Adverse Health Effects of Silica in Michigan

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John Henry: The Untold Story of an American Legend

Scott Nelson, 2006

Died Age 23, 1849-1872, 5ft 2in, African-American Prisoner at Virginia State Penitentiary

10 years for shop lifting

Lewis Tunnel/C & O Railroad, 1869-1872

West Virginia – Virginia Line

4.5 Miles from Hawk’s Nest Tunnel
Objectives

• Health Effects of Silica Exposure
• Occurrence of Silicosis in Michigan
• Industries where Silica Exposure Expected
• Medical Monitoring in New OSHA Standard
# Silica

<table>
<thead>
<tr>
<th>Non-Malignant</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alveolar Proteinosis (Acute Silicosis)</td>
<td>Lung Cancer</td>
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<tr>
<td>Parenchymal Fibrosis (Silicosis)</td>
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<tr>
<td>Tuberculosis</td>
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<tr>
<td>Connective Tissue Disease</td>
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<tr>
<td>Chronic Renal Failure</td>
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<td>COPD</td>
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## Connective Tissue Disease

<table>
<thead>
<tr>
<th>Condition</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Rheumatoid Arthritis</strong></td>
<td>(2-5 fold risk)</td>
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<tr>
<td>Silicosis Registries</td>
<td></td>
</tr>
<tr>
<td>Silica-Exposed Cohorts</td>
<td></td>
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<tr>
<td>Prevalence Rheumatoid Factor</td>
<td></td>
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<tr>
<td><strong>Scleroderma</strong></td>
<td></td>
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<tr>
<td>Case Series (&lt;50% with Silicosis)</td>
<td></td>
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<tr>
<td>Dose Response</td>
<td></td>
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<tr>
<td><strong>Sjogren’s Syndrome</strong></td>
<td></td>
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<tr>
<td>Silica-Exposed Cohorts</td>
<td></td>
</tr>
<tr>
<td><strong>Systemic Lupus Erythematositis</strong></td>
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<tr>
<td>Case Reports</td>
<td></td>
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<tr>
<td>Silica-Exposed Cohorts</td>
<td></td>
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<tr>
<td>Prevalence ANA</td>
<td></td>
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</tbody>
</table>
Objective: To determine whether individuals with simple silicosis have obstructive and restrictive decrements.

Methods: The prevalence of spirometric abnormalities by radiograph profusion, smoking, duration, and latency from first silica exposure was evaluated among confirmed silicotics.

Results: Among 526 silicotics, 17.3% who had never smoked and 26.5% of smokers had obstruction, 30.1% and 28.1% had restriction, and 22.4% and 25.7% had a mixed obstructive and restrictive pattern. Individuals with category 3 profusion or progressive massive fibrosis were more likely to have abnormalities.

Conclusion: BOTH OBSTRUCTIVE AND RESTRICTIVE PATTERNS WERE OBSERVED REGARDLESS OF SMOKING STATUS WITH A LOW PROFUSION CATEGORY OF SIMPLE SILICOSIS. There was an increased prevalence of restrictive changes with increased profusion. After controlling for age, smoking, and duration of exposure to silica, there was a statistically significant increased risk of obstructive and mixed changes with progressive massive fibrosis.


**Background:** The risk of developing clinical connective tissue disease (CTD) has been reported to be increased among individuals with silica exposure.

**Methods:** We reviewed the medical records of individuals reported to the Michigan Silicosis Surveillance system from 1985 to 2006 to confirm the diagnosis of silicosis and determine the presence of CTDs.

**Results:** From 1985 to 2006, 1,022 cases were confirmed to have silicosis. Medical records of 790 cases were available. Thirty-three individuals had rheumatoid arthritis (RA) [prevalence 4.2% (prevalence ratio (RR) ranged from 2.26, 95% CI: 1.57–3.25 to 6.96, 95% CI: 2.93–16.53) depending on the reference rate used], two had scleroderma [prevalence 0.3% (RR 28.3, 95% CI: 6.09–129.98)], one had systemic lupus erythematosus [prevalence 0.1% (RR 2.53, 95% CI: 0.30–21.64)], two had Sjogren’s syndrome [prevalence 0.3% (RR 0.42, 95% CI: 0.09–2.08)], and six had anti-neutrophil cytoplasm antibody (ANCA) vasculitis [prevalence 0.8% (RR 25.3, 95% CI: 6.34–101.04)]. There was no difference between those with and without CTD with respect to age, race, industry type, history of tuberculosis, application for workers’ compensation, or severity of fibrotic changes on chest X-ray.

