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LITERATURE REVIEW Open Access

LITERATURE REVIEW: COAL DUST EXPOSURE AND PULMONARY PHYSIOLOGY STATUS

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Abstract

Introduction: *Occupational disease is a problem due to the dangers that exist in the work environment. One of the dangers is dust. Dust, either organic or inorganic, is a chemical agent that can cause impairment in the human respiratory tract. As a side result of the processing process in coal mining, coal dust is one example of the danger in the working environment. The flying dust can enter the worker's respiratory tract and cause adverse effects, which should be noted. This study aims to analyze coal dust exposure to pulmonary physiology status and explore what risk factors cause a decline in pulmonary physiology status.* ***Discussion:*** *This study used the literature review method by using research data with the same topic as secondary data. The selected research was a cross-sectional design. The literature review results showed that the inclusion of coal dust was influenced by several variables, such as dust content, age, employment, smoking habits, and the use of PPE.* ***Conclusion:*** *The most widely found variable has a relationship with the pulmonary physiology status is a variable of coal dust levels, age, length of work, and smoking habit.*

INTRODUCTION

Occupational Disease (PAK) is a disease caused by work and arises from the influence of the work environment. There are several risk factors for PAK, namely physical, chemical, biological or psychosocial factors in the workplace. These factors in the work environment are the cause of occupational diseases (1). International Labor Organization (ILO) data in 2016 stated that every 15 seconds, a worker dies from a work accident or disease. Every 15 seconds, 153 workers have work-related accidents. ILO data also shows that 2.78 million people die from their work each year. Occupational diseases were the leading cause of death, with 2.4 million cases (2). In the United States, occupational lung disease is the number one occupational disease with the most deaths. In 2002, the ILO recorded at least 294,500 new cases of occupational lung disease (3).

When working, everyday people have the potential to be exposed to dangers. One of the hazards that may endanger workers is dust. When dust, both organic and inorganic, enters the human body and respiratory tract, it will cause harmful effects. Dust, in this case, coal dust, is a chemical agent that can cause work problems, such as visual disturbances, lung function status, and worker poisoning. Dust, as a byproduct of the coal mining process, with a small size, has the potential to cause lung problems in mining workers. Dust with a size of less than one micro can enter the alveoli, while dust with fewer than 0.1 micros can move in and out of the alveoli freely but does not stick to the alveoli surface (4).

Coal is still an essential energy source globally; although there are many alternative energies available, coal is still used. About 30% of global energy needs are covered by coal, which generates 41% of the world's electricity (5). It is used in 70% of world steel production. Data shows that in 2012, total world coal production reached a record level of 7831 million tonnes (MT), which is an increase of 2.9% compared to 2011. Then, in 2018, total coal production in the world was 7813.3 MT; it shows that coal demand is increasing (6).

The increase in demand for coal is in line with the increase in production. The Mundi Index data noted that in 2018, China was the largest coal producer in the world. China can produce 4.4 billion short tons of coal. One short ton is equivalent to 907.2 kg. Under China, the United States is the second-largest coal-producing country in the world, with a total production of 985 million short tons. In third place in India, with a production of 675 million short tons. Then there is Indonesia in fourth place with 539 million short tons (7).

In Indonesia, the three regions that produce the most coal resources are South Kalimantan, East Kalimantan and South Sumatra. In Indonesia, coal consumption increases every year. It is recorded that in 2014 the coal consumption figure was 76 million tons. Then, this figure increased by 10 million to 86 million tonnes in 2015. In 2016, this figure increased to 91 million tonnes and increased to 97 million tonnes in 2017. Recent data shows that in 2018 coal consumption figures in Indonesia reached 115 million tonnes (8).

The role of coal in Indonesia is crucial, especially for domestic income. The coal industry contributes about 85 percent of the mining sector's revenue. Also, the role of coal cannot be separated from electricity generation. Coal-fired power plants generate at least 27% of the world's total energy output and more than 39% of all electricity.

