

## LITERATURE REVIEW

# The Impact of Viscose Rayon Fiber Exposure on Lung Function

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## ABSTRACT

Viscose rayon fiber is a semi-synthetic material derived from regenerated cellulose. The cellulose used to make viscose rayon is extracted from natural sources, resulting in fibers that are physically similar to cotton and have characteristics such as softness and high absorbency. The viscose manufacturing process involves chemical modification of cellulose using carbon disulfide (CS<sub>2</sub>), which is dangerous if exposed to humans. Carbon disulfide residues, along with endotoxin biological agents present on rayon fibers, can be inhaled into the respiratory tract. This causes oxidative protein damage, which then activates the oxidative stress response. This response ultimately results in the release of oxidants that induce inflammatory mediators, triggering acute or chronic inflammatory reactions in the airways and alveoli, resulting in decreased lung function. A systematic approach is essential for gathering and interpreting relevant data. This approach can be organized into seven steps to diagnose occupational lung diseases. The use of personal protective equipment (PPE) represents the final but most important defense. Recommended PPE includes respirator masks with suitable particle filters, protective eyewear to prevent eye irritation, chemical-resistant gloves to protect the skin from direct contact, and full-body work clothing.

## INTRODUCTION

Globally, agricultural land produces only approximately 2.5% of the cotton harvest, leaving a significant gap between the demand for and supply of this textile fiber.<sup>1</sup> In response to the growing need for alternative fibers and the environmental concerns associated with non-biodegradable synthetic polymers, rayon fibers have emerged as a promising substitute.

Rayon, particularly viscose rayon, is produced using chemicals that pose serious health risks, especially to workers with prolonged exposure. Exposure to rayon fibers at various stages of textile production can have adverse effects on lung health. This issue is critical, considering that approximately 60% of the textile industry relies on rayon as an alternative to silk.<sup>1,2</sup>

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Boccia (2024) highlighted that fibers are among the most common materials found in the environment.<sup>3</sup> A study by Chung, *et al.* (2017) in Korea revealed alarming health outcomes among 633 former workers exposed to carbon disulfide (CS<sub>2</sub>), a chemical used in rayon production.<sup>4</sup> The findings showed that 69.2% suffered from hypertension, 13.9% from coronary artery disease, 24.8% from cerebrovascular conditions, 24.5% from diabetes, 1.3% from psychological disorders, and 65.7% from nervous system disorders.<sup>4</sup> Additionally, Nafees (2023) found that respiratory disorders affected 3% of textile workers, a rate that exceeds the occupational health standard of less than 1%.<sup>5</sup>

Respiratory failure can manifest as acute or chronic, each with specific clinical characteristics. Acute respiratory failure develops suddenly, often with severe and life-threatening symptoms, while chronic respiratory failure develops more gradually and may not be immediately apparent during clinical evaluation. Among the various types, hypoxemic respiratory failure is more common than hypercapnic respiratory failure. This literature review explored the definition, causes, underlying mechanisms, clinical signs, diagnostic procedures, and management strategies for type 1 respiratory failure. Carbon disulfide, a chemical used in

dissolving wood cellulose to make pulp for rayon production, has been associated with adverse respiratory effects, particularly in cases of asthma.<sup>6</sup> Understanding the mechanisms by which viscose rayon affects lung function and developing effective countermeasures is essential. This review aimed to provide a comprehensive overview of the factors associated with rayon fibers that influence lung exposure and their potential health consequences.

## REVIEW

### VISCOSE RAYON

Viscose rayon is a type of semi-synthetic fiber made from regenerated cellulose. The cellulose used in its production is sourced from natural materials, resulting in fibers that have physical properties similar to cotton. In recent years, viscose rayon has become increasingly integrated into the global textile sector. Textile products are generally made from fibers that fall into two categories: natural and synthetic. Natural fibers are obtained from plants and animals, including materials such as cotton, wool, linen, and silk. In contrast, synthetic fibers are engineered by humans.<sup>7,8</sup>

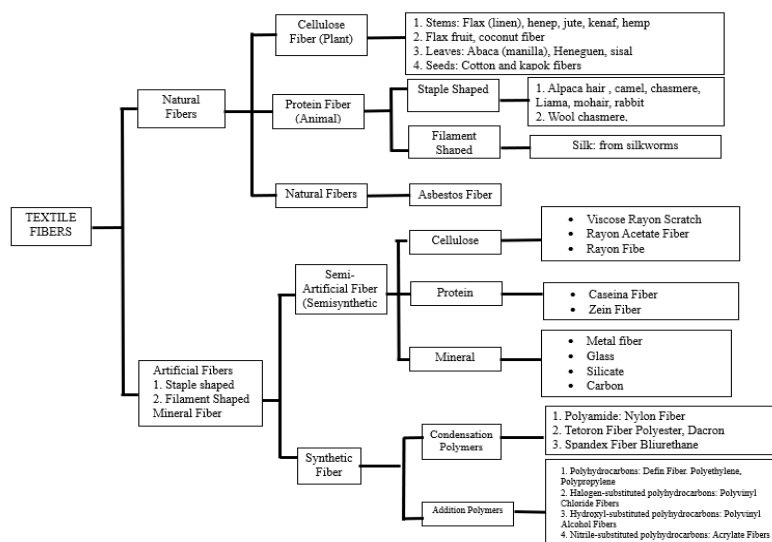


Figure 1. Types of fibers<sup>9</sup>

### CHARACTERISTICS OF VISCOSE RAYON FIBER

Textile products are made from a variety of fibers, which are generally categorized into two main types: natural and synthetic. Natural fibers are obtained from plants or animals, while synthetic fibers are created through human innovation using a variety of materials. Figure 1 provides examples of natural and synthetic fibers. Natural fibers include common materials such as cotton, wool, linen, and silk. Synthetic fibers, on the other hand, are further divided into three categories:

fibers derived from natural polymers such as viscose rayon, modal, and lyocell; fibers produced from synthetic polymers such as polyester, nylon, acrylic, and spandex; and fibers composed of inorganic substances, including metals.<sup>9,10</sup>

Viscose rayon fibers, measuring 12–40 microns, are soft, highly absorbent, and blend well with other fibers. They are resistant to static electricity, but are susceptible to tearing and color fading. Despite environmental concerns related to the use of chemicals such as CS<sub>2</sub>, continuous improvements have enhanced

their strength, flame resistance, and antibacterial properties, making them widely used in the textile industry.<sup>11,12</sup>

Viscose rayon is often compared to cotton due to its similar characteristics. However, there are key differences between the two. Cotton is a natural fiber that requires relatively simple processing to produce textiles, while rayon involves a more complex production process. In addition, cotton cultivation has a significant environmental impact, mainly due to the extensive use of pesticides, which can cause considerable ecological damage. This environmental burden has led to the increasing use of viscose rayon fiber as an alternative.<sup>8,13</sup>

## VISCOSE RAYON FIBER PRODUCTION PROCESS

The viscose process remains the predominant technique globally for extracting fiber from cellulose. This method was pioneered in 1891 by Charles Cross, Edward Bevan, and Clayton Beadle, who discovered that cellulose from cotton or wood could be converted

into cellulose xanthate using alkali and CS<sub>2</sub>. In 1898, the viscose production process involved transforming the viscose solution into yarn through coagulation with various solvents, including alcohol, brine, ammonium sulfate, chloride, and other coagulants. Paul Koppe, in 1904, enhanced the process by patenting a rotary bath containing a mixture of sulfuric acid and dissolved salts.<sup>14,15</sup>

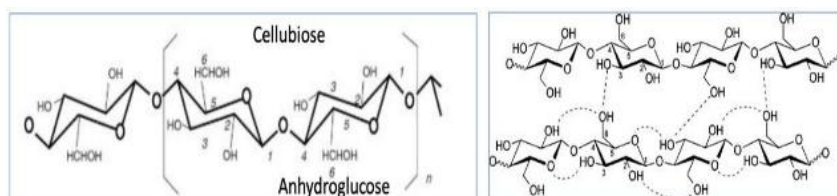
The commercialization of viscose fiber began in 1905 by the British company Samuel Courtauld & Company, followed by production in the United States (US) in 1911 by the American Viscose Corporation. Significant advancements in rayon fiber technology were made in 1947. The viscose process, which chemically modifies cellulose using CS<sub>2</sub>, a substance that poses health risks with prolonged exposure, remains at the core of rayon fiber production. Cellulose, derived from hardwood, softwood, and non-wood sources, is the primary raw material. Among these materials, hardwood fibers, known for their length, are particularly suitable for cellulose production. A detailed list of materials used in cellulose production is presented in Table 1.<sup>8,15-17</sup>

**Table 1.** Types of materials and percentage of raw material yield<sup>17</sup>

| Basic Material  | Cellulose (%) | Hemicellulose (%) | Lignin (%) |
|-----------------|---------------|-------------------|------------|
| Hardwood        | 43-47         | 25-35             | 16-24      |
| Coniferous wood | 42-50         | 24-34             | 15-22      |
| Sugarcane pulp  | 40            | 30                | 30         |
| Corn stalk      | 37            | 25                | 35         |
| Wheat           | 43.7          | 23                | 22.3       |
| Paddy           | 43            | 25                | 16         |
| Cheese          | 46            | 32                | 12         |
| Bamboo fiber    | 48            | 26                | 18         |

Cellulose is the most common polysaccharide found in plant cell walls. This complex molecule consists of two D-glucose units joined by a beta-1,4 ( $\beta$ -1,4) glycosidic bond, with a degree of polymerization potentially up to 10,000 glucose units. The term “degree of polymerization” refers to the number of glucose units in a single cellulose chain. In cellulose, the free

hydroxyl groups located at positions 2, 3, and 6 are capable of forming intra- and intermolecular hydrogen bonds. These hydrogen bonds facilitate the formation of microfibrillar structures, which are essential for providing mechanical strength and chemical stability to cellulose, as illustrated in Figure 2.<sup>17,18</sup>



