest coal producers [8].

Heretofore, it has been difficult to obtain accurate prevalence data related to black lung disease in Asia. Moreover, there are no screening measures and procedures for examining and reporting of black lung disease in Asian countries, which are additional obstacles to the availability of data related to the prevalence of black lung disease cases in these countries. Therefore, the aim of this review was to analyze data from previous studies from the last 10 years on black lung disease in various countries in Asia to enable us to determine the prevalence of black lung disease in this region. We also aimed to identify the factors that influence black lung disease among coal miners. This is the first study investigating the prevalence of black lung disease in Asia. The prevalence value we have determined can be used as the baseline value for the prevalence of black lung disease in Asia.

2. Materials and methods

2.1. Search strategy and inclusion criteria

This systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. We searched for articles related to black lung disease from the following scientific article databases: EBSCO, ScienceDirect, PubMed, and Scopus. Articles included for analysis were published in English from January 2014 to February 2023, and the subject of the article was coal miners from any of the 49 Asian countries [9].

Coal workers' pneumoconiosis, also known as black lung disease, is a lung disease that can occur due to coal dust inhalation. Over time, continuous inhalation of coal dust causes scarring of the lungs and impaired breathing. It is an occupational lung disease that is most common among coal miners [10,11]. A coal miner is a person whose job is to extract and process coal deposits from the surface of the Earth and from underground [12,13].

Article searches in the four databases used the following keywords: "Black lung disease," "Coal Miners," "Coal workers' pneumoconiosis," "Occupational lung disease," "Coal miners disease," "Asia," and the names of the 48 countries in Asia. We excluded the following types of articles: experimental studies, systematic reviews, qualitative studies, and case–control and cohort studies; in addition, we excluded articles that did not provide estimates of the prevalence of black lung disease. The selection process is shown in Fig. 1.

2.2. Data analysis

The quality of each article was analyzed using the Critical Appraisal Skills Program (CASP), a tool that provides a specific checklist to check items according to the desired study design. CASP reduces bias due to differences in study design and checklists used in article reviews. In particular, we used CASP for cross-sectional studies, which consist of 10 checklists for systematic reviews. These 10 checklists are divided into the following three sections: validity of the study, results, and community impact. CASP checklists offer three options for each checklist: "Yes," "Can't tell," and "No." These responses determine the CASP score for each article, where the minimum score is 0 and the maximum score is 10 [14].

In conducting the critical appraisal, a comprehensive approach was adopted, involving cross-review and cross-validation by all authors who collectively possess expertise in occupational health research. The reviewing team comprises two authors, each holding advanced qualifications in occupational health and related fields. The combined knowledge ensures a thorough evaluation of the research methodology, data analysis, and overall study quality. This multidisciplinary approach was intentional to bring diverse perspectives and insights to the critical appraisal process, enhancing the robustness of the evaluation.

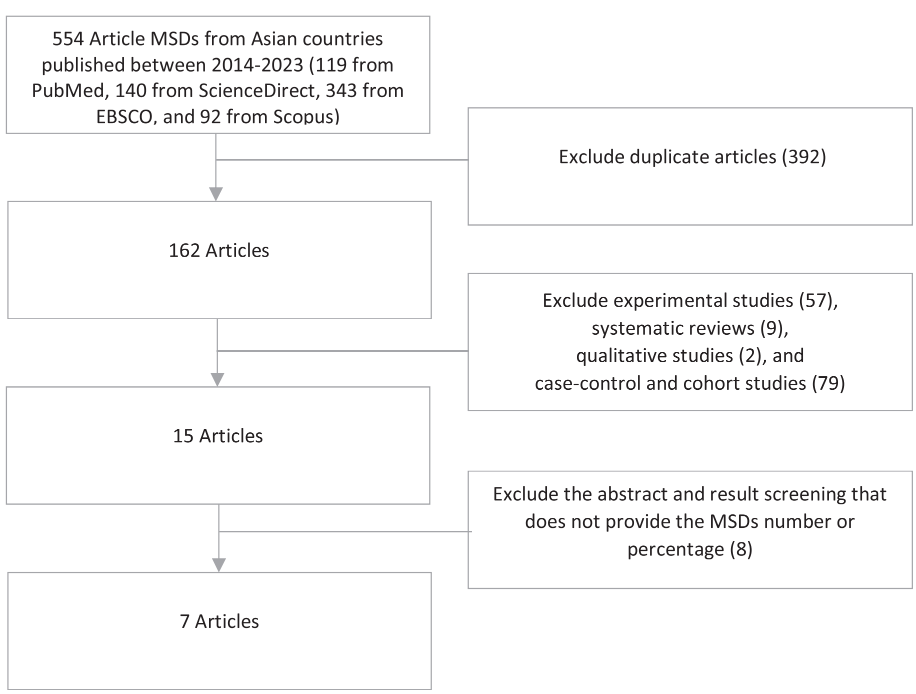

Fig. 1. Article selection flowchart based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.

