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Work - Related Chronic Obstructive Pulmonary Disease

Biruk Getahun and Abebe Ayalew Bekel

Abstract

Chronic obstructive pulmonary disease (COPD) is a progressive lung disease characterized by airflow obstruction and increasing breathlessness. COPD is increasing worldwide, both in developed and developing countries. The most important risk factor of developing COPD is cigarette smoking; however, occupational exposures such as vapors, gases, dusts and fumes present an important risk factor for the development of the disease, by itself and through interaction with other risk factors. The dusts from coal, stone quarries, wood, cereals and agricultural work, animal stables, textiles, and paper production that can arise in occupational environments have been regulated by the International Labor Organization and considered possible as contributors to COPD. A better understanding of these causes paves the way for effective interventions to reduce the future incidence of this unpleasant condition. Breathlessness and occupational exposures to vapors, gases, dusts and fumes were identified as the main modifiable factors associated with unemployment and poor work productivity in COPD patients.

Keywords: occupational exposures, work place, air pollutions, airflow obstruction

1. Introduction

Chronic obstructive pulmonary disease (COPD) accounts worldwide for considerable and increasing morbidity and mortality [1].

COPD is a long-term respiratory disease which is not completely reversible and is characterized by airflow obstruction. For several months, the airflow obstruction does not alter markedly and is typically progressive. COPD is mainly caused by smoking [2]. Other factors, such as harmful dust and chemicals, can also contribute to the development of COPD, especially occupational exposure [3]. People with COPD often have exacerbations when symptoms are quickly and sustainably exacerbated beyond their normal regular variation. The prevalence of COPD has major regional differences and is closely correlated with levels of deprivation. The prevalence of COPD has not decreased in recent years, unlike many other prevalent chronic illnesses [2].

Early diagnosis and treatment will help to delay the deterioration in lung function and improve the amount of time people with COPD have to enjoy an active life. COPD is treatable but not curable. In spite of having only minimal or no effect on airflow obstruction, pharmacological and other therapies can help manage symptoms and disabilities caused by COPD and improve the quality of life of the individual [1].

2. Definition and description of COPD

COPD is a progressive lung disease, characterized by airflow limitation [4]. Chronic respiratory disease is generally divided into obstructive and restrictive conditions (**Figure 1**). The Global Initiative on Obstructive Lung Disease (GOLD) has recommended that obstruction should be defined as the ratio of the forced expiratory volume in 1 s (FEV1) to forced vital capacity (FVC) of <70% (**Table 1**).

Figure 1. Volume-time and flow-volume curves: A & B are volume – Time curves; C: Flow volume curve [5, 6].

Disease severity	GOLD staging	Spirometry criteria
Mild	GOLD 1	FEV ₁ /FVC < 0.70 FEV ₁ > 80% predicted
Moderate	GOLD 2	FEV ₁ /FVC < 0.70 50% < FEV ₁ < 80% predicted
Severe	GOLD 3	FEV ₁ /FVC < 0.70 30% < FEV ₁ < 50% predicted
Very severe	GOLD 4	FEV ₁ /FVC < 0.70 FEV ₁ < 30% predicted

Table 1. Global initiative for chronic obstructive lung disease (GOLD) classification disease severity staging [4].

If any of the FVC, FEV₁, PEF or FEV₁/FVC are outside the normal range, the presence of ventilator abnormality can be inferred. A reduction of FEV₁ would result in a low FEV₁/FVC in comparison to the forced vital capacity and is characteristic of obstructive ventilator defects. The lower limit of normal for FEV₁/FVC is around 70–75% but the exact limit is dependent on age. In restrictive ventilator defect the FEV₁/FVC ratio remains normal or high (typically >70%) with a reduction in both FEV₁ and FVC. A reduced FVC together with a low FEV₁/FVC ratio is a feature of a mixed ventilator defect in which a combination of both obstruction and restriction appear to be present [7, 8].

3. Occupational exposure and COPD

Associations between chronic respiratory symptoms and workplace exposures have been suggested as early as the 15th century, although documentation of the connection between ‘dusty trades’ and chronic bronchitis has been more prominent from the 19th century. The inconsistent definitions of COPD and unreliable measure of exposures have led to a delay in the recognition of the causal link between occupational exposures and COPD. However, over recent years strong associations have been found between particular occupational groups and exposures to vapors, gases, dusts and fumes (VGDF) and the development of COPD [4, 9].

