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# Occupational Asbestos-containing Materials Exposure and Risk of Asbestosis among Construction Workers

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**Abstract**
**Purpose:** Asbestos-containing materials are often found at construction sites, and long-term exposure to accumulated asbestos can increase the risk of asbestos-related diseases, including asbestosis. The present study aimed to further describe the exposure to asbestos in construction workers and the risk of asbestosis, as well as the management and prevention of asbestos exposure.
**Methodology:** The narrative review method was used to conduct this study with a comprehensive literature search of the following databases: PubMed, Scopus, ScienceDirect, and Google Scholar.
**Results:** According to the review, we finally found that many materials in the construction sector contain asbestos and have the potential to spread asbestos fibers into the air and can be inhaled by workers. Cumulative asbestos exposure that occurs in high doses over a long period of time will cause an increases the risk of asbestos-related diseases, including asbestosis. Apart from asbestos exposure, several other factors, such as genetics, smoking, sex, age, and physiology, are closely related to the occurrence and development of asbestosis. The construction sector has the highest exposure to asbestos compared to other sectors or industries and has a high number of asbestosis cases. Thus, it is necessary to provide precautions for workers, such as the use of adequate personal protective equipment of international standards, the presence of health inspectors, and routine checks on workers' health, as well as management of materials or construction waste containing asbestos.
**Limitations:** This study is limited to describing general exposure to asbestos-containing materials and the increased risk of asbestosis in construction workers. Future research regarding further analysis of causal factors, management, and prevention of asbestos exposure, as well as case reports and mapping of asbestosis cases, especially in Indonesia, where related research is still limited, may be warranted.
**Contribution:** This review can be used as a basic reference for conducting further research regarding asbestos exposure to workers and the prevention and management of asbestos-containing materials at construction sites.
**Keywords:** *asbestos, asbestosis, pneumoconiosis, construction, construction workers.*
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## 1. Introduction

Asbestos is a natural fibrous silicate mineral (Govorko, Fritschi, White, & Reid, 2017), classified into two groups, namely the amphibole group which consists of crocidolite, amosite, tremolite, actinolite, and anthophyllite asbestos, and the serpentine group which only consists of chrysotile abscess (Frank & Joshi, 2014). Apart from being used in various manufactured goods, asbestos is widely used in construction materials (Frank, 2020). The reason is because it is considered a cheap mineral and has the properties of high tensile strength, non-flammability, thermal and electrical resistance and stability, and resistance to chemicals (Allen, Baez, Stern, Takahashi, & George, 2018; Thives, Ghisi, Júnior, & Vieira, 2022). Many construction materials contain asbestos fiber, including duct and pipe insulation, cement, wall coverings, floors, roofs, and in sealants, caulks, glass, water tanks, chimneys, and gutters (Campopiano et al., 2021; Franzblau, Demond, Sayler, D'Arcy, & Neitzel, 2020).

Even so, the use of asbestos is still quite high, especially in Asia where it is still the largest in the world and continues to increase, from 14% in 1920-1970 to 64% in 2000-2007, with Indonesia being the eighth largest importer, processor, consumer and exporter of asbestos in the world and with annual consumption of 65,000 tons per year (Leong, Zainudin, Kazan-Allen, & Robinson, 2015).

The World Health Organization (WHO) has stated very clearly that asbestos is a very dangerous substance, on a par with mercury, lead and pesticides, which currently causes 125 million people to be exposed to asbestos at work and more than 107,000 deaths every year (Organization, 2018). It is dangerous and carcinogenic because exposure to asbestos has an impact on respiratory and lung-related diseases, including mesothelioma, asbestosis, pleural fibrosis and plaque, benign asbestos pleural effusion, small cell lung carcinoma, and non-small cell lung carcinoma (Chen et al., 2012; Lestari, Hairunisa, & Ridwan, 2023; Musk et al., 2020; Solbes & Harper, 2018).

One of the diseases caused by inhalation of asbestos fibers is asbestosis. Asbestosis is an industrial pneumoconiosis that causes interstitial pulmonary fibrosis, with shortness of breath, dry cough, and auscultation findings of fine inspiratory crepitation and limited pulmonary function test patterns are the clinical manifestations that appear in affected individuals (Barber & Fishwick, 2016; J, PK, & YR, 2020; Leong et al., 2015). Asbestosis is caused by diffuse pleural thickening (Norbet, Joseph, Rossi, Bhalla, & Gutierrez, 2015) and the risk of occurrence can increase if the individual has a smoking habit (Vujoviæ, Vukoviæ, & Beg-Zec, 2003). Crocidolite and amosite asbestos, the strongest types, play a role in the production of reactive oxygen species and reactive nitrogen species which trigger chronic inflammation (Benedetti, Nuvoli, Catalani, & Galati, 2015), which in turn plays a role in increasing the risk of developing malignancies (Benvenuto et al., 2016).