**Figure 2.** Chemical structure of cellulose<sup>18</sup>

Cellulose is converted into a special form known as soluble pulp, which is derived from softwoods and hardwoods. Soluble pulp is characterized by high alpha-cellulose content, excellent brightness, and better resistance to alkaline conditions. The production of this pulp involves several important steps: debarking, cutting, and pulping. Debarking removes the outer bark

from the wood, which also reduces its moisture content, making it easier to process in the subsequent stage. Cutting involves slicing the wood into smaller fragments using sharp metal tools, which are then further processed into sawdust. This step is very important because it affects the quality of the pulp before it undergoes further processing.<sup>12,19</sup>

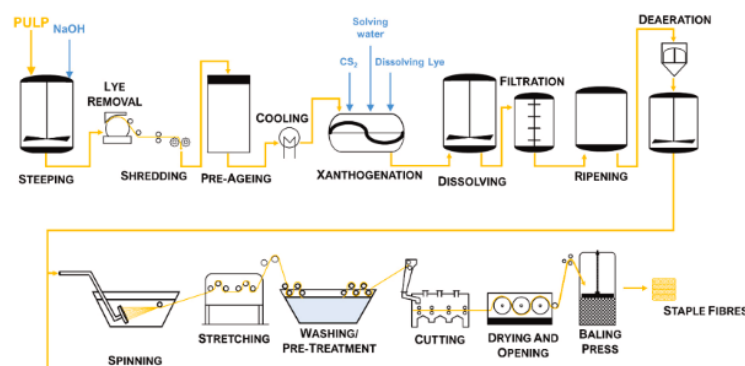
The pulping process is the most crucial stage in the production of viscose rayon fiber. This stage focuses on the separation of cellulose fibers from other wood components, which are the main raw materials for fiber production. The pulping process can be performed through mechanical, chemical, or semi-chemical methods. Unlike the mechanical pulping process, the chemical pulping process has a more significant impact by substantially reducing energy consumption, although it also affects the quality of the final product and increases production costs. The semi-chemical process, which combines mechanical and chemical methods, produces soluble pulp with high alpha-cellulose content, excellent brightness, and strong alkali resistance.<sup>20</sup>

Initially, mechanical pulping involved grinding the fibers to produce coarser, lower-quality cellulose. Advances in chemical pulping began with the discovery by Watt and Burgess in the mid-19<sup>th</sup> century, who demonstrated that lignin could be removed from wood using sodium hydroxide (NaOH) at high temperatures. This led to the development of the sulfite and kraft pulping processes in 1866 and 1879, respectively. Chemical pulping involves pre-cooking the wood chips

and subsequently using the sulfite or sulfate process to dissolve the lignin, separating it from the cellulose.<sup>20</sup>

The semichemical process, which is mainly used to produce crude pulp for paper manufacturing, separates cellulose fibers from lignin. The sulfate process is preferred over the sulfite process due to its superior alkali recovery and more effective handling of pollutants during the pulping process. The resulting pulp then undergoes the viscose process, which combines NaOH and CS<sub>2</sub>. Figure 3 illustrates the complex stages of viscose rayon production, including alkalization, pressing, shredding, aging, xanthation, dissolving, ripening, spinning, washing, and refining.<sup>8,20</sup>

In the initial stage, alkalization involves soaking the pulp in a 17-20% NaOH solution at a temperature of around 18°C. This step produces alkali cellulose, breaks hydrogen bonds between cellulose molecules, changes the crystal structure, and removes impurities from the pulp. It also helps dissolve hemicellulose. The following pressing stage removes excess NaOH solution and dissolved short-chain cellulose, aiming to achieve a ratio of 2.7-3.0 before air-drying the pulp.<sup>9,18</sup>



**Figure 3.** Pulp conversion process into viscose fiber<sup>8</sup>

Each stage in the production of viscose rayon fiber contributes to the quality of the final product. However, it also poses health risks due to exposure to chemicals such as CS<sub>2</sub>. These risks primarily affect the respiratory health of workers and the environment. Therefore, the implementation of strict occupational safety measures and effective chemical management is the key to minimizing negative impacts and ensuring safer and more sustainable production.<sup>21</sup>

## IMPACT OF VISCOSE RAYON FIBER EXPOSURE ON LUNG FUNCTION

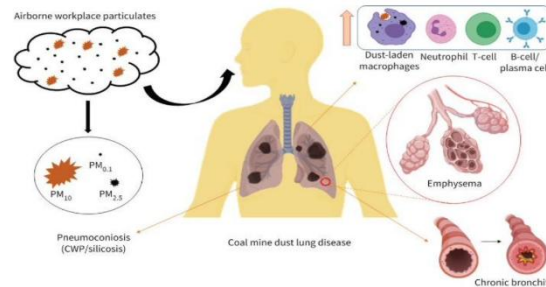
In daily life, humans encounter various materials made from natural and synthetic fibers, which are widely used in health-related products and textiles. A study by Dris (2016) identified the presence of artificial fibers in the air, indicating that the atmosphere around us may contain particles that can pose health risks.<sup>22</sup> The

potential impact of viscose fibers on lung health may come from the raw materials of the fibers or the chemicals used during the viscose rayon production process.<sup>6,22,23</sup>

A study by Cao (2024) highlighted that fibers produced by the textile industry can have adverse effects on lung health not only through prolonged exposure but also due to the structural properties of the fibers.<sup>23</sup> Even small particles of these fibers can be inhaled and reach the proximal alveolar pathway. In these airways, the fibers pose a significant risk, potentially contributing to severe conditions such as pulmonary fibrosis or lung cancer. Furthermore, the accumulation of rayon fibers can trigger a series of inflammatory responses, oxidative stress, and cell death, particularly affecting the respiratory tract.<sup>23,24</sup> Rayon fiber particles that penetrate the lungs can accumulate through three main mechanisms. The first mechanism is inertial impaction,

where particles are transported by airflow through curved airways that fail to follow the airflow and instead settle in certain areas. The second mechanism is sedimentation, which occurs when the airflow velocity drops below 1 cm/s, causing particles to fall out of the air due to gravity.<sup>11</sup> The third mechanism is Brownian motion, where particles move irregularly in the airstream and come into contact with the alveoli, causing deposition.