According to the US Bureau of Labor Statistics, underground coal mining is a relatively dangerous industry, and miners are at high risk of facing various types of health problems or more and can be fatal as operations carried out in the field vary widely (9). Mining is one of the most "dusty" fields of work. Work-related illnesses or accidents can very well occur to workers in coal mining, given the hazardous work environment. One of the diseases that can be experienced by workers is a problem with the respiratory tract. The pulmonary function status of workers can also experience adverse effects because they are exposed to coal dust daily and directly.

Mining workers are at high risk of being impacted by exposure to coal dust. The effects experienced by workers include bronchitis, CWP (Coal Worker's Pneumoconiosis), COPD (Chronic Obstructive Pulmonary Disease), decreased lung function, and other respiratory diseases exposure to coal dust. These disorders can lead to organ disability, even premature death. In general, if workers are exposed to coal dust for a long duration, the pulmonary dysfunction experienced by workers is classified as obstructive, restrictive, or mixed.

According to data from the ILO, it is detected that there are about 40,000 new cases of pneumoconiosis occurring worldwide each year, and among all occupational diseases, 10% to 30% are lung diseases (10). In the United States, in 2004, pneumoconiosis was the leading cause of death in 2,531 cases. Based on survey results by the Directorate General of Disease Control and Environmental Health in Indonesia, chronic obstructive pulmonary disease ranks first as a contributor to morbidity (35%), followed by bronchial asthma (33%), lung cancer (30%), and 2% (11).

Research by the American Lung Association states that particles' air contamination in the work environment is a risk factor for respiratory problems. COPD (Chronic Obstructive Pulmonary Disease) can also be found in mining workers. Data from the World Health Organization (WHO) noted that COPD in 1990 became the 6th disease with the most deaths globally. Then from 2002 to 2013, it rose to number 5. WHO also estimates that by 2030, COPD will become the 3rd leading cause of death in the world (12). Through calculations carried out by WHO, it is noted that COPD has the highest prevalence globally, and the mortality rate always increases every year. This figure is above cardiovascular disease and cancer. Worldwide, moderate to severe COPD affects people over 30 years of age, with a prevalence of 6.3%.

Therefore, considering the severe impact of coal dust exposure on worker health, the authors are interested in examining how coal dust exposure to a person's lung function status. The author was summarizing and examining research with similar topics that have been done before. This article uses a literature review method to systematically study and interpret all studies' results according to a specified topic.

An important literature review method can be done to examine more deeply a problem topic. This method can also be used to summarize all available facts and data to bring up new facts about a particular topic.

DISCUSSION

The author searches for scientific publication articles on several sites on the internet, such as PubMed, Medline, Science Direct, DOAJ, and Google Scholar. Search for articles using keywords such as coal dust exposure, pulmonary function status, and pulmonary disorders with criteria predetermined by the author. After entering the keywords, the writer finally got 115 articles that were relevant to the topic taken. After that, the articles were selected so that eight articles published between 2015-2020 were selected. The research article chosen was a study on the relationship between coal dust exposure and pulmonary function status in coal mining workers. The flow for selecting selected articles is as follows in Figure 1.

Initially, there were 120 references obtained from search results on the internet. The references obtained are selected according to predetermined inclusion criteria, namely the publication year between 2015-2020, observational research, and articles published in accredited journals, both domestic and foreign. Also, the exclusion criteria were defined as articles that discussed respiratory diseases.

After going through several stages and being selected several times to produce as many as ten references for review, selected references are in journal articles and theses. The reference is chosen is research conducted not only in Indonesia but also abroad. So this forms a diversity of results that is still significant and not too far away because it uses the keywords coal dust and lung function for each journal.

