Environment International 77 (2015) 16–24

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review

# Selenium and exposure to fibrogenic mineral dust: A mini-review

Basilua Andre Muzembo [a,d,*], Yoji Deguchi [b], Nlandu Roger Ngatu [a,c], Masamitsu Eitoku [a], Ryoji Hirota [a], Narufumi Suganuma [a]

[a] Division of Social Medicine, Department of Environmental Medicine, Kochi Medical School, Kochi University, Kochi, Japan
[b] School of Nursing, Faculty of Medical Sciences, University of Fukui, Fukui, Japan
[c] Disaster Graduate School of Health and Nursing Sciences, Disaster Nursing Global Leader program (DNGL), University of Kochi, Kochi, Japan
[d] Research Fellow of the Japan Society for the Promotion of Science (JSPS), Tokyo, Japan

ARTICLE INFO

*Article history:*
Received 26 August 2014
Received in revised form 28 December 2014
Accepted 4 January 2015
Available online xxxx

*Keywords:*
Selenium
Selenoproteins
Pneumoconiosis
Silicosis
Asbestosis
Coal miner's pneumoconiosis

ABSTRACT

Individuals exposed to fibrogenic mineral dust may exhibit an impaired antioxidant system and produce high levels of reactive oxygen and nitrogen species through immune cells, contributing to the perturbation of immune cell function, inflammation, fibrosis and lung cancer. The lung diseases which are caused by inhalation of fibrogenic mineral dust, known as pneumoconioses, develop progressively and irreversibly over decades. At the moment there is no known cure. The trace element selenium has potent antioxidant and anti-inflammatory properties mediated mainly through selenoproteins. Research has demonstrated that selenium has the ability to protect against cardiovascular diseases; to kill cancer cells in vitro and reduce cancer incidence; and to immunomodulate various cellular signaling pathways. For these reasons, selenium has been proposed as a promising therapeutic agent in oxidative stress associated pathology that in theory would be beneficial for the prevention or treatment of pneumoconioses such as silicosis, asbestosis, and coal worker's pneumoconiosis. However, studies regarding selenium and occupational lung diseases are rare. The purpose of this study is to conduct a mini-review regarding the relationship between selenium and exposure to fibrogenic mineral dust with emphasis on epidemiological studies. We carried out a systematic literature search of English published studies on selenium and exposure to fibrogenic mineral dust. We found four epidemiological studies. Reviewed studies show that selenium is lower in individuals exposed to fibrogenic mineral dust. However, three out of the four reviewed studies could not confirm cause-and-effect relationships between low selenium status and exposure to fibrogenic mineral dust. This mini-review underscores the need for large follow-up and mechanistic studies for selenium to further elucidate its therapeutic effects.


**Contents**



* Corresponding author at: Division of Social Medicine, Department of Environmental Medicine, Kochi Medical School, Kochi University, Kohasu, Oko-cho, Nangoku-shi, Kochi 783-8505, Japan.
*E-mail address:* andersonbasilua@yahoo.fr (B.A. Muzembo).