Strong evidence implicates occupational exposures as one of the causes of COPD [4, 10, 11]. A significant part of the literature accumulated over the past two decades demonstrated the relationship between vapor, gases, dust, and fumes (VGDF) and the development of COPD. Based on a review by the American Thoracic Society (ATS) [12], and a subsequent updated review it has been estimated that approximately 15% of COPD may be attributable to workplace exposures [4]. Workers are exposed to respiratory toxicants in various occupations such as mining, manufacturing, and even office buildings, which can cause disease along the respiratory tract at any point [13, 14]. Up to 15 percent of asthma and 10 percent of lung cancer can be due to occupational exposure. Workers are exposed to a distinct and more complex spectrum of respiratory exposures in developing countries than workers in developed countries, as laws may not be as functional and environmental regulations may not be as advanced [13].

At any point along the respiratory tract, which spans the nasal cavity into the small air sacs (alveoli) in the lung tissue, disease may occur. Disease may involve the airways inside the lung itself, contributing to common diseases such as asthma and chronic obstructive pulmonary disease (COPD). There is a wide variety of exposures to airway disease, including animal and plant materials, various synthetic chemicals, metal and wood products, and irritants such as welding fumes and acid gases [13, 14]. Inflammation and scarring of lung parenchyma, the internal lung tissue, may also be caused by lung disease [13, 15]. Popular causes of such diseases include exposure to asbestos in the textile and shipping industries and exposure to silica in the sandblasting and concrete breaking industries [13, 16].

Industrialization has exposed workers to high levels of respiratory toxicants in developing countries, many of which have been successfully controlled in industrialized countries [13, 17, 18]. For example, a program to eradicate silicosis worldwide has been launched by the World Health Organization (WHO). Agricultural workers’ respiratory health has also earned growing attention.

A number of narrative and systematic reviews, indicate that a substantial proportion of cases of COPD are indeed attributable to exposures in the workplace. Occupationally-related causes of COPD have been identified from a wide-range of industry based studies including those in: coal mining; work with crystalline silica

in the construction industry, tunneling, brick manufacture, pottery and ceramic work, the silica sand industry and iron and steel foundry work; welding; cotton manufacture; and agriculture [16, 19]. Other occupations of concern are work in smelters, iron and steel processing, rubber and tyre manufacturing and exposure to wood dust, ceramic fibers and a range of chemicals such as cadmium, isocyanates, vanadium, polycyclic aromatic hydrocarbons, particularly in asphalt fumes, and those in spray painting, and in coke oven work [20, 21].

3.1 Occupational dust exposure and COPD

Productive dust refers to solid micro-particles produced by the activities of human production that can float for a long period of time in the production atmosphere. Industrial and agricultural development sectors, such as mining, machinery manufacturing, smelting, building materials, textiles, road construction, hydro-power, and food industries, generate productive dust. It can be categorized as inorganic dust, organic dust, and mixed dust according to the composition of the dust. Mineral dust, metal dust, and artificial inorganic dust are inorganic dust; biological dust, plant dust, and animal dust are organic dust [22]. It is a significant hazardous occupational hazard that pollutes the workplace environment and affects workers' health, contributing to the creation of different occupational lung diseases. Studies stated that occupational dust exposure may be causally associated with the pathogenesis of COPD [23]. Different literature on coal miners' airflow obstruction concluded that there was an obvious link between exposure to coal dust and the creation of chronic obstruction of airflow. In-depth research on the role of occupational dust exposure in the occurrence and development of COPD is therefore of great importance in reducing its incidence and alleviating the burden of its disease [21, 24]. Based on prior observations and using new data from published literature, the association between occupational dust exposure and COPD risk was further evaluated [24].

3.2 Street sweepers and dust

In the maintaining of health and hygiene in cities, street sweepers play an important role. This work exposes street sweepers to a number of risk factors that make them vulnerable to some occupational diseases, such as dust, bioaerosols, volatile organic matter and mechanical stress (**Figure 2**). The major morbid conditions observed in these workers include respiratory and eye diseases, accidents, burns, cuts and wounds, skin infections, animal bites, etc. [25, 26].

Dusts are solid particles that, depending on their origin, physical characteristics and environmental conditions, may be or become airborne, varying in size from below 1 μm to at least 100 μm [27].

Examples of the dust types contained in the working environment include:

- Mineral dust, such as free crystalline silica (e.g. quartz), coal and cement dust;
- Metallic particles, such as dust of lead, cadmium, nickel, and beryllium;
- Other chemical dusts, e.g., many bulk chemicals and pesticides;
- Dusts of organic and vegetables, such as flour, wood, cotton and tea dusts, pollen;
- Biohazards, such as viable particles, spores and molds

Figure 2.
Street sweeper at work, not using any protective devices [25].