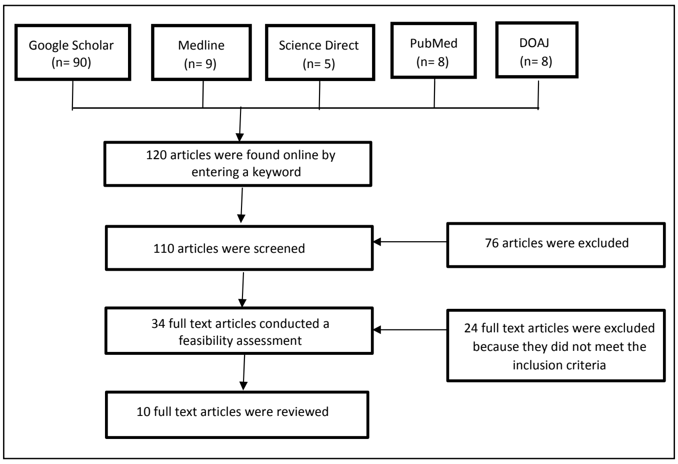

Figure 1. Article Selection Flowchart

The selected journals are shown in table 1. Based on table 1 of the eight articles summarized, overall, all articles stated the same results: a relationship between coal dust exposure and a decrease in the respondents' lung function. All studies were summarized using the spirometric test to assess lung function, then analyzed the relationship to decreased lung function using statistical tests.

Although, in general, the article discusses the effect of coal dust exposure on lung function status, each article adds several other independent variables. Some of the independent variables most frequently cited among these articles were age, years of service, and smoking status. Apart from these three variables, other variables are also called. This variable is the use of PPE (Personal Protective Equipment). The addition of different independent variables between these articles will affect the final results of the study later. A summary of the relationship between several independent variables on pulmonary function status is presented in the table below.

Based on table 2, there is a difference in the number of articles that state the relationship between variables.

Dust Content

Coal mining carries out its production activities every day. The process carried out in coal mining has several stages, starting from the preparation of mining (mine development), the process of clearing the land

and removing the overburden, mining coal to processing coal in the form of coal crushing and washing coal (8). The stages in coal mining will produce dust of various sizes, especially at the coal crushing stage (13).

Coal crushing is the process of breaking coal from large to small sizes. The device for breaking coal is called a crusher (14). At this stage, coal is broken down into smaller sizes, which can produce dust. The resulting