In cases where differences of opinion or disputes arose during the critical appraisal, a collaborative resolution strategy was implemented. We engaged in constructive discussions to address varying viewpoints and concerns. This process involved a careful examination of the specific points in question, drawing upon the diverse expertise within the authorship team. The aim was to achieve a consensus through transparent communication and a shared commitment to uphold rigorous standards in the critical appraisal process.

3. Results

After implementing our inclusion and exclusion criteria, we selected seven articles for further analysis. Of the seven articles, five, one, and one are from research in China, India, and Turkey, respectively. These seven articles have CASP scores in the range of 7–10, which indicates that the quality of the articles is considered good. Specifically, one, five, and one of the articles have CASP scores of 7, 8, and 10, respectively. The information of each article is listed in Table 1, whereas the CASP score checklist of each article is provided in Supplement Material Table S1.

Each of the countries studied had a high prevalence of black lung disease among coal miners. The setting of five articles is in China, where 652,818 coal miners were study participants; of these, 59,675 individuals experienced black lung disease; thus, the prevalence of black lung disease among coal miners in China is 9.14%. One article is set in India, where 360 coal miners participated in the study; of these, 132 individuals were diagnosed with black lung disease. Thus, the prevalence of black lung disease among coal miners in India is 36.67%. The setting of one article is in Turkey, where 457 coal miners were study participants; among these, 191 individuals had black lung disease. Thus, the prevalence of black lung disease among coal miners in Turkey is 41.79%.

Overall, as many as 653,635 coal miners working in various types of coal mines in three different countries in Asia participated in the various studies. Of these, 59,998 coal miners experienced black lung disease; thus, the prevalence of black lung disease among coal miners in Asia is 9.18%.

Various factors contributed to the high prevalence of black lung disease among coal miners in Asia, including age, years of dust exposure, smoking, drinking, working types, and sizes of mines, type of mines, respiratory functions, spirometry parameters, tenure, and lack of attention to occupational health, inefficient surveillance, and weak occupational health service. More detail is listed in Table 2.

4. Discussion

Our systematic review found only seven articles set in three Asian countries and that aligned with our study's objectives, indicating a scarcity of research on the prevalence of black lung disease among Asian coal miners. Because of the mining sector's sensitivity toward economic and energy sectors and the crucial role it plays in coal-producing nations to maintain the trust of coal-consuming countries, it is necessary to address occupational health concerns, especially those related to safety issues. Based on our analysis, black lung disease is more prevalent among Asian coal miners compared with those in other regions, where preventive efforts and regulations are more consistently implemented. Collecting more data through increased research on black lung disease in Asia is essential to enhance coal miners' health in this region [21–25].

Our analysis found that the prevalence of black lung disease among coal miners in Asia is four times higher than the current prevalence rate worldwide. This higher prevalence can be

Table 1
General information of articles included in this study

Article code	Title	Authors	Journal	CASP score
A1	Prevalence Characteristics of Coal Workers' Pneumoconiosis (CWP) in a State-Owned Mine in Eastern China [15]	Han, Lei, et al., 2015	International Journal of Environmental Research and Public Health	8
A2	Effects of occupational exposure to dust on chest radiograph, pulmonary function, blood pressure and electrocardiogram among coal miners in an eastern province, China [16]	Wu, Q., et al., 2019	BMC Public Health	10
A3	Combined effect of coal dust exposure and smoking on the prevalence of respiratory impairment among coal miners of West Bengal, India [17]	Kumari Prasad, S., et al., 2019	Archives of Environmental & Occupational Health	8
A4	Focusing on Coal Workers' Lung Diseases: A Comparative Analysis of China, Australia, and the United States [7]	Han, S., et al., 2018	International Journal of Environmental Research and Public Health	8
A5	Descriptive characteristics of coal workers' pneumoconiosis cases in Turkey [18]	Ayoglu FN, et al., 2014	Iran Journal of Public Health	7
A6	Study on the burden of coal workers' pneumoconiosis in China from 1990 to 2019 [19]	Zu, X., et al., 2022	BMC Public Health	8
A7	Prevalence of pneumoconiosis in Hubei, China from 2008 to 2013 [20]	Xia Y., et al., 2014	International Journal of Environmental Research and Public Health	8