In the gaseous phase (gases and vapors) or as aerosols, airborne pollutants exist. In the form of airborne particles, sprays, mist, smoke and fumes, aerosols can exist. Both these types may be relevant in the occupational setting since they contribute to a wide range of occupational diseases. Airborne dust is of particular concern since it is well known that it is associated with typical widespread occupational pulmonary diseases such as pneumoconiosis, as well as systemic intoxications such as lead poisoning, especially at higher exposure levels. Other dust-related illnesses, such as cancer, asthma, allergic alveolitis and irritation, as well as a wide variety of non-respiratory diseases, which can occur at much lower levels of exposure, are also increasingly involved in the modern period.

3.3 Penetration and deposition mechanism of dust particles in human respiratory regions

Dust particles small enough to stay airborne may be inhaled through the nasal route (nose) or the oral route. Dust passes through the different regions of nasopharyngeal or extra-thoracic region, trachea-bronchial region and alveolar region. The probability of inhalation depends on particle aerodynamic diameter,

air movement around the body and breathing rate. The inhaled particles may then either be deposited or exhaled again, depending on a whole range of physiological and particle-related factors.

Tiny dust particles have the potential to penetrate the lungs and the body more easily posing a risk to the health of exposed individuals. Although coarse dust is collected in the airways that conduct (nasal passages and bronchi). The fine dust in the bronchioles will enter (smaller airways). Ultrafine dust is almost entirely capable of accessing the deepest regions of the lungs (the alveoli) where oxygen reaches the blood and waste gases are left to be exhaled.

3.4 Effects of dust on the respiratory function

Occupational exposures to dust, fumes, and gases are associated with increased prevalence of respiratory symptoms and impairment of lung function. Any part of the respiratory tract can be adversely affected by poor air quality from the nose to the alveoli [23, 28] mechanisms, the inherent toxicity of particles, pattern of deposition, removal from the respiratory tract and the properties of the air contaminants (WHO, 2005).

The respiratory problems caused by dust exposure include chest pain, occasional cough, occasional shortness of breath and wheezing. Dust inhalation over time contributes to proliferation and fibrotic changes in the lungs. Severity depends on many factors, including the chemical nature, physical condition of the material inhaled, size, dust particle concentration, length of exposure, and individual susceptibility to exposure. The extent of impact is influenced by the proximity to sensitive receptors, wind speed, velocity and nature of work topography. The reaction of the respiratory system to inhaled particles largely depends on where the particles settle. The most important lung reactions occur in the deepest regions of the lungs. Dust particles and dust containing macrophages collect in the lung tissues, causing injury to the lungs [28].

3.5 Exposure to disinfectants with incidence of chronic obstructive pulmonary disease

Exposure to cleaning products and disinfectants is prevalent at work and at home, and among women it is more common. In the health care sector, exposure levels are particularly high. There is a growing awareness of the respiratory health risks associated with exposure to cleaning products and disinfectants. Studying a wider variety of respiratory effects confirms the irritant properties of certain chemicals used in disinfectants. Studies have documented an increased risk of COPD among cleaning workers, an accelerated decrease in lung function and higher rates of death due to COPD.

3.5.1 Cleaning agents

A cleaning product is defined as any material used in general work environments to clean or disinfect surfaces. These items have become an essential part of everyday life, as they are used in almost all workplaces and homes on a daily basis. To facilitate dust and dirt removal, and for disinfection and surface maintenance, a wide range of cleaning agents have been developed [29]. In general, cleaning agents can be defined as natural or synthetic substances used to assist with the cleaning process.

However, cleaning is not without risks. Both volatile and non-volatile compounds contain cleaning agents. Excessive exposure to potentially harmful volatile contaminants results from the application of popular cleaning products [29].

For staff, cleaning materials have emerged as a major respiratory threat. Most cleaning agents (e.g. chlorine and ammonia) have an irritating effect on mucous membranes and the skin and have a sensitizing ability (e.g. monoethanolamine and aldehydes). These products have also been implicated in numerous respiratory disorders, including job-related asthma [29, 30].

The glass cleaner and other hard-surface cleaner chemicals also contain ammonia, which can irritate the skin, eyes, mouth, and lungs. A family of chemicals recognized for their disinfectant and detergent properties are ammonium quaternary compounds. They are found in cleaning products such as disinfectant sprays and toilet cleaners, and have been identified among cleaning workers as a known cause of occupational asthma [31, 32].

The most widely used disinfecting and cleaning agent is chlorine bleach or sodium hypochlorite. It is also used for various applications in everyday life, such as water and food disinfection and surface cleaning in public and private buildings [33]. Chlorine bleach, however, is unstable and is a highly reactive chemical. Chlorine bleach can emit chlorine or tri-chloramine, two gases that are significant irritants to the eyes and the respiratory tract, when mixed with other cleaning agents. Chlorine gas exposure can lead to coughing, shortness of breath, chest pain, nausea, and other symptoms [31, 33]. The acute inhalation of respiratory irritants such as hypochlorite and chlorine gas at toxic concentrations results in a clinical entity known as reactive airway dysfunction syndrome [34].