**Conclusion:** A TWO TO EIGHTFOLD RISK FOR RA AND SYSTEMIC LUPUS ERYTHEMATOSUS, WITH A GREATER THAN 24-FOLD RISK FOR SCLERODERMA AND ANCA VASCULITIS WAS FOUND IN INDIVIDUALS WITH SILICOSIS. The most common CTD among silicotics in the Michigan disease registry was RA. Though not classically included in the category of CTD, ANCA-associated vasculitis was found to have a much greater prevalence amongst silicosis patients than the general population.
### Calculated Chronic Kidney Disease Stage in Study Population vs. General Population

GFR = 186 X [Scr]<sup>-1.154</sup> x [Age]<sup>-0.203</sup> x [0.742 if patient is female] x [1.212 if patient is black]

Age=age the SCr was recorded, SCr= Serum creatinine (mg/dL)

<table>
<thead>
<tr>
<th>CKD Stage</th>
<th>All (All)</th>
<th>HBP or Diabetes</th>
<th>No HBP or Diabetes</th>
<th>NHANES 1999-2006 ≥ 60 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>97 (31%)</td>
<td>54 (26.6%)</td>
<td>43 (38.9%)</td>
<td>61.2%</td>
</tr>
<tr>
<td>1 (GFR &gt;90)*</td>
<td>2.5 (0.8%)</td>
<td>1.5 (0.8%)</td>
<td>1.5 (1.4%)</td>
<td>2.3%</td>
</tr>
<tr>
<td>2 (GFR 60-89)*</td>
<td>13.5 (4.3%)</td>
<td>8.3 (4.4%)</td>
<td>2.5 (2.3%)</td>
<td>8.4%</td>
</tr>
<tr>
<td>3 (GFR 30-59)</td>
<td>160 (51.1%)</td>
<td>96 (51.6%)</td>
<td>57 (51.8%)</td>
<td>26.3%</td>
</tr>
<tr>
<td>4 and 5(GFR &lt;30)</td>
<td>40 (12.8%)</td>
<td>32 (17.2%)</td>
<td>5 (4.6%)</td>
<td>1.8%</td>
</tr>
<tr>
<td>Total</td>
<td>313</td>
<td>191.8</td>
<td>109</td>
<td></td>
</tr>
</tbody>
</table>

*Persistent albuminuria

All vs. NHANES, χ<sup>2</sup>=389, p<.0001
HBP or Diabetes, χ<sup>2</sup>=361, p<.0001
No HBP or Diabetes, χ<sup>2</sup>=45, p<.0001
States with Reporting Requirements for Silicosis

(N=26)
Distribution of Individuals Confirmed with Silicosis by County of Exposure
Confirmed Silicosis Cases
by Year Reported, Michigan 1987-2015

*Provisional data; there are 5 reports for 2014 and 16 reports for 2015 that are pending interview to confirm diagnosis.
Silicosis: Number of deaths, crude and age-adjusted death rates, U.S. residents age 15 and over, 1968–2010

Mortality From Silicosis as Collected and Reported by CDC in National Statistics is an Inadequate Marker of the Burden of Silica’s Toxicity.

- Silicosis is only found on the death certificate of 14% of individuals with confirmed silicosis.
- The ratio of individuals with new onset silicosis who are living is 7.17 times that found on death certificates.
- Hospitalization for silicosis has not decreased: 1993 - 2,028 hospitalizations nationwide and 2011 - 2,082 hospitalizations. (Nationwide Inpatient Sample. Agency for Healthcare Research and Quality (AHRQ)).
- The ratio of living to dead people with silicosis is not a function of silicosis being a benign condition but reflects the lack of familiarity by health care providers with silicosis and the lack of awareness of the medical history of the health care provider who completes the disease information on the death certificate.
- Silicosis is just one of multiple adverse health outcomes of silica exposure.
- One can attribute almost all the decrease seen in silicosis to a decrease in the population at risk:
  1. The number of workers in Michigan foundries decreased 75% from 1973 to 1991 and the number of cases identified in Michigan surveillance system decreased 83%. (Decrease from 1993 to 2011 (factoring in 20 year latency for silicosis development)
  2. The number of abrasive blasting companies in Michigan using silica went from 125 to 36, a 71% decrease, from 1995-2011 (Percent of abrasive companies using silica went from 89% to 43% (52% decrease)).
  3. Industries where there has been increased number of workers exposed to silica, such as construction doing highway repair, countertop installation, or in oil and gas fracking have not had a sufficient time since the increase in employment for silicosis to develop and accordingly have not caused an increase in silicosis statistics.
Michigan Ferrous Foundries and Employees, 1960-2011