Table 1. Summary of Literature Study Results

Authors	Title	Population	Methode	Result	Conclusion
Qing-Zeng Qian, Xiang-Ke Cao, Qing-Qiang Qian, Fu-Hai Shen, Qian Wang, Hai-Yan Liu, dan Jun-Wang Tong (24)	Relationship Of Cumulative Dust Exposure Dose And Cumulative Abnormal Rate Of Pulmonary Function In Coal Mixture Workers	The study group consisted of 328 mine workers in Tangshan and the control group consisted of 169 workers from various industries in the same area.	Analytical descriptive method with cross sectional design approach	1. The rate of abnormal lung function (FVC%, FEV1%, and FEV1 / FVC%) in the study group (35.1%) was much higher than that of the control group (10.1%). 2. Significant decreases in FVC%, FEV1%, and FEV1 / FVC% were seen in the group of workers who had worked for 20-29 years and> 30 years (all p <0.05).	The pulmonary function of mining workers has decreased which is indicated by a decrease in FVC%, FEV1%, FEV1 / FVC%. In addition, years of service and time exposed to dust can be risk factors for decreased lung function.
Sarang Dhatrak, Subroto Nandi, dan Shweta Gupta (29)	Comparative Study Of Pulmonary Impairment Among Diverse Working Groups In Coal Mine	The study group consisted of 115 mining workers who were directly exposed to dust and the control group consisted of 92 mechanical parts workers who were not directly exposed to dust	Cross-sectional	1. Significantly decreased all pulmonary parameters, namely FVC, FEV, and FEF seen in the study group, except for the PEFR parameter. 2. A significant reduction in FVC and FEV parameters is seen in the group of workers with exposure time> 30 years.	Pulmonary dysfunction in mining workers was more pronounced in their early years of work. In addition, the smoking status of the respondents is a risk factor for lung disorders.
Shilpi K Prasad, Siddhartha Singh, Ananya Bose, dkk (21)	Combined Effect of Coal Dust Exposure and Smoking on The Prevalence of Respiratory Impairment In Coal Miners Of West Bengal, India	The study group consisted of 230 mining workers who were directly exposed to dust and the control group consisted of 130 mechanical parts workers who were not directly exposed to dust	Analytical observational method. cross-sectional approach	Lung function index was significantly (p <0.050) impaired in the study group (43.91%) and the control group (23.85%). In addition, a very significant reduction in lung volume also occurred in the study group. The association between spirometry results and time of exposure was negative in the study group.	This study states that there is a correlation between time of exposure and decreased lung function.
Deepa Agarwal, Jai Krishna Pandey, Asim Kumar Pal (31)	Pulmonary Function Test Of Mine Workers Exposed To Respirable Dust In Jharia Coalfield India	The research subjects were 170 workers	Cross sectional	1. The FVC value of subjects from various groups is far from the normal limit for men, namely 4.8 L. 2. FEV and FEV / FVC values in subjects with smoking and alcohol consumption habits were lower than in subjects lainnya	Impaired lung function was associated with increasing age, duration of dust exposure, consumption of tobacco and alcohol, and smoking.
Tanzeel Ahmed, Muhammad Waqas, Sadia Ahmed Zuberi, dan Qaiser Iqbal (43)	Lung Function Comparison by the Technique of Spirometry Between Different Working Groups of Pakistan: A Cross-Sectional Survey Based Study	The research subjects were 300 people consisting of 100 mining workers, 100 carpenters, and 100 stone breakers	Cross sectional.	The average FVC values for coal mine workers are (84.36 ± 08.35), FEV1 (60.79 ± 08.77), PEFR (74.44 ± 13.01), and FEV1 / FVC (72.13 ± 08.14)	The pulmonary function of coal mine workers is more at risk of decreasing compared to carpenters and stone crushers.
Qing-Zen Qian, Xiang-Ke Cao, Fu-Hai Shen, dan Qian-Wang (30)	Correlations Of Smoking With Cumulative Total Dust Exposure And Cumulative Abnormal Rate Of Pulmonary Function In Coal-Mine Workers	376 mining workers as the study group and 179 workers from other industries as the control group	Cross-sectional Study	1. In the results of the study, the FVC, FEV1, and FVC / FEV1 values were lower in the study group 2. The number of smokers in the study group is greater than the control group 3. The period of service is not related to the value of FVC, FEV1, and FVC / FEV1	Smoking habit is the most influencing factor in the damage to lung function.
Nubia Gonzalez, Sara Lucia Diaz, Myriam Rocio Wilches, Mabel Patricia, Cesar Mendez, Andrea dan del Rosario Herrera (22)	Spirometry Assessment Of Coal Miners In Paipa, Colombia	226 miners	Cross-sectional Study	1. 28 workers experienced changes in lung function 2. The average age of workers is 36 years 3. The average tenure was 16 years	Age and years of service have a significant relationship with changes in workers' lung function.

Authors	Title	Population	Methode	Result	Conclusion
Subroto Shambhu Nandi, Shweta Rameshprasad Gupta, dan Sarang Vilas Dhatrak (49)	Occupational Impact Of Increased Dust Duration On Pulmonary Capacities Of Workers	240 mining workers as the study group and 92 administrative staff as the control group	Cross-sectional	1. It was observed that 15.8% of exposed workers had limiting lung disorders compared to 6.5% among absent workers, and the difference was statistically significant (p <0.05) 2. The difference between the mean of forced vital capacity and volume of forced expiration in one second (FEV1) between the studied groups was statistically significant (p <0.01). 3. This decrease in lung function was statistically significant (p <0.001) Pearson's correlation value shows a poor correlation between duration of dust exposure and worker lung function.	This research emphasizes the need for regular monitoring of dust levels and awareness of the importance of personal protective equipment among workers
Ndinomholo Hamatui, Rajen N. Naidoo, dan Nnenesi Kgabi (23)	Respiratory Health Effects Of Occupational Exposure To Charcoal Dust In Namibia	307 workers in the Namibian coal mines.	Cross-sectional	Adjustable dust exposure levels are above occupational exposure limits in most sectors, with packaging and weighing having the highest dust exposure levels (median 27.7 mg / m3, range: 0.2–33.0 for highest dust exposure levels (median 27.7 mg / m3, range: 0.2–33.0 for 8-hour time-weighted average).	It is advisable to further enforce regulations regarding work safety in mining
Yuvaraj R, Suganya K, dan Chandrasekhar M (25)	Pulmonary Function Test in Coal Handling Workers	50 workers in a coal mine	Cross-sectional	The results show that the value of Vital capacity, Forced Expiratory Volume in the 1st second, Forced Vital Capacity, Maximum Ventilator Volume and Peak Expiratory Flow Rate decreased significantly compared to standard prediction values. The FEV_1 / FVC ratio is found increased significantly in workers.	Coal mine workers are at risk of chronic obstructive airway disease shown by this study. Pulmonary function tests on workers showed indications of pulmonary fibrosis.