Monoethanolamine (MEA) is a surfactant that is frequently found in detergents that improves its cleaning efficiency. MEA is used in cleaning items such as laundry detergents and floor cleaners and has been described as a suspected occupational asthma inducer for cleaning employees [31].

Aldehydes are commonly used to clean heat-sensitive devices, such as fiber optic endoscopes, in medical facilities. They may induce hypersensitivity reactions induced by mucous irritation, respiratory symptoms and immunoglobulin IgE, and are well-known causative agents of occupational asthma [29].

4. COPD and its effect on work

The burden of chronic obstructive pulmonary disease (COPD) and its effect on quality of life is well known. Of the main long-term health conditions, there is a growing interest in the impact of chronic obstructive pulmonary disease (COPD) on the ability to work [35, 36]. As COPD progresses patients are increasingly faced with a number of functional limitations, and as a result, can experience effects on their personal, social and work life [36, 37].

COPD is a debilitating disease affecting the daily lives of patients. Having COPD adversely affects patients' rates of employment and work productivity. Physical activity levels are low even in patients in the early stages of COPD [38]. Increasing severity of COPD is associated with decreasing physical activity [39]. In a more recent study of approximately 2,500 patients aged 45–67 years in Brazil, China, Germany, Turkey, the United States, and the United Kingdom, nearly 40% retired early due to COPD at an average age of 54 years, and several subsequent studies have shown that people with COPD are more likely not working because of COPD. In certain cases, failure to work can indicate the fact that occupational exposure worsens symptoms and, of course, exposure may also lead to the development of COPD (**Figure 3**). COPD employees indicated that problems causing them to stop working involved work that worsening their COPD [40, 41].

In addition to causing work to stop, COPD contributes to increased absenteeism. People with COPD are almost half as likely to have a short-term disability and are

Figure 3.
Chronic obstructive pulmonary disease (COPD) and work [40].

more than four times more likely to have a long-term disability, but this can also be affected by comorbidity. The efficacy of patients who stay at work can also be limited by symptoms (**Figure 3**). In the United States and other nations, a number of major cross-sectional studies showed that people with COPD were substantially more likely to report presentism, and findings from studies using self-report data suggest that about 13–18 percent are restricted in what they can do [40].

Working generally has a positive effect on health and functioning [40]. There is increasing evidence that being in work is good for physical and mental health and wellbeing. Being in work provides a feeling of self-worth but also has economic advantages for both the individual and society. Evidence suggests that being out of work may be harmful for individuals [4].

Becoming unemployed, together with lower self-esteem and trust, is associated with significantly higher levels of depression and anxiety; however, it can lead to improved physical health in the short term, particularly when symptoms have been aggravated by working conditions. In countries that do not have welfare programs to help the unemployed or in which healthcare must be paid for, the impact of COPD-related loss of jobs on individuals is likely to be highest [42]. In 2010, 384 million people are projected to have COPD worldwide, with the largest burden falling in Latin America, Sub-Saharan Africa, India, China, and Southeast Asia. Compared to average earnings, the cost of medicine is very high in many of these countries, and its availability across government health services is low. These costs intensify the financial insecurity of households in low- and middle-income countries without an income and may push patients to fund treatment by household borrowing and selling functional properties [40].

Occupational chronic respiratory diseases pose a public health concern with economic consequences in all countries. In the world's poorest countries, innovations which are outdated or banned in developed countries are still largely used. Occupational diseases are usually less apparent and are not sufficiently regarded as

an issue in low and middle income countries. In addition, most patients are not paid in those countries and typically continue to function until the illness is serious and disabling.

5. Conclusion

Chronic obstructive pulmonary disease (COPD) is a slowly progressive, potentially highly disabling, respiratory condition with many potential causes. COPD is a major cause of chronic morbidity and mortality throughout the world. Many people suffer from this disease for years and die prematurely from it or its complications. The most important risk factor of developing COPD is cigarette smoking; however, occupational exposure, exposure to air pollutions, and respiratory infections can also be attributed to developing COPD. Workers in various occupations such as mining, construction, and even office buildings are exposed to respiratory toxicants, which can cause disease at any point along the respiratory tract. The dusts from coal, stone quarries, wood, cereals and agricultural work, animal stables, textiles, and paper production that can arise in occupational environments have been regulated by the International Labor Organization and considered possible as contributors to COPD. A better understanding of these causes paves the way for effective interventions to reduce the future incidence of this unpleasant condition. There is a growing interest in the impact of chronic obstructive pulmonary disease on the ability to work. As COPD progresses patients are increasingly faced with a number of functional limitations, and as a result, can experience effects on their personal, social and work life.

Conflict of interest

The authors declare that they have no competing interest.

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