Since it is widely used in the construction industry, exposure to asbestos in construction workers has had negative health impacts, one of which is an increased risk of asbestosis (Noonan, 2017; Sen, 2015). In the United States, as many as 1.3 million construction and industrial workers were exposed to asbestos during the renovation or demolition of old buildings (Prevention, 2009). Construction workers in Sweden are also among the workers with cases of mesothelioma due to exposure to asbestos, especially insulation workers and pipefitters (Järvholm & Englund, 2014).

Working in the construction sector is very easy to be exposed to asbestos and has a higher chance of experiencing negative health impacts, one of which is experiencing asbestosis. Although the risk of asbestosis in construction workers has been discussed in previous research, this review provides an update summary regarding exposure to asbestos-containing materials and the risk of asbestosis in construction workers. Therefore, this review was carried out to review and discuss further the exposure to asbestos in construction workers and the risk of asbestosis, as well as the handling, management and prevention that can be done to minimize exposure to asbestos which triggers asbestos-related diseases.

## 2. Literature Review

### *2.1 Asbestos*

Chrysotile, asbestos that belongs to the serpentine group, is flexible, curly, and less dangerous than that found in amphibole fibers. Because chrysotile is more soluble, flexible, and curved, it accumulates in the upper respiratory tract. Chrysotile fibers are easy to remove from the upper respiratory system due to the more prominent mucociliary function there (J et al., 2020). Chrysotile asbestos is widely used throughout the world, accounting for around 90-95% of asbestos worldwide. However, this type of asbestos cannot be said to be safe to use, because it can still cause asbestos-related diseases (Frank & Joshi, 2014). The fibers that make up amphiboles are more brittle, straight like needles, and stiff, which is less soluble and straight compared to serpentine fibers, so they are more toxic. Amphibole fibers can align themselves with air flow and penetrate the epithelium to reach deeper into the lung and interstitium (Bhandari et al., 2023).

### *2.2 Asbestosis*

Determining the diagnosis of asbestosis of course through various supporting examinations. On visual examination, there was pleural effusion and local fibrous plaque on the diaphragm and lateral surfaces of the lungs which indicated significant thickening of the visceral pleura. In the section, diffuse fibrosis was clearly visible in the lower lobes of the lung (J et al., 2020). In addition, the initial radiographic criteria for asbestosis are opacification, irregularity or reticularity especially at the base of the lungs, the presence of adjacent peribronchiolar and alveolar interstitial fibrosis, and, sometimes, a honeycomb appearance, thickening of the pleura. Meanwhile, on a more sensitive CT scan, more advanced features of fibrosis such as honeycomb cysts can be found (Cha, Kim, Kim, & Kim, 2016). Furthermore, in cases diagnosed with asbestosis, on radiological examination a ground glass shadow appeared and was accompanied by bilateral pleural thickening and on the CT scan a slight honeycomb appeared and most of it was a glass shadow, whereas on pathological examination the honeycomb was found to be small and atypical (Kishimoto et al., 2011). In cases of asbestosis, the results of histopathological examination show fibrosis accompanied by the presence of asbestos bodies in the walls of the respiratory bronchioles and their surroundings, and severe fibrosis accompanied by a honeycomb appearance in the lungs (Kishimoto et al., 2011).

### *2.3 Construction Environment*

The construction sector is the sector with the highest rate of work accidents, work-related diseases and work-related deaths, where this sector accounts for more than 30% of deaths from all work sectors (Newaz, Davis, Jefferies, & Pillay, 2018). Not only are they exposed to dangerous equipment, machines and situations, but construction workers also have a high risk of occupational diseases caused by physical factors such as noise, vibration and heat stress; chemical factors such as aerosols, gases, and vapors; and ergonomic factors including manual handling, unergonomic body positions, excessive force exertion, and repetitive movements (Jazari et al., 2018).

This sector also involves low-paid workers who are vulnerable to occupational health hazards and thus experience exposure to hazardous substances, which have the potential to cause serious negative impacts on health and occupational diseases in construction workers (Gupta, 2021). There are studies that show several occupational diseases in the construction sector, including musculoskeletal disorders, eye diseases, skin diseases, mental disorders, hearing disorders, respiratory disorders and fall injuries (Jazari et al., 2018; Lette, Ambelu, Getahun, & Mekonen, 2018). One of the occupational diseases in the construction sector that causes respiratory problems is asbestosis, the main cause of which is cumulative asbestos exposure.

## 3. Methodology

The narrative review method was used to conduct this study. The narrative review or traditional literature review method aims to collect, study, compile and provide a general description of the research topic (Li & Wang, 2018), in this case related to asbestos exposure in construction workers and the risk of asbestosis in these workers. In conducting a literature search, we conducted a comprehensive search in the following databases: PubMed, Scopus, ScienceDirect, and Google Scholar.