dust can fly around the work environment and can be inhaled by mining workers and harmful.

The dust suppression process is a process to suppress the emergence of coal dust by spraying water during the crushing process (15).

The coal dust that flies can be inhaled by the workers and enter the workers' bodies. Dust that enters the body will accumulate and settle in the workers' lungs organs, depending on its size (16). The accumulation of dust in the body will impact the smooth passage of air into the body. The dust that accumulates in the body will block the air entrances and disturb lung function (17).

When micro-sized coal dust particles enter the body, the body's defense mechanism is that the dust will be eaten by interstitial and alveolar macrophages (18). After that, it will proceed to the mucociliary system to be jointly excreted with mucus or re-enter the lymphatic system. If these two mechanisms are unsuccessful, the dust particles will remain in the bronchioles and stimulate an immune response. One of the possible immune responses is the formation of ROS (Reactive Oxygen Species). The formation of this ROS will have a direct impact on the lung tissue. ROS will damage the alveolar epithelium and cause inflammation of the lung tissue. ROS can result from many environmental and occupational exposures (19).

The results shown by the ten selected studies were different. Some studies suggest a significant relationship between coal dust levels and lung function, but some states the opposite. The methods used by the research are different. Some studies only measure total dust in the work environment, but some measure workers' dust. These measurement methods can show the level of dust around the worker, and to know more specific result concentration can use the personal dust.

Table 2. The Relationship Between Independent Variables Against Pulmonary Physiological Status

Independent Variable	Related	Not Related
Dust level	5 Studies	3 Studies
Age	4 Studies	3 Studies
Work of period	4 Studies	2 Studies
Smoking status	5 Studies	2 Studies
Use of PPE	-	2 Studies

The dust level that enters the worker's body, both total dust and personal dust, will significantly affect the lungs' function. The size also determined the physical properties of the dust. The size of dust that can cause respiratory problems is smaller than 10 microns. The smaller the dust size, the deeper its accumulation in the respiratory tract (20).

The results showed that almost all selected studies stated a relationship between dust levels and pulmonary function status. A study conducted in India showed a p-value of 0.046 for the relationship between dust content and pulmonary function status. This study also revealed that more respondents who worked in closed mining (78%) had lung problems. In the closed mining working environment, the spread of pollutants associated with coal dust is limited, whereas, in open mining, the dust content is relatively much lower, as it is spread in the free air. Another result is that the FVC value of various categories of workers is in the range between 0.945 ± 0.021 to 3,966 ± 0.018, which is far below the standard value for men, namely 4.8 L and for women is 3.1 L. Reduction in the FVC value indicates that there are obstructive and restrictive disorders in workers' lungs (21).

Research conducted at a mine in Colombia found that as many as 75.5% of workers exposed to dust had an impaired pulmonary function status. The study also stated that the risk of workers experiencing pulmonary disorders who received high dust exposure was 1.21 times greater than that of workers with lower exposure. Direct measurements of dust levels indicate that the mine's dust levels are high and exceed TLV, which is 2.02 mg/m^3 (22). So it can be said that the higher the dust level, the more potential for workers to experience interference with their lungs.

The results of one study in Namibia have shown conflicting results. The study results stated that there was no relationship between dust levels and workers' lung function status, with a p-value of 0.38. The results of this study also indicate that the FEV1 and FVC values do not decrease when compared with their average values (23).