Larger particles tend to settle in the upper airways, while smaller particles penetrate deeper and settle in the alveoli. Figure 4 illustrates the process of dust accumulation in the lungs, highlighting how different parts of the respiratory system react to particles, often resulting in lung disorders. This occurs because the smooth muscles around the airways are stimulated, causing them to narrow. Prolonged and elevated levels of exposure can also trigger occupational asthma.<sup>11</sup>



**Figure 4.** Process of particle accumulation in the lungs<sup>11</sup>

The production of viscose rayon fibers uses CS<sub>2</sub>. Long-term exposure to CS<sub>2</sub> can cause a variety of serious health problems, including adverse effects on the skin, eyes, reproductive system, nervous system, endocrine system, cardiovascular system, and respiratory system. Short-term exposure can cause skin irritation. For instance, the Agence Nationale de Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail (ANSES) has reported that workers exposed to CS<sub>2</sub> often suffer from severe small blisters.<sup>25</sup> In addition, CS<sub>2</sub> exposure can irritate the eyes and cause damage to the central and peripheral nervous systems, leading to conditions such as neuropathy, which is characterized by axonal demyelination, neurobehavioral changes, polyneuropathy, and motor system disorders.<sup>20,25</sup>

Cardiovascular effects of CS<sub>2</sub> exposure include disturbances in cardiac function and structure, such as myocardial necrosis or arteriosclerosis, which are often associated with cholesterol accumulation and protein damage. In terms of reproductive health, CS<sub>2</sub> exposure can reduce testosterone levels, cause damage to sperm morphology, reduce sperm viability, and decrease antioxidants in semen. In the endocrine system, CS<sub>2</sub> causes increased hypothalamic activity, which boosts steroid metabolism and raises low-density lipoprotein levels in the blood. Concerning the respiratory system, CS<sub>2</sub> exposure is associated with decreased lung function.<sup>25,26</sup>

Although CS<sub>2</sub> is not classified as a carcinogen, high levels of exposure, particularly in the context of viscose fiber production, pose significant health risks. Carbon disulfide residues attached to viscose fibers can be inhaled, leading to oxidative protein damage and subsequent oxidative stress responses. These responses

releases oxidants that trigger inflammatory mediators, leading to inflammation, particularly in the lungs. Over time, such inflammation can lead to decreased lung function, as illustrated in Figure 5.<sup>6,24,27</sup>

The various stages of viscose fiber production expose workers to risks of lung dysfunction. The first stage involves exposure during the dissolving and washing phases, in which CS<sub>2</sub> is used. The second stage occurs during the spinning of pre-processed viscose rayon fibers. The final product is then used in textile manufacturing for further distribution. Carbon disulfide exposure poses several pathological risks, including chronic lung inflammation and impaired gas diffusion, as well as potential cardiovascular problems such as ischemic heart disease and arrhythmias.<sup>28</sup>

Moreover, exposure to CS<sub>2</sub> and endotoxins during the production of viscose rayon fibers can have significant impacts on respiratory health. Inhalation of carbon disulfide over prolonged periods can cause various health problems, affecting multiple systems in the body, including the skin, eyes, reproductive organs, nervous system, endocrine system, cardiovascular system, and respiratory system. Short-term exposure can cause skin irritation and other acute symptoms, while chronic exposure can lead to severe conditions such as neuropathy and cardiovascular disorders.<sup>20,25</sup>

Endotoxins, which are lipopolysaccharides found in the outer membrane of Gram-negative bacteria, present another concern. These toxins, found in cotton dust, can cause acute and chronic respiratory problems if inhaled. Studies have shown that endotoxin levels in viscose rayon production can trigger inflammatory reactions in the lungs, leading to decreased lung function. For example, high levels of endotoxin have



been detected in certain textile mills, while others have reported lower levels. However, regulations or guidelines that address endotoxin levels in cotton dust remain limited. The risk of endotoxin exposure is particularly high during the spinning and weaving stages of viscose rayon production. During these stages, impurities are removed from the cotton, which increases dust concentrations. Poor working conditions, such as high humidity, inadequate ventilation, and suboptimal machinery, exacerbate this problem. The quality of the viscose material and the method for endotoxin sampling can also affect the levels detected.<sup>28</sup>

Pulmonary function tests are essential to assess the impact of endotoxin exposure on respiratory health. These tests measure forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). Reductions in these measurements may indicate restrictive, obstructive, or mixed lung function disorders. Decreased FVC characterizes restrictive disorders, while obstructive disorders are characterized by reduced FEV1 and FVC. Mixed disorders involve both restrictive and obstructive features.<sup>28,29</sup>