http://dx.doi.org/10.1016/j.envint.2015.01.002
0160-4120/

## 1. Introduction

### 1.1. Background

Occupational exposure to fibrogenic mineral dust is associated wih the development of pneumoconiosis; fibrogenic dust refers to dust that causes fibrosis. Fibrosis is derived from the Latin word fiber for filament or thread; as a sequela of various persistent inflammatory pathologies, it refers to an increased accumulation of extracellular matrix (ECM) components, such as collagens and fibronectin, in organs and tissues resulting from proliferation and activation of fibroblasts and myofibroblasts (Wick et al., 2013). Lung fibrosis is a chronic lung disease characterized by an increased accumulation of ECM accompanied by remodeling of the lung with physiologic, clinical and radiographic features (Todd et al., 2012). During lung fibrosis, there is a wound-healing process in the lung that leads to a persistent inflammation cascade coupled with lymphocyte–monocyte crosstalk that withstands growth factor release, proteolytic enzyme production and fibrogenic cytokine release, leading to the accumulation of connective tissue and a remodeling of the lung architecture destroying the normal lung structure irreversibly (Wynn, 2004). Fibrotic diseases are a major issue of public concern since efficacy of available drugs is very poor (Scotton and Chambers, 2007). However, these diseases have been neglected worldwide; for example, in the United States, fibrotic diseases are responsible for 45% of deaths (Wick et al., 2013; Wynn, 2004). Fibrotic diseases such as pneumoconioses also remain an issue of occupational concern because they are among the leading causes of morbidity and mortality. Approximately 125,000 lives are lost every year due to pneumoconioses (Lozano et al., 2012). Although pneumoconioses can be prevented by controlling exposure to hazardous dust, they still remain a significant problem worldwide. For this reason, increased awareness of occupational vulnerability to pneumoconioses is required. This will help in preventive measures for pneumoconioses. Pneumoconiosis is a broad term that refers to a range of diseases due to the inhalation and accumulation of dust in the lungs (Chong et al., 2006), leading to interstitial fibrotic disease or non-fibrotic pneumoconiosis (Chong et al., 2006; McLoud, 1991). Fibrotic pneumoconioses have similar clinical patterns such as pulmonary fibrosis characterized by lung function decline, and respiratory symptoms that can lead to premature death (Wang and Christiani, 2000). Pneumoconioses are disabling and they lead to clinical symptoms including dyspnea, dry cough, poor appetite, chest pain and pulmonary cachexia (Mossman and Churg, 1998; Zare Naghadehi et al., 2014). Fibrotic pneumoconioses include common ailments such as asbestosis, silicosis, and coal worker's pneumoconiosis (CWP) and the rarer types of pneumoconiosis such as berylliosis and talcosis (Chong et al., 2006). Non-fibrotic pneumoconioses include stanosis, siderosis and baritosis. Silicosis and asbestos-related lung diseases remain an issue of major concern due to past exposure to silica dust and to the huge amount of asbestos fibers used during the 20th century. Symptoms of chronic phases normally develop many years after exposure; the latency period may take up to 40 years from the time of initial exposure (Kamp, 2009). Fibrotic pneumoconiosis has a progressive and irreversible development and there is no currently known effective treatment (Attfield and Kuempel, 2003). Previous studies have demonstrated that individuals exposed to fibrogenic dust exhibit an impaired antioxidant system while producing high levels of reactive oxygen species contributing to the initiation and development of inflammation, fibrosis and lung cancer (Kamp et al., 1992; Quinlan et al., 1994).

### 1.2. Common forms of pneumoconiosis

#### 1.2.1. Silicosis

Silicosis is a fibrotic lung disease due to the inhalation of respirable crystalline silicon dioxide (silica) (Leung et al., 2012), the most common quartz, in occupational settings such as tunneling, mining, sandblasting, and quarrying (McLoud, 1991; American Thoracic Society, 1986). Respirable crystalline silica refers to particulates having a diameter of $<10$ μm, the range most likely to reach the lung alveolus while escaping retention in the upper respiratory airways such as the nose or throat. Silicosis often develops progressively and irreversibly over decades even after exposure has ceased. Clinical features of silicosis include simple silicosis, silicoproteinosis (acute silicosis), complicated silicosis (progressive massive fibrosis), and interstitial fibrosis. Radiographic features of silicosis include rounded opacities (1–10 mm) in the upper zones of both lungs (Greenberg et al., 2007). Silicosis may develop in some cases together with a variety of diseases including tuberculosis (Xia et al., 2014); CWP and autoimmune diseases (Maeda et al., 2010). Silica exposure is still prevalent in low and middle income countries, and developed countries also are not immune to new silica exposure (Steenland and Ward, 2014).

#### 1.2.2. Asbestosis

Asbestosis is a bilateral diffuse lung fibrosis due to the inhalation and accumulation of asbestos fibers in the lungs (Mossman and Churg, 1998; American Thoracic Society, 1986) during asbestos production, use, removal, or disposal. Occupational exposure occurs, for example, during the manufacture or installation of asbestos-containing building materials (Cullinan and Reid, 2013). Asbestos is a sextet of naturally occurring silicate minerals grouped in serpentine (chrysotile), and amphibole (amosite, crocidolite, tremolite, anthophyllite, and actinolite) (Kanarek, 2011). Asbestos is characterized by physical properties that make it commercially useful for builders; these physical properties include resistance to fire, heat, electrical and biochemical alterations. For safety reasons, most developed countries have fully banned the use of asbestos in construction; however, some developed countries such as the USA and many developing countries still use asbestos (Prazakova et al., 2014). Radiographic features of asbestosis include ground glass opacities, small nodular opacities, pleural plaques, “Shaggy” cardiac silhouette, ill-defined diaphragmatic contours, honey combing and volume loss (Roach et al., 2002).

#### 1.2.3. Coal workers' pneumoconiosis

Coal is a natural brownish black or black graphite-like material which is a fossil fuel for producing energy such as electricity. CWP, which is known also as a black lung disease, is due to the inhalation and accumulation of coal mine dust in the lungs (Castranova and Vallyathan, 2000). Radiographic appearance allows classifying CWP into simple pneumoconiosis and progressive massive fibrosis. Simple CWP is characterized by small rounded lung opacities in the upper zones of both lungs, while progressive massive fibrosis features large