During selecting studies, we applied inclusion criteria in the form of Indonesian and English-based articles, peer-reviewed articles, but limitations on year of publication and type of article were not applied in study selection. There are several stages in conducting this review, based on the guidelines for conducting a narrative review (Paul & Barari, 2022; Snyder, 2019), namely designing the study, conducting, analyzing, and finally structuring and writing the literature review manuscript.

## 4. Result and discussion

Asbestos exposure consists of three forms, namely direct exposure originating from the work environment and occurring in workers, including construction workers; bystander exposure is common in certain occupations, such as electricians, bricklayers, and painters; as well as the most common public exposure and is found in users of asbestos in residential buildings, road surfaces, playgrounds, rubbish dumps, and chemical paints (J et al., 2020). In construction workers, exposure to asbestos can come from materials that contain asbestos, including duct and pipe insulation, cement, wall coverings, floors, roofs, and in sealants, caulks, glass, water tanks, chimneys, and gutters (Campopiano et al., 2021; Franzblau et al., 2020).

Asbestosis will occur if workers are exposed to high levels of exposure. At low levels of exposure, workers may experience mild fibrosis (Wolff, Vehmas, Oksa, Rantanen, & Vainio, 2015). A previous study suggested that the cumulative asbestos exposure dose for the occurrence of asbestosis was estimated at 25 fibers(f)/ml-year (Dupré & commissioner, 1984) and other research stated that a dose in the range of 25-100 f/ml-year was needed for the development of asbestosis (AM., 1988; Browne, 1986). However, as time goes by, several cases summarized in research conducted by show a decrease in the dose required for the development of asbestosis, detected with exposure of 10-20 f/ml-year and there are also cases where cumulative asbestos exposure is found below 10 f/ml-year (Roggli et al., 2010). In addition, inhaled fibers have special criteria, according to NIOSH, a fiber length of >5 μm with a length-to-width aspect ratio of ≥3. However, according to the Asbestos International Association, apart from fiber length >5 μm and ratio ≥3, fiber width must also be <3 μm (Mossman et al., 2011).

Apart from the main cause of exposure to asbestos, the development of asbestosis is also exacerbated by other factors, including genetic factors (Franko, Dolžan, Arnerić, & Dodič-Fikfak, 2013; Ugolini et al., 2008), construction and petrochemical workers (Ross, 2003), workplace and environmental factors (Baumgartner et al., 2000), including cigarette smoke, wood dust, metal dust, sand or silica, and agricultural exposure (Gulati & Redlich, 2015), gender, age and physiological factors (Keskitalo, Salonen, Vähänikkilä, & Kaarteenaho, 2021), as well as active smokers (Franko et al., 2013; Khatab et al., 2014). In addition, deaths caused by asbestos are also influenced by several factors such as age, gender, household exposure, asbestos-related cumulative non-malignant diseases, and malignant pathology (Abós-Herràndiz et al., 2017). Therefore, it can be concluded that asbestosis in construction workers does not immediately occur once exposed to asbestos fibers, but requires cumulative asbestos exposure that occurs over a long duration of time, and can be exacerbated or influenced by other factors. Apart from that, smoking is also a factor that can worsen the condition of asbestosis, leading to malignancy.

Regarding pathophysiology, asbestos exposure causes asbestosis if asbestos fibers are inhaled and enter the lungs, which will then cause a foreign body reaction, consisting of activating the local lung immune system and triggering an inflammatory reaction. Macrophages migrate to the fiber deposition site within one day and carry out phagocytic activity against asbestos fibers and stimulate fibroblasts with the aim of storing connective tissue. However, macrophages ultimately die due to the resistance of asbestos fibers to digestion, resulting in the release of cytokines and further attracting macrophages and fibroblastic cells to form fibrous tissue, which ultimately forms a fibrous mass and causes interstitial fibrosis (Matsuzaki et al., 2012; Mossman et al., 2011; Norbet et al., 2015).