Work Period

The working period is one of the risk factors for lung function disorders. The period of employment is the length of time a person works at the workplace, which is counted from when a person has entered work in a matter of years. In theory, if a person works in a dusty place for a long time, the percentage of risk for developing lung function disorders will increase (16). The length of service life corresponds to a significant increase in pulmonary dysfunction among coal mine workers. The longer a person works and is exposed to coal dust, the more coal dust will settle in his respiratory tract.

A summary of ten studies looking for an association between years of service and decreased lung function showed that three of them stated a significant relationship between years of service and decreased lung function. Research conducted in coal mining in China revealed a p-value of 0.021 between years of service and workers' lung function status. The FEV1, FVC, and FEV / FVC values of the workers show that workers with a service period of more than ten years experience decreased lung function parameters from their standard values (24).

However, other studies indicate that tenure is not associated with workers' pulmonary function status (25). These different results could be caused by several things, for example, because most of the respondents' average tenure was still under ten years. The latency period and the appearance of symptoms or signs of several occupational diseases, such as pneumoconiosis, takes more than ten years (26). This makes it difficult to see the effect of coal dust exposure if the observed working period is still below ten years.

Research in China stated that the group of workers who had worked for more than ten years experienced a decrease in the pulmonary function parameter, with a p-value of <0.05. The length of time a person is exposed to dust can be associated with impaired lung function because long-term exposure to coal dust can lead to pulmonary nodules and interstitial fibrosis, thereby affecting pulmonary ventilation and air exchange function (27). Also, previous studies have shown that prolonged exposure to coal dust over 15 years shows a significant reduction in FVC, FEV1 / FVC (28). It will cause severe problems if not treated early.

Smoking Habit

Smoking is one of the risk factors in decreasing lung function status cause of health risks and the emergence of respiratory and cardiovascular diseases (29). Smoking can also damage the alveoli in a person's lungs. The number of functional alveoli will decrease, even though functional alveoli are very important in respiration. If it is damaged, it will have a harmful impact so that later there will be a decrease in lung function. The combination of exposure to coal dust and smoking can worsen a person's lung condition. Several epidemiological studies studying the association of coal dust exposure with tobacco smoke's effect on workers' lung status have shown decreased lung function (29).

Of the eight studies, six studies described the relationship between the respondents' smoking habits and pulmonary function status. Only two studies stated there was no relationship between smoking habits and pulmonary function status. The research was conducted at a mine in China (30), with a p-value of 1.00 and a mine in India (21), with a p-value of 0.12. The difference in results in the two studies can be influenced by several factors, such as the number of cigarettes, duration of smoking, and others.

According to a study, someone who smoked had an 8.19 times greater risk of decreased lung function than nonsmokers. Smoking can accelerate the decline in lung function. Research conducted in India states that respondents aged 25-40 years who smoke are moderately obstructive (31). Smoking can indicate that worsen a person's health condition, especially if the person is exposed to coal dust. Also, the FEV1 value in people with smoking habits will decrease by more than

50 ml per year, while the FEV1 value in healthy people will only be 20 ml per year (32).

Smoking can cause mucosal cell hypertrophy and increased mucus secretion. The respiratory tract quickly absorbs the nicotine. The combined effect of the parasympathetic ganglia and cholinergic nerve endings, resulting in increased intestinal tone and motor activity. Smoking will result in the release of solid and gas pollutants due to tobacco and nicotine combustion. Then, cigarette smoke will cause mucus secretions. Also, nicotine will kill the cilia's function, ultimately causing obstructed airway clearance (33). The more prolonged the smoking habit, the more sediment there is in the lungs so that the air passages to enter and exit become narrower (34).

The smoke produced by smoking can reduce or even eliminate the function of cilia (35). Cilia are cell organelles that are shaped like hair. Cilia function to prevent the entry of foreign objects into the body. Cigarette smoke, which contains many harmful chemicals in it, must be warded off by the cilia to enter the body's organs. Finally, the cilia have to work harder, reducing the cilia's rate and function and leading to infection in the lungs (36).