- Number of Firms
- Number of Employees (thousands)

- Employees
- Firms
Ford Motor Company River Rouge
“When the white man had a job, his job wasn’t molding and shaking out. He had a job like setting cores. You couldn’t hardly find a one that shake out [foundry department with the highest silica dust levels].” (Quote from a black retired Michigan foundry worker describing work from the mid 1950’s to the mid 1970’s)
Distribution of Duration of Work for African-American and Caucasian Workers
Distribution of Cumulative Silica Exposure for African-American and Caucasian Workers

Cumulative Silica Exposure (mg-day/m³)

- <240
- 240-720
- >720-2,160
- >2,160

Percent

African-American  Caucasian

• Black - White Wages Equal
• Blacks Placed in Hot, Dangerous Foundry Jobs
• Blacks Significantly Lower Quit Rates
Ablasive Blasting Survey of Michigan Companies by Year of Survey and Use of Silica

Year of Survey

- 1995
- 1999
- 2005
- 2011
- 2016

Number of Companies

- Total Abrasive Blasting Companies
- Use Silica

- 1995: 89%
- 1999: 72%
- 2005: 55%
- 2011: 40%
- 2016: 35%
Concrete Sawing

demo saw 5.5 X PEL

walk-behind saw 5.1 X PEL

5. 1. 1999
View of tunnel interior, 13 March 1932.
Hydraulic Fracturing

Hydraulic fracturing, or "fracing," involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
Lower 48 states shale plays

Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011
Sand transfer operations – silica

sand mover

transfer belt

Operator Exposure 27 X PEL
Summary of Foundry Inspections in Michigan, 2007-2009

- Chest X-rays - Pre Placement - 13%
  Periodic - 5%
- Spirometry - Pre Placement - 34%
  Periodic - 13%
When is Medical Examination Required?


Exposed to respirable crystalline silica ≥25 μg/m³ (action level)
for ≥30 days per year.

Construction - 9/23/2017

Required to wear a respirator (entry in a regulated area (> 50 μg/m³ (PEL))
for ≥30 days per year.
Content of Silica Medical Exam

- **Medical and work history**, with emphasis on: past, present, and anticipated exposure to respirable crystalline silica, dust, and other agents affecting the respiratory system; any history of respiratory system dysfunction, including signs and symptoms of respiratory disease (e.g., shortness of breath, cough, wheezing); history of TB; and smoking status and history.

- **Physical examination**, with special emphasis on the respiratory system - Initial examination and every three years.

- **TB testing** - Initial examination.

- **Spirometry** - Initial examination and every three years. Must be administered by a spirometry technician with a current certificate from a NIOSH approved course.

- **PA radiograph** of the chest at full inspiration - Initial examination and every three years. Must be interpreted and classified according to the ILO International Classification of Radiographs by a NIOSH-certified B Reader.

- **Additional testing** the provider deems appropriate.
Written medical report to employee within 30 days must include:

- The results of the medical examination, including any medical condition(s) that would place the employee at increased risk of material impairment to health from exposure to respirable crystalline silica and any medical conditions that require further evaluation or treatment;
- Any recommended limitations upon the use of a respirator;
- Any recommended limitations on exposure to respirable crystalline silica;
- A statement that the employee should be examined by a Board Certified Specialist in Pulmonary Disease or Occupational Medicine, where the B reading is 1/0 or higher for rounded opacities or where the PLHCP has determined such a referral is necessary.

Written medical report to employer within 30 days must include:

- Date of the examination;
- A statement that the examination has met the requirements of this section; and
- Any recommended limitations on the employee’s use of a respirator.
Thank you! Any questions?
Compressed-Air Cleaning

>100 mg/m³