

C. Health-Related Effects of Respirable Coal Mine Dust

1. Description of Major Health Effects

Consistently, epidemiological studies have demonstrated miners to be at risk of developing respiratory symptoms, a loss of lung function, and lung disease as a consequence of occupational exposure to respirable coal mine dust. As noted previously, risk factors include type(s) of dust, dust concentration, duration of exposure, age of the miner (often measured as age at time of medical examination), and coal rank.

a. Simple Coal Workers' Pneumoconiosis (Simple CWP) and Progressive Massive Fibrosis (PMF)

In earlier stages of pneumoconiosis the term, "simple coal workers' pneumoconiosis" (simple CWP), has been used, while in more advanced stages, the terms "complicated CWP" and PMF have been used interchangeably. Simple CWP and PMF involve the lung parenchyma and are produced by deposition and retention of respirable coal dust in the lung.

To determine if a miner has simple CWP or PMF, chest x-rays are taken and classified by a certified radiologist or reader. Opacities (both irregular and rounded) are identified on chest films and then classified using a scale of 0 through 3 (e.g., simple CWP category 1), where higher category values indicate increasing concentration of opacities. In some instances, two category values may be given. For example, simple CWP category 2/3 signifies that the reader decided the film was category 2, but suspected that it might have been category 3. The International Labour Office (ILO) has provided a full description of the criteria for these classifications (ILO, 1980).

Studies have shown that the prevalences of both small rounded and small irregular opacities increase with increasing coal mine dust exposure (Amandus *et al.*, 1976; Cockcroft *et al.*, 1983; Collins *et al.*, 1988). Miners with small opacities (rounded and/or irregular) on their chest x-rays were more likely to report chronic cough and phlegm, and breathlessness, than miners without small opacities (category 0/0) (Collins *et al.*, 1988). This effect was more common among miners with predominately small rounded opacities (Collins *et al.*, 1988; Rae *et al.*, 1971). Small irregular opacities have been associated with impaired lung function (Amandus *et al.*, 1976; Cockcroft *et al.*, 1982b,c; Collins *et al.*, 1988). The

pattern of lung function impairment reported by Collins *et al.* (1988) was consistent with that typically associated with dust exposure in coal miners, and was distinctly different from the pattern observed among smokers.

Because simple CWP represents an early stage of a progressive disease, miners who have had a chest x-ray classified as ILO category 1 or greater are more likely than those with a clear x-ray (category 0) to progress to the more severe stages of the disease, including the complicated form, PMF (categories A, B, or C) (Cochrane, 1962; Jacobsen, *et al.*, 1971; McLintock, *et al.*, 1971; Morfeld *et al.*, 1992; Balaan, *et al.*, 1993). In addition, miners with simple CWP were found to have an increased risk of dying from pneumoconiosis (as the underlying or a contributing cause on the death certificate), and this risk tended to increase with increasing radiographic category (Kuempel *et al.*, 1995).

Progressive massive fibrosis (PMF) is associated with decreased lung function and increased premature mortality (Rasmussen, *et al.*, 1968; Atuhaire, *et al.*, 1985; Miller and Jacobsen, 1985; Attfield and Wagner, 1992). Progressive massive fibrosis is also associated with increases in respiratory symptoms such as chest tightness, cough, and shortness of breath. Miners with PMF also have an increased risk of acquiring infections and pulmonary tuberculosis (Petsonk and Attfield, 1994; Yi and Zhang, 1996). Finally, miners with PMF have an increased risk of right-side heart failure (*i.e.*, cor pulmonale) (Cotes and Steel, 1987).

b. Other Health Effects

During a medical examination, a miner may be questioned by his/her physician about symptoms such as cough, phlegm production, chest tightness, shortness of breath, and wheezing. Occupational physicians may also conduct pulmonary function tests using spirometry or plethysmography. Pulmonary performance may be assessed via repeated measurements of lung volumes and capacities, such as the forced expiratory volume in one second (FEV1), vital capacity (VC), forced vital capacity (FVC), residual volume (RV), and total lung capacity (TLC) (West, 1990; 1992). Changes in lung volumes and capacities may indicate a loss of the integrity of the lung (*i.e.*, respiratory system). More importantly, they can provide information for diagnosis of diseases affecting the airways and/or elasticity of the lung (*i.e.*, obstructive vs. restrictive lung disease) (West, 1990; 1992).

The term, chronic obstructive pulmonary disease (COPD), refers to three disease processes that are often difficult to properly diagnose and differentiate: Chronic bronchitis, emphysema, and asthma (Coggon and Taylor, 1998; Garshick, *et al.*, 1996; West, 1990; 1992). As indicated by several studies, the exposure of miners to respirable coal mine dust places them at increased risk of developing COPD. Furthermore, COPD may occur in miners with or without the presence of simple CWP or PMF.

COPD is characterized by airflow limitations, and thus there is a loss of pulmonary function. As in simple CWP or PMF, a miner with COPD may have a variety of respiratory symptoms (*e.g.*, shortness of breath, cough, sputum production, and wheezing) and may be at increased risk of acquiring infections. COPD is associated with increased premature mortality (Hansen, *et al.*, 1999; Meijers, *et al.*, 1997).

Briefly, in chronic bronchitis and in asthma, there is excess mucous secretion in the mid to lower airways (West, 1990; 1992). In contrast, emphysema is characterized by dilatation (enlargement) of alveoli that are distal to the terminal bronchioles, which leads to poor gas exchange (*i.e.*, poor transfer of oxygen and carbon dioxide). Additionally, there is a breakdown of the interstitium between the alveoli. These pathological changes may be confirmed upon autopsy. With asthma, the airflow limitations may be partially or completely reversible, while they are only partially reversible with chronic bronchitis and emphysema.

The Mine Safety and Health Administration (MSHA) and the NIOSH recognize that respiratory symptoms, loss of lung function, and COPD may impair the ability of a miner to perform his/her job and may diminish his/her quality of life (65 FR 49215). Additionally, miners having such health effects are at increased risk of morbidity (*e.g.*, from cardio-pulmonary disease, infections) and premature mortality.

2. Toxicological Literature

To better understand the human health effects of exposure to respirable coal mine dust and to more fully characterize the associated risks, it is important to consider data that have been obtained in animal based toxicological studies. To date, sub-acute studies (a study with a duration of 30 days, or less, in which multiple exposures of the same agent are given) and chronic studies (a study with a duration of more than 3-months, in which multiple exposures of same agent are given) attempted to mimic miners'

exceeds 5 percent. However, no effect occurs until the quartz content exceeds 10 percent.