In addition, smoking can cause changes in the structure and function of the human respiratory tract. In the large airways, mucosal cells experience hypertrophy, while the mucus glands will experience hyperplasia. Meanwhile, the narrowing due to cell increase and mucus buildup will occur in the small airways. In the lungs, inflammatory cells will increase, and the alveoli will be damaged. These changes can interfere with lung function (37).

Apart from the smoking habit itself, other factors affect the decrease in lung function, such as smoking duration and cigarette dose. One study revealed that a person with a dose of 35 cigarettes/day had a 40 times greater risk of developing lung problems than nonsmokers (38). All selected studies did not include the factor of cigarette dose consumed by workers in a day, so it is not possible to know whether the respondent's cigarette dose is related to their pulmonary function status.

Age

The age factor is one of the factors that can naturally affect the condition of a person's lungs. In older people, the function and performance of the body's organs decrease. Increasing age also causes several lung organ changes, such as changes in tissues, muscles and bones, and the nervous system (19). The older the person is, the more susceptible a person is to disease and changes in the human immune system as he gets older (39).

The average lung capacity of people over 30 years of age is 3,000 ml to 3,500 ml, but people with more than 50 years of age have decreased lung capacity. Lung capacity for people over 50 years will be less than 3,000 ml. When a person reaches 30 years, the mean pulmonary function values begin to decline (40). The decrease in the value of lung function will occur by approximately 20 ml every time a person increases by one year. The mean age of the respondents in the study was over 30 years. This figure is the age number when the person's lung capacity has reached its optimal point and cannot develop anymore; even his lung function will decrease (41).

The reduced rate of lung function is caused by reduced elastic deterioration and stiffness in the lung tissue associated with aging. The structure and immunity of the human respiratory system will change with age. With increasing age, lung and respiratory muscle strength, vital capacity, FEV1, and FVC, and epithelial antioxidant fluid will decrease (42).

Of the ten studies, six studies looked for the relationship between age and decreased lung function. Of the six studies, four studies stated a relationship between age and decreased pulmonary function of the respondents. A study in India showed a relationship between age and pulmonary function disorders with a p-value of 0.041. The study also stated that the group of respondents aged 40 - 55 had severe obstructive pulmonary action. This study also showed that over 30 years of age tended to have 1.7 times the risk of experiencing lung function disorders (31).

Also, one study stated that increasing age in a person would affect their FEV1 and FVC values. The respondents' FEV1 and FVC values decreased significantly with the increasing age of the respondents. The FVC value will continue to increase until the age of 25-30 years and decrease ten years after that (43).

Different results are shown in one study. One study found no association between age and impaired pulmonary function status (24). The absence of a relationship between age and decreased pulmonary function of respondents can be caused by other variables that directly affect lung function. Although age is not an absolute factor affecting a person's lung function decline, age can be a risk factor for aggravating it.

Use of PPE

Based on the screening results, two studies state that PPE is not related to the pulmonary function status of workers. The same research was carried out in mines in India to get the p-value of 0.625 (21) and 0.59 (31).

PPE is the equipment used by workers to protect their bodies from hazards in the workplace. The regular use of PPE on workers from every worker in mining has an essential role in protecting against occupational health hazards. PPE can be used as a barrier from excessive dust exposure because, in principle, PPE is used to protect workers' bodies from dust exposure.

PPE must also be appropriate. Respirators and masks are examples of PPE that can be given to workers exposed to dust in their work environment. A respirator is a personal protective device used to reduce the risk of hazardous particles in the air, gases and vapors (44). The masks provided must also meet the standards to prevent small size dust from entering the worker's body (45). Although masks cannot protect the body from the entry of coal dust perfectly, the use of masks can reduce and prevent dust from entering. The use of masks can prevent dust buildup in the lungs, so it is hoped that it can reduce the risk of lung function disturbances.

CONCLUSION

The most commonly found variables to correlate with pulmonary function status were coal dust level, age, and smoking habits. It is hoped that future research will include other external variables that might affect a person's lung function status due to exposure to coal dust. Harmful impacts on workers can be prevented by paying attention to the work environment factors.

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