The Problem of Silicosis
Why is it such a challenge to prevent
In the Construction Industry

John E. Parker, MD
Professor and Chief
Pulmonary and Critical Care Medicine
West Virginia University
Parma 2012 October

Silica disorders in construction:

• Outline a few dust hazards in industrial economies; mixed complex exposures in construction of roads and buildings
• Health surveillance tools for respiratory health recognition and detection
• Mechanisms of dust diseases
  – Pathologic – physiologic correlations
• Lung disease airflow obstruction and silicosis
Respirable Exposures

- Respirable Exposures frequently mixed dusts, frequently low level with intermittent high exposures for short time periods
- Construction - building and road construction
- Ceramic industry
- Mining
Pneumoconiosis 2012

• Why worry about pneumoconiosis, and dust diseases is this not a disease of the past?

• In US, several recent findings raise concerns in both mining and construction industries

---


Category 1/0 +

In 10 years Dust disease rates doubled
June 2008
53 yr old miner

Sept. 2007
54 yr old miner

Advanced Pneumocystis
Among Working Underground Coal
Miners — Eastern Kentucky and
Southwestern Virginia, 2006

Current regulations for U.S. underground coal miners, insti-
tuted by federal legislation in 1969 and amended in 1977,
include provision to prevent the occurrence of pneumoconioses
(6). However, in 2005 and 2006, clusters of rapidly-
progressing and potentially disabling pneumoconioses were
reported in certain geographic areas (7,8). In response to these
episodes, CDC’s National Institute for Occupational Safety and
Health (NIOSH) (9,10) and the authors conducted under the
Enhanced Coal Workers’ Health Surveillance Program
(ECWSP) (11–13). This report describes the results of these sur-
evses, which were conducted in three counties in eastern
Kentucky (Knott, Leslie, and Pike) and four counties in
southwestern Virginia (Wise, Unicoi, Scott, and Scott) in
2006.

The number of 53 cases of advanced pneumoconioses,
including Pneumocystis, was reported in the three eastern
Kentucky counties. An additional 15 cases were noted in
the southwestern Virginia counties.

Occupational Lung Disorders

Clinical overlap

Oncocutaneous Immunologic Lung Disease (OLLD)

Oncocutaneous Immunologic Lung Disease (OLLD)

Occupational Asthma

Hypersensitivity Pneumonitis

Beryllium Disease

Toxic and Pharmacologic Agents

Berylliosis

Organic Dust Toxic Syndrome (ODTS)

Bronchiolitis Obliterans

Goodpasture Syndrome

T2K pneumonitis, bronchitis, RADS

Dust Diseases

Mineral Dust

Asbestosis

Lung Cancer

Emphysema
Airway Caliber and Particle Deposition

Mechanism: 
impaction  sedimentation  diffusion

Particle size:  
large (>5μ)  medium (1-5μ)  small (<0.1μ)

Representative site:  
nasopharynx  small airways  alveoli

Clearance of Particles by Alveolar Macrophages
	oo many  "overload"
too long  "frustrated phagocytosis"
Clearance of Particles by Alveolar Macrophages

Pulmonary alveolar macrophages

Dust diseases – particle deposition

Fiber

Particle
Respirable silica – a well known hazard

- Crystalline silica (SiO2) is a major component (~75%) of the earth’s crust
  - Resists abrasion, water, heat
- Crystalline silica exists in three major forms
  - Quartz, cristobalite, and tridymite
  - Also amorphous SiO2, glass, and silicates – less toxic

Figure from Iowa State University, www.ndt-ed.org.

Respirable silica

- Recognized health effects of inhalation:
  - Silicosis
  - Bronchitis, COPD
  - Lung infection especially mycobacteria
  - Lung cancer
  - Renal disease
  - Immunologic disorders
    - SSc, RA, SLE, vasculitis, ? sarcoidosis
Respirable silica

- Recognized health effects of inhalation:
  - Autoimmune disease – Parks et al, EHP 1999;107:793
  - COPD – Hnizdo and Vallyathan. Occup Environ Med 2003;60:237
  - Silica hazard review - DHHS (NIOSH) Pub. No. 2002-129, April 2002
  - Silicosis – Petsonk & Parker, Fishman 4th Ed. 2008:967

Silica: Immune-Mediated Complications

- Altered Markers of Immune Function:
  Increased serum IgG, IgM, IgA; increased prevalence of autoantibodies (ANA, RF) and circulating immune complexes.

- Progressive Systemic Sclerosis: Association with silicosis first reported in Scottish stonemasons in 1914. Multiple studies have continued to support an association.