The work environment in the construction sector is quite challenging and the most dangerous compared to other sectors (Timofeeva, Ulrikh, & Tsvetkun, 2017) due to long working hours, conflicts, heavy work hours and work schedules, dangerous work, and exposure to hazards from the work environment,

with one of these dangerous exposures coming from asbestos which has a negative impact on health (Boadu, Okeke, Boadi, Bonsu, & Addo, 2023; Ghani & Ridho, 2024; Gulzar, Hassan, & Gulzar, 2022). Construction workers are the occupation most at risk of asbestos exposure and there is an increased risk of asbestosis and increased death due to cumulative asbestos exposure (Luberto et al., 2019).
Proven by research conducted in England which found 160 cases of asbestosis in 2001-2015, with 44% of asbestosis cases occurring in workers in the construction sector, which is the highest compared to other sectors (Walters, Robertson, Bhomra, & Burge, 2018). A clinical study stated that 44.3% of workers exposed to asbestos showed symptoms of asbestosis (Horska et al., 2006). Furthermore, workers with asbestosis who are exposed to chrysotile asbestos have a high mortality rate from lung cancer (Zhong, Eiji, Zhi-Ming, Mian-Zhen, & Ya-Jia, 2008). Regarding deaths due to asbestosis, research in the UK found that the standardized death ratio for workers exposed to asbestos and experiencing asbestosis was 51.3 (Harding & Darnton, 2010). In research conducted in Canada which included 2.18 million workers and 737 cases of asbestosis from 1983 to 2014, it was stated that construction work had a higher incidence of asbestosis compared to other jobs (HR=3.64; 95% CI=3.11-4.25) (DeBono et al., 2021). Compared to workers in sectors or industries other than construction, workers in the construction sector have a very high risk of exposure to asbestos originating from construction materials and have the possibility of developing asbestosis if this occurs over a long period of time and is accompanied by other factors. Asbestosis in workers also has the opportunity to become more severe and can lead to death. Thus, it may be inferred that there is a strong correlation between asbestos exposure and a higher incidence of asbestosis among construction workers.

In examining air samples from construction workers at the demolition of old houses in Iran using phase-contrast optical microscopy (PCM), scanning electron microscopy (SEM) and polarized light microscopy (PLM), results showed that asbestos fiber levels showed a range of 0.01-0.15 PCM f/ml and 0.02-0.42 SEM f/ml, while the geometric calculation results were 0.07 PCM f/ml and 0.20 SEM f/ml, which the results are far above the threshold value of the American Conference of Governmental Industrial Hygienists, namely 0.1 f/ml (Kakooei & Normohammadi, 2014). In Alaska, similar research on a construction project in the form of road construction that monitored breathing zone air found that 3% of samples detected exposure approaching 0.1 PCM f/cc and 36 PCM samples underwent transmission electron microscopy (TEM) analysis and showed that around 40% of the fibers were asbestos (Perkins, Hargesheimer, & Vaara, 2008). This shows, in accordance with previous studies, that construction sites have high asbestos exposure and are dangerous for workers' health, especially negatively impacting respiratory conditions.

Regarding the negative impacts resulting from cumulative exposure to asbestos, primary prevention for construction workers is very crucial. Construction workers, especially those working in environments with a risk of asbestos exposure, must strictly and regularly use international standard respiratory protective equipment. In addition, workers must be introduced to the necessary tools such as installing detectors to prevent wider environmental contamination from exposure to asbestos and silica. No less important, the use of adequate and appropriate personal protective equipment while working on construction sites, as well as the existence of health inspectors and routine assessments of the level of exposure to pneumoconiosis risk factors and the status of construction workers must be implemented routinely (Kunpeuk et al., 2021).

Apart from preventing workers while working, there are also techniques for managing and handling materials containing asbestos which are very important to implement. One method that can be used to manage asbestos exposure is by removing asbestos, if possible, or by control measures, such as covering the material before removal, spraying with sealants, penetrative locking encapsulants, and physical coverings with controlled air flow to contain the resulting fibers (Bolan et al., 2023). Furthermore, asbestos waste can be disposed of by physical, chemical, biological degradation methods, and by asbestos landfilling or underground storage (Staroń, Kijania-Kontak, Kozak, & Banach, 2020). So, if removing asbestos is not possible, then control measures must be taken to prevent the spread of asbestos fibers into the surrounding environment and increase the risk of increased accumulation of inhaled asbestos fibers. With routine prevention and supervision at construction sites, asbestos exposure is expected to decrease and so will the risk of developing diseases related to asbestos exposure in workers.

## 5. Conclussion

We finally concluded from the results of this review that many materials in the construction sector contain asbestos and have the potential to spread asbestos fibers into the air and can be inhaled by workers. Cumulative asbestos exposure that occurs in high doses and over a long period of time will cause an increased risk of asbestos-related diseases, including asbestosis. The construction sector is the highest, compared to other sectors or industries, to be exposed to asbestos and has a high number of asbestosis cases. So it is necessary to provide precautions for workers, such as the use of adequate personal protective equipment of international standards, the presence of health inspectors and routine checks on workers' health, as well as management of materials or construction waste that contain asbestos.

This study is limited to only describe generally regarding exposure to asbestos-containing materials and the increased risk of asbestosis in construction workers. Future research regarding further analysis of causal factors, management and prevention of asbestos exposure, as well as case reports and mapping of asbestosis cases, especially in Indonesia where related research is still very limited, may be warranted.

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