A study in Tulungagung, East Java, has demonstrated a significant association between elevated endotoxin levels and reductions in FEV1 and FVC among textile workers.<sup>28</sup> Similarly, studies in Daran, Iran, and Pakistan have reported increased cases of obstructive and restrictive pulmonary dysfunction among workers exposed to endotoxins.<sup>30,31</sup> Symptoms such as coughing, sneezing, and shortness of breath can progress to more severe conditions, such as byssinosis, with prolonged exposure.<sup>30,31</sup>

Endotoxin levels can be measured using the limulus amebocyte lysate (LAL) test, which detects lipopolysaccharides from Gram-negative bacteria. These endotoxins, if inhaled, can have adverse health effects, similar to the impact of tobacco exposure. High levels of endotoxins in viscose dust are associated with decreased FVC and FEV1 levels, indicating impaired lung function.<sup>32</sup>

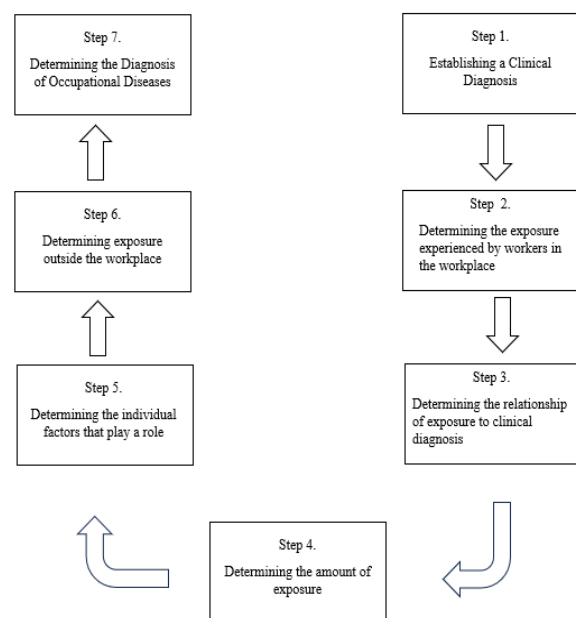
Both age and duration of employment are contributing factors to the risk of lung dysfunction. More prolonged exposure to endotoxins and age-related declines in respiratory function can worsen the impact. Workers over the age of 50 have a higher risk of developing obstructive pulmonary dysfunction compared to those under the age of 40, as shown by studies in Ethiopia.<sup>31,33</sup>

## DIAGNOSTIC APPROACH

Healthcare providers should thoroughly assess patients with respiratory symptoms potentially associated with viscose rayon fiber exposure. This evaluation includes a detailed history of the patient's

illness, occupational background, and daily activities. Key points include identifying hazardous substances at work, smoking habits, symptom progression, and the correlation between symptoms and the duration, timing, and location of exposure. Understanding these factors helps determine the connection between occupational exposure and respiratory health issues.<sup>4</sup>

A structured methodology is essential for collecting and interpreting this information, outlined in a seven-step framework as illustrated in Figure 5. This process includes: diagnosing the lung condition clinically, identifying the type of workplace exposure, establishing a relationship between the exposure and the clinical diagnosis, assessing the level of exposure, identifying personal factors involved, evaluating exposures outside the workplace, and confirming the diagnosis of occupational lung disease. The initial step consists of establishing a clinical diagnosis of lung disease through a complete history, physical examination, and additional testing. The history should include current health problems, past medical conditions, employment history, and lifestyle.<sup>34</sup>



**Figure 5.** Seven steps in the diagnosis of occupational lung disease<sup>34</sup>

When evaluating patients exposed to viscose rayon fibers, healthcare providers must conduct a thorough assessment, beginning with a detailed exploration of the patient's medical and occupational history. This history should include information about lifestyle factors such as smoking habits, as well as any record of previous respiratory conditions. Common symptoms to be identified include cough, sputum production, shortness of breath, and chest pain. To support the anamnesis, a focused physical examination of the respiratory system must be performed carefully,

along with supporting diagnostic tests such as spirometry and radiology to help establish a diagnosis or rule out other possible diseases. The second step involves investigating occupational exposure factors. This includes documenting the patient's employment history, specifying the duration of each role, the tasks performed, the materials handled, and the levels of exposure to potentially hazardous substances.

Reviewing Material Safety Data Sheets (MSDS) and analyzing symptom patterns that correlate with specific job tasks or exposure levels are essential parts of this stage. The third step focuses on establishing a causal relationship between exposure and the clinical condition observed. At this point, it is necessary to conduct a literature review and examine available scientific evidence to assess how exposure to viscose rayon fibers, or related chemicals, could lead to the respiratory disorders identified. The fourth step is to evaluate the level of exposure by determining either a qualitative or quantitative threshold limit value (TLV).