- Other Autoimmune Diseases: Associations with RA, SLE, MCTD, and SVV reported: multiple studies suggestive of causation.
Silica and Renal Disease

- A relationship between silicosis and renal disease suspected since the 1930s.
- A report in 1933 documented a 45% increase in death rate from chronic nephritis in silica-exposed English and Welsh men relative to age-specific rates in the reference population.
- Case reports suggest an association between acute silicoproteinosis and glomerular injury.

Silica Exposure and Lung Cancer

- Intratracheal instillation of silica in rats leads to neoplasms resembling human lung cancer.
- Recent reviews of human studies support the conclusion that silicosis is associated with increased risk for lung cancer. The evidence for this association is best in smokers.
- In October, 1996, the International Agency for Research on Cancer (IARC) classified silica as “carcinogenic in humans” concluding that there is “sufficient evidence of carcinogenicity in humans.”
Silicosis and Silica Exposure
Exposure – Response (one example

Data derived from 3300 gold miners. Cases identified by death certificate or x-ray during two previous surveys.

Respirable silica

- Some exposure limits:
  - US NIOSH/ REL 50 ug/m3 TWA 10/40 hrs
  - ACGIH 25 ug/m3 respirable
  - US OSHA and MSHA PEL + 100 ug/m3
  - EU OELs range from 50 – 300 ug/m3
- Particle toxicity varies
  - Freshly fractured crystals ↑
  - Clay occlusion of particle surfaces ↓
  - Increased risk seen with short term peak levels
- Adverse Health effects are observed below current limits
Silicosis - clinical imaging patterns

- Acute silicosis – latency months to few years
  - After highest exposures
  - Silicoproteinosis – radiographic alveolar filling pattern
  - May be fatal or progress to chronic silicosis
- Accelerated silicosis - latency 5 - 10 years
  - High exposures
  - Radiographic pattern similar to chronic silicosis
- Chronic silicosis – latency ≥ 15 years
  - ‘Simple’ form, small opacities (<10 mm)
  - Complicated form (Progressive Massive Fibrosis, PMF), large (> 10 mm) radiographic opacities

Lung diseases caused by inhalation of dust and the body’s reaction to it

- Fibrotic diseases – damage/destroy lung tissue
  - Pneumoconiosis
- Airflow diseases – block movement of air
  - Bronchitis
  - Emphysema
  - Mineral dust airway disease “COPD”
- Infectious diseases – dust reduces immunity
  - Tuberculosis especially with silica and/or HIV
- Cancers of lung and pleura

Dust often causes more than one disease
Airway diseases caused by inhalation of dust

- Airflow obstructive diseases
  - Bronchitis
  - Mineral dust airway disease “COPD”
  - Emphysema

Dust diseases in the lungs
- pathologic consequences
Contrary to this cartoon, there is no simple medical test other than clinical suspicion to determine the work-relatedness of disease, and that depends primarily on a careful occupational history.

From LEVY BS, WEGMAN DH. Occupational health (3rd ed), p.60
Dust diseases in the lungs
– Tools for periodic health surveillance

• Questionnaires
• Radiographs
• Spirometry

Dust diseases in the lungs
– Periodic health surveillance

• Questionnaires
  – Responses to standardized questionnaire items are simple and valid screening tools
Dust diseases in the lungs  
– Periodic health surveillance

• Spirometry  
  – Monitoring changes in FEV1 is practical and useful in identifying workers at risk of lung disease  
  – **Rapid Declines in FEV1 and Subsequent Respiratory Symptoms, Illnesses, and Mortality in Coal Miners in the United States**  

LUI-ANN F. BECKMAN, MIULIN WANG, EDWARD L. PETSONK,  

Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Morgantown, West Virginia

AJRCCM 2001;163:633-9

---

Dust diseases in the lungs  
– Periodic health surveillance

• Spirometry  
  – Professional standards are available  
  – Training of personnel is essential for data quality

**SERIES “ATS/ERS TASK FORCE: STANDARDISATION OF LUNG FUNCTION TESTING”**  
Edited by V. Brusasco, R. Crapo and G. Vignola  
Number 1 in this Series

General considerations for lung function testing  

Dust diseases in the lungs – Periodic health surveillance

- Spirometry
  - [http://www.cdc.gov/niosh/topics/spirometry/](http://www.cdc.gov/niosh/topics/spirometry/)

‘Something old’ - Respirable silica

- Silica has long been recognized as a respiratory hazard
- Human exposures to respirable silica from mining, industrial, and construction activities
‘Something old’ - Respirable silica

Good News and Bad News

- Silica is common mineral dust
- Freshly fractured is more toxic
- Radiographic silicosis is common
- However functional impairment is not common
- Cancer and TB are important additional complications of exposure