Table 2
Definitions of black lung disease, disease prevalence, and the main factors associated with the disease based on seven selected articles

Article code	Location	Participants	Definition of black lung disease	Methodology	Main result	Main factor with black lung disease	Definition of outcome
A1	China	495 coal miners	Black lung disease in any stage (simple black lung disease stage and complicated stage)	Black lung disease diagnosed by using Chinese diagnostic criteria	The prevalence of black lung disease on stage I (simple stage) is 71.11%	The majority were diagnosed at 52.3 ± 11.0 years of age and tunneling worker are riskier to get black lung rather than any other worker in coal mining area. Age and duration of dust exposed (years) are also significant with black lung disease ((OR/95% CI = N/A)	Present black lung prevalence from 1980 to 2014 majority were black lung disease stages I (71.11%)
A2	China	11,061 coal miners in 2015 and 12,597 coal miners in 2016	Black lung disease in any stage (simple black lung disease stage and complicated stage)	Black lung disease diagnosed by using radiograph machine, spirometer, sphygmomanometer, and electrocardiograph	A total of 80 persons were diagnosed with coal workers' pneumoconiosis (CWP) in 2015–2016, which occupied 0.34% of the coal miners	Abnormal pulmonary function, blood pressure, and electrocardiogram and radiograph of coal miners were closely associated OR (95% CI) with age >50 y 1.98 (1.39–2.81), years of dust exposure >20 y 2.64 (2.09–3.34), smoking 1.92 (1.34–2.71), drinking 2.20 (1.61–3.00), working types 2.43 (1.88–3.14) and size of mines 1.88 (1.39–2.55).	Present prevalence data of black lung disease diagnosed from 2015 to 2016 in China is 0.34%
A3	India	230 exposed by coal dust 130 not exposed by coal dust	Black lung disease in any stage (simple black lung disease stage and complicated stage)	Personnel dust exposure data were collected based on the files in the Dust Detection (Safety) Department of the respective coal mine, India. Lung function test was performed using Spirometer (Schiller, SpirovitSP-1)	132 participants from both groups indicated as black lung disease stage I	Lung function impairment was significantly higher in the exposed group than the nonexposed group (OR/95% CI = N/A)	Present diagnosed black lung disease prevalence in West Bengal, India, was 36.67%
A4	China, Australia, and USA (only use China prevalence)	43,700 coal miners in Australia and 50,680 in the USA, 525,000 coal miners in China (this review only included data from China)	Black lung disease in any stage (simple black lung disease stage and complicated stage)	Black lung disease data were collected by using secondary data from the National Bureau of Statistics of China, the Australian Bureau of Statistics, the Bureau of Labor Statistics of the USA, and the National Institute for Occupational Safety and Health	The prevalence of black lung disease in China is 9.86%	Mine type, coal rank, and geological conditions (OR/95% CI = N/A)	The present prevalence of black lung disease from 2003 to 2016 in China is 9.86%

A5	Turkey	457 coal miners in Zonguldak, Turkey	N/A	Black lung disease was diagnosed by using a radiograph machine, and categories were determined with radiographs classified according to the International Labor Office International Classification of Pneumoconiosis	191 (41.79%) cases of black lung disease were reported from Zonguldak, Turkey	Black lung disease is significant with smoking status, tuberculosis, respiratory functions, spirometric parameters, underground working day, age and tenure.with $\alpha = 0.05$ (OR/95% CI = N/A)	The prevalence of black lung disease from 2008 to 2009 in Zonguldak, Turkey is 41.797%
A6	China	100.000 coal miners	N/A	Black lung disease data based on secondary data from the National Health Commission of China, 2019	In 1990–2019, there were 4974 (4.97%) cases of black lung disease	CWP was mainly caused by male groups and more elderly miners (OR/95% CI = N/A)	The prevalence of black lung disease during 1990–2019 in China is 4.97%
A7	China	3665 cases of pneumoconiosis	N/A	Black lung disease data based on secondary data annual reports of pneumoconiosis from Hubei Province from the National Occupational Disease and Occupational Health Information Monitoring System	Coal workers' pneumoconiosis (2504) and silicosis (76), which accounted for 97.19% of the total, were the most common types of pneumoconiosis	Lack of attention to occupational health, inefficient surveillance, and weak occupational health services may have contributed to the increased new pneumoconiosis cases (OR/95% CI = N/A)	The prevalence of black lung disease from 2008 to 2013 is 97.19%