The TLV specifies the maximum acceptable exposure level during a standard work period of eight hours a day or 40 hours a week. The fifth step assesses individual factors, including the patient's compliance with the use of personal protective equipment (PPE), previous exposure history, and relevant family medical history, all of which may influence susceptibility to occupational diseases. The sixth step expands the evaluation to include potential non-occupational exposures, such as hobbies, household activities, or side jobs, which might also contribute to respiratory health problems. Finally, the seventh step is diagnosing occupational lung disease based on the integration of all the data gathered from the previous steps and conducting additional diagnostic tests to confirm exposure to CS<sub>2</sub> or other relevant substances.<sup>35</sup>

To support the diagnosis of CS<sub>2</sub> exposure, several examinations can be conducted. Spirometry is commonly used to assess lung function, specifically measuring FVC and FEV<sub>1</sub>, to detect restrictive and obstructive lung disorders.<sup>24,28,36</sup> Radiological examinations such as chest X-ray or high-resolution computed tomography (HRCT) can reveal lung damage, including fibrosis and bronchial changes, due to CS<sub>2</sub> exposure.<sup>37,38</sup>

Blood tests help identify systemic effects of CS<sub>2</sub>, including assessment of liver and kidney function. A lung biopsy may be necessary to diagnose severe conditions if non-invasive tests are inconclusive, allowing direct assessment of tissue damage. Bronchial provocation testing can evaluate airway sensitivity to CS<sub>2</sub>, which can trigger bronchoconstriction and asthma symptoms in susceptible individuals.<sup>24,39</sup>

Measurement of CS<sub>2</sub> concentrations in the workplace environment using detection equipment such as spectrophotometers ensures compliance with TLV. Biological monitoring involves the analysis of biomarkers such as CS<sub>2</sub> in blood or its metabolites, such as 2-thiothiazolidine-4-carboxylic acid (TTCA) in urine, which indicate the level of exposure.<sup>6,25,38</sup>

## PREVENTION OF EXPOSURE TO VISCOSE RAYON FIBERS

Primary prevention aims to avert the onset of disease by implementing strategies to ensure worker safety and minimize the risk of accidental exposure. This stage prioritizes controlling exposure levels and enforcing effective safety protocols. To reduce the risk of occupational disease, early intervention is essential in identifying and addressing potential sources of exposure before they cause health problems.<sup>35</sup>

In primary prevention, technical measures play a central role. Effective ventilation systems and dust collection methods help reduce airborne fiber concentrations. Job rotation and work hour restrictions are additional strategies to reduce prolonged exposure. Personal protective equipment serves as an essential last line of defense, including items such as respirators equipped with appropriate filters, goggles to prevent eye irritation, chemical-resistant gloves to protect against skin contact, and full-body protective clothing.<sup>11,25,27</sup>

A review by Wang (2023) highlighted the importance of using masks with appropriate filtration capabilities to reduce dust exposure during viscose rayon production.<sup>40</sup> Recommended masks include cloth masks, surgical masks, N95 respirators, KN95 masks, and P100 respirators, each of which offers varying levels of particle filtration. Cloth masks filter particles as small as 20–30 microns, surgical masks block particles as small as 10–15 microns, and N95 masks are effective against particles around 0.1–0.3 microns. Mask selection should be based on the specific exposure levels at different stages of production.<sup>40</sup>

Workers need to be educated on the proper use and disposal of PPE, accompanied by regular health monitoring, such as lung function tests, to enable early detection of exposure-related effects. A comprehensive occupational health program, along with continuous education on safety and risk management, can significantly reduce the incidence of fiber exposure in the workplace.<sup>11,25,27</sup>

Secondary prevention focuses on the early detection and management of occupational diseases through trained healthcare providers, employer-led health surveillance, and exposure monitoring. Supportive policies and continued research are essential to validate prevention strategies and ensure fair

compensation and adequate care for workers.<sup>35</sup> According to Walkoff and Hobbs (2020), medical check-ups (MCU) play an essential role in secondary prevention by enabling periodic health assessments of workers, allowing for early identification of occupational health risks.<sup>41</sup> Regular MCU helps in detecting subclinical conditions before they develop into severe health issues, particularly for workers exposed to hazardous environments. Periodic MCU programs can significantly reduce the burden of occupational diseases by facilitating timely medical interventions.<sup>41</sup>

Tertiary prevention focuses on managing the complications and long-term impacts of existing occupational diseases. This includes medical rehabilitation to prevent further deterioration of the worker's health condition. Legislative measures may be needed to relocate affected workers to less hazardous roles and manage the socioeconomic impacts of their condition.<sup>35</sup>

## SUMMARY

Viscose rayon fiber, a semi-synthetic alternative to cotton, offers many benefits but involves the use of hazardous chemicals such as CS<sub>2</sub>, which can harm lung health with prolonged exposure. This exposure may trigger inflammatory reactions and reduce lung function. Diagnosing occupational lung disease requires evaluating symptoms, exposure, and risk factors. Prevention strategies involve three stages: primary (reducing exposure through ventilation and PPE), secondary (early detection via screenings), and tertiary (rehabilitation and medical care). Implementing these strategies is essential to protect workers and maintain a safe work environment.

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## Conflict of Interest

The authors declared there is no conflict of interest.

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## Authors' Contributions

Designing and determining the topic, conducting the literature search, analyzing and evaluating the literature, drafting the article, revising and editing: MK. Intellectual contribution and final approval: IE, SS.

## REFERENCES

1. Tlatlaa JS, Tryphone GM, Nassary EK. Unexplored Agronomic, Socioeconomic and Policy Domains for Sustainable Cotton Production on Small Landholdings: A Systematic Review. *Front Agron*; 5, <https://www.frontiersin.org/journals/agronomy/articles/10.3389/fagro.2023.1281043> (2023).
2. Berman D. Another Killer Industry: A Review of Fake Silk by Paul Blanc. *Int J Heal Serv* 2018; 48: 400–411. [Journal]
3. Boccia P, Mondellini S, Mauro S, *et al.* Potential Effects of Environmental and Occupational Exposure to Microplastics: An Overview of Air Contamination. *Toxics*; 12. Epub ahead of print April 2024. [PubMed]
4. Chung H, Youn K, Kim K, *et al.* Carbon Disulfide Exposure Estimate and Prevalence of Chronic Diseases after Carbon Disulfide Poisoning-Related Occupational Diseases. *Ann Occup Environ Med* 2017; 29: 52. [PubMed]
5. Nafees AA, Muneer MZ, Irfan M, *et al.* Byssinosis and Lung Health among Cotton Textile Workers: Baseline Findings of the MultiTex Trial in Karachi, Pakistan. *Occup Environ Med* 2023; 80: 129–136. [PubMed]
6. Song J, Wang D, Zhou M, *et al.* Carbon Disulfide Exposure Induced Lung Function Reduction Partly through Oxidative Protein Damage: A Cross-Sectional and Longitudinal Analysis. *J Hazard Mater* 2023; 454: 131464. [PubMed]
7. Singh S, Patra S, Khan AM. Health Care Services: Utilization and Perception among Elderly in an Urban Resettlement Colony of Delhi. *J Fam Med Prim Care* 2022; 11: 1468–1473. [PubMed]
8. Mendes ISF, Prates A, Evtuguin DV. Production of Rayon Fibres from Cellulosic Pulps: State of the Art and Current Developments. *Carbohydr Polym* 2021; 273: 118466. [PubMed]
9. Biantoro R, Purwita C. Review: Pembuatan Serat Rayon. *J Selulosa* 2019; 9: 51. [Journal]
10. Athey SN, Almroth BC, Granek EF, *et al.* Unraveling Physical and Chemical Effects of Textile Microfibers. *Water*; 14. Epub ahead of print 2022. [Journal]
11. Lestari M, Fujianti P, Novrikasari N, *et al.* Dust Exposure and Lung Function Disorders. *Respir Sci* 2023; 3: 218–230. [Journal]
12. Purwita C, Sugesty S. Pembuatan dan Karakterisasi Dissolving Pulp Serat Panjang dari Bambu Duri (*Bambusa blumeana*). *J Selulosa* 2018; 8: 21. [Journal]
13. Bae YJ, Jang MJ, Um IC. Silk/Rayon Webs and Nonwoven Fabrics: Fabrication, Structural Characteristics, and Properties. *Int J Mol Sci*; 23. Epub ahead of print July 2022. [PubMed]
14. Baker I. *Fifty Materials That Make the World*. Epub ahead of print 8 September 2018. [Book]
15. Zhang S, Chen C, Duan C, *et al.* Regenerated Cellulose by the Lyocell Process, a Brief Review of the Process and Properties. *BioResources* 2018; 13: 1–16. [Journal]
16. Cohen RA. The Ongoing History of Harm Caused and Hidden by the Viscose Rayon and Cellophane Industry. *American Journal of Public Health* 2018; 108: 1274–1275. [NCBI]