CI, confidence interval; OR, odds ratio.

attributed to the desire of some coal-producing countries in Asia to increase productivity without taking into account the health consequences of coal miners [4]. Increasing coal prices due to the recent energy crisis in several countries have resulted in an increasing demand for coal. This need is being filled by the coal exporting sector of coal-producing countries in Asia [26].

In addition to prevalence findings, we also identified various factors influencing the high prevalence of black lung disease among coal miners in Asia. Among the individual characteristic factors (i.e., factors inherent in coal miners in Asia), the most important are age, tenure, year of dust exposure, respiratory functions, and spirometry parameters. Coal miners in Asia are generally between 18 and 60 years old, which is the legal age range for working in various countries in Asia. To work in the coal industry, coal miners must meet this age requirement. We found that the incidence of black lung disease among miners aged 35–44 years is higher than the other age range; this age range corresponds to a worker's productive age. At this age range, it can be assumed that the miner has worked in coal mines for more than 5 years, which increases the risk of black lung disease. The three individual characteristics of age, tenure, and year of dust exposure are interrelated, that is, coal miners who are aged 35–44 years have likely worked for more than 5 years, which means they have been exposed to coal dust for the same duration as their length of service [17,27–29].

Among the individual characteristic factors are also respiratory functions and spirometry parameters, which were the foci of several studies. Working in coal mines is very risky due to exposure to coal dust, which affects the airway, and results in decreased respiratory functions. This is reflected by measurements of spirometry parameters. Various studies have reported measurements that characterize the early stages of black lung disease [7,30–32].

Behavioral factors refer to the habits of Asian coal miners before, during, and after work. Two habits among Asian coal miners that impact black lung disease are drinking alcohol and smoking. From seven articles, we found that several coal miners in Asia smoke, and although smoking in the mining area is prohibited, these coal miners often smoke outside the mining area. Smoking has been shown to exacerbate decreased respiratory function, which is reflected by measurements of spirometry parameters among coal miners [16,18,33,34].

Job factors refer to the type of work engaged in, as well as the size and the type of mines. These factors contribute to the high prevalence of black lung disease among coal miners in Asia. Work types that increase the exposure of coal miners to coal dust are associated with a higher risk of getting black lung disease. The type and size of the mine are also associated with black lung disease, as high-producing mines tend to increase the risk of black lung disease among coal miners. Moreover, underground coal mining greatly increases the risk of the incidence of black lung disease [7,16,18,35].

Managerial factors that are associated with black lung disease include lack of attention to occupational health, inefficient surveillance, and weak occupational health service. These factors indirectly affect the occurrence of black lung disease in coal miners. Nevertheless, addressing these three factors is necessary to reduce the occurrence of black lung disease in Asia [7,20].

This review did not include a meta-analysis of data because of the variations in the quantitative references found in each article obtained. These variations include diverse metrics, measurement scales, or units used across the selected articles to report the prevalence of black lung disease among coal miners in Asia. Because of the limited amount of research on black lung disease among coal miners, we were unable to find sufficient articles suitable for a reliable meta-analysis. However, the prevalence of the disease and its associated factors, as disclosed in each study, has been thoroughly reviewed, summarized, and presented.

5. Conclusion

The prevalence of black lung disease among coal miners in Asia is considerably higher than that worldwide. Factors that contribute to this high prevalence include individual characteristics, behavioral factors, job factors, and managerial factors. This finding should be useful to all Asian countries attempting to reduce the prevalence of black lung disease. Sustained research on the prevalence of black lung disease in Asia is needed. Moreover, effective programs for the prevention, monitoring, control, and case reporting of black lung disease are essential for resolving the high prevalence of this disease in Asia.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2024.01.005.

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