17. Li P, Xu Y, Yin L, *et al.* Development of Raw Materials and Technology for Pulping-A Brief Review. *Polymers (Basel)*; 15. Epub ahead of print November 2023. [PubMed]
18. Biswas SC. *Chemistry of the Viscose Process*. 2020. Epub ahead of print 31 October 2020. [ResearchGate]
19. Krilek J, Čabalová I, Výbohová E, *et al.* Assessment of the Chipping Process of Beech (*Fagus sylvatica* L.) Wood: Knives Wear, Chemical and Microscopic Analysis of Wood. *Wood Mater Sci Eng* 2024; 19: 473–484. [Journal]
20. Pratiwi W, Sugiharto A, Sugesty S. The Effect of Pulping Process Variable and Elemental Chlorine Free Bleaching on the Quality of Oil Palm Trunk Pulp. *J Selulosa* 2018; 8: 85. [Journal]
21. Gelbke HP, Göen T, Mäurer M, *et al.* A Review of Health Effects of Carbon Disulfide in Viscose Industry and a Proposal for an Occupational Exposure Limit. *Crit Rev Toxicol* 2009; 39 Suppl 2: 1–126. [PubMed]
22. Dris R, Gasperi J, Saad M, *et al.* Synthetic Fibers in Atmospheric Fallout: A Source of Microplastics in the Environment? *Mar Pollut Bull* 2016; 104: 290–293. [PubMed]
23. Cao Y, Shao L, Jones TP, *et al.* Anthropocene Airborne Microfibers: Physicochemical Characteristics, Identification Methods and Health Impacts. *TrAC Trends Anal Chem* 2024; 170: 117442. [ScienceDirect]
24. Prata JC, da Costa JP, Lopes I, *et al.* Environmental Exposure to Microplastics: An Overview on Possible Human Health Effects. *Sci Total Environ* 2020; 702: 134455. [PubMed]
25. Agence Nationale de Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail (ANSES). *Regulatory Management Option Analysis (RMOA)*. Maisons-Alfort, [https://www.consultations-publiques.developpement-durable.gouv.fr/IMG/docx/rmoa\\_carbon\\_disulfide\\_oct2022\\_vf2-clean.docx](https://www.consultations-publiques.developpement-durable.gouv.fr/IMG/docx/rmoa_carbon_disulfide_oct2022_vf2-clean.docx) (2022).
26. Guo Y, Ma Y, Chen G, *et al.* The Effects of Occupational Exposure of Carbon Disulfide on Sexual Hormones and Semen Quality of Male Workers From a Chemical Fiber Factory. *J Occup Environ Med* 2016; 58: e294-300. [PubMed]
27. Australia SW. *Workplace Exposure Standards for Airborne Contaminants*. Canberra, [https://www.safeworkaustralia.gov.au/sites/default/files/2024-01/workplace\\_exposure\\_standards\\_for\\_airborne\\_contaminants\\_-\\_18\\_january\\_2024.pdf](https://www.safeworkaustralia.gov.au/sites/default/files/2024-01/workplace_exposure_standards_for_airborne_contaminants_-_18_january_2024.pdf) (2024).
28. Umayiah C, Adriyani R, Savitri R. Exposure to Endotoxins as a Risk Factor for Decreased Lung Function in Workers in the Cotton-Based Textile Industry: (Literature Review). *J Kesehat Lingkung J dan Apl Tek Kesehat Lingkung* 2022; 19: 239–244. [Journal]
29. Nisa K, Sidharti L, Adityo MF. Pengaruh Kebiasaan Merokok terhadap Fungsi Paru pada Pegawai Pria di Gedung Rektorat Universitas Lampung. *JuKe Unila* 2015; 5: 38–42. [Journal]
30. Neghab M, Soleimani E, Nowroozi-Sarjoeie M. Pulmonary Effects of Intermittent, Seasonal Exposure to High Concentrations of Cotton Dust. *World J Respirol* 2016; 6: 24. [Journal]
31. Zele YT, Kumie A, Deressa W, *et al.* Reduced Cross-Shift Lung Function and Respiratory Symptoms among Integrated Textile Factory Workers in Ethiopia. *Int J Environ Res Public Health*; 17. Epub ahead of print April 2020. [PubMed]
32. Ghani N, Khalid A, Tahir A. Cross-Sectional Study on the Endotoxin Exposure and Lung Function Impairment in the Workers of Textile Industry Near Lahore, Pakistan. *J Pak Med Assoc* 2016; 66: 803–814. [PubMed]
33. Koohpaei A, Malakouti J, Arsang-Jang S, *et al.* Pulmonary Effects of Exposure to Synthetic Fibers: A Case Study in a Textile Industry in Iran. *Arch oh Hyg Sci* 2015; 4: 114–122. [Journal]
34. Ikhsan M. Prinsip-Prinsip Diagnosis Penyakit Paru Kerja. In: Rasmin M, Jusuf A, Yunus F, *et al.* (eds) *Buku Ajar Pulmonologi dan Kedokteran Respirasi*. Jakarta: UI Publishing, 2018, pp. 129–138.
35. Desdiani. *Penyakit Paru Akibat Kerja*. Bandung: CV. Media Sains Indonesia, [https://eprints.untirta.ac.id/24260/1/Buku Digital - Penyakit Paru Akibat Kerja.pdf](https://eprints.untirta.ac.id/24260/1/Buku_Digital_-_Penyakit_Paru_Akibat_Kerja.pdf) (2020).
36. Park D, Ha EK, Jung H, *et al.* Associations of Personal Urinary Volatile Organic Compounds and Lung Function in Children. *J Asthma* 2024; 61: 801–807. [PubMed]
37. Velasco E, Osumi Y, Teat SJ, *et al.* Fluorescent Detection of Carbon Disulfide by a Highly Emissive and Robust Isorecticular Series of Zr-Based Luminescent Metal Organic Frameworks (LMOFs). *Chemistry* 2021; 3: 327–337. [Journal]
38. Chalansonnet M, Carreres-Pons M, Venet T, *et al.* Effects of Co-Exposure to CS(2) and Noise on Hearing and Balance in Rats: Continuous versus Intermittent CS(2) Exposures. *J Occup Med Toxicol* 2020; 15: 9. [PubMed]
39. Yang L, Li C, Tang X. The Impact of PM2.5 on the Host Defense of Respiratory System. *Frontiers in Cell and Developmental Biology*; 8, <https://www.frontiersin.org/articles/10.3389/fcell.2020.00091> (2020).
40. Wang AB, Zhang X, Gao LJ, *et al.* A Review of Filtration Performance of Protective Masks. *Int J Environ Res Public Health*; 20. Epub ahead of print January 2023. [PubMed]
41. Walkoff L, Hobbs S. Chest Imaging in the Diagnosis of Occupational Lung Diseases. *Clin Chest Med* 2020; 41: 581–603. [PubMed]