

## Lung Function Abnormalities In U.s. Indium-Tin Oxide Production Workers

**K. J. Cummings<sup>1</sup>, E. Suarathana<sup>1</sup>, G. Day<sup>2</sup>, M. L. Stanton<sup>1</sup>, R. Saito<sup>1</sup>, K. Kreiss<sup>3</sup>**

<sup>1</sup>Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health, Morgantown, WV, <sup>2</sup>National Institute for Occupational Safety and Health/CDC, Morgantown, WV, <sup>3</sup>National Institute for Occupational Safety and Health, Morgantown, WV

**Corresponding author's email: cvx5@cdc.gov**

### **Introduction:**

Indium-tin oxide (ITO) is used to manufacture flat panel displays, touch screens, solar cells, and architectural glass. Two cases of pulmonary alveolar proteinosis, including one fatality, occurred at a U.S. ITO production facility. We evaluated the burden of lung function abnormalities in the workforce and risk of disease in relation to exposure.

### **Methods:**

Using annual medical testing records from 2002-2010, we identified restrictive pattern on spirometry, excessive decline in forced expiratory volume in one second (FEV<sub>1</sub>), low total lung capacity, and low diffusing capacity on the basis of the lower limits of normal.

Chest radiographs with International Labour Organization profusion criteria of 1/0 or greater were considered abnormal. We calculated average indium exposures from personal air sampling data from 2004-2010. We examined distributions of lung abnormalities by employment status, hire date, job category, and indium exposure. We determined prevalence ratios of restrictive pattern on spirometry from comparisons with the U.S. adult population adjusted for race, sex, age, smoking status, and body mass index.

### **Results:**

Fifty-seven (85%) of 67 workers had medical data; all were male, with mean age of 37 years. Prevalence of restrictive pattern on spirometry after hire was 33% (n=14/43), 3.9-fold (95% CI 2.4-6.7) higher than expected. Excessive decline in FEV<sub>1</sub> occurred in 34% (n=14/41 tested more than once). Of 35 workers tested after hire, 8 (23%) had low total lung capacity and 9 (26%) had low diffusing capacity. Two (7%) of 28 workers imaged after hire had abnormal chest radiographs. Abnormalities tended to be more common in former workers and those hired before 2007. Higher indium air concentrations were found in the refinery (geometric mean [GM]=1.5 mg/m<sup>3</sup>), where clinical abnormalities were uncommon, and reclaim area (GM=0.7 mg/m<sup>3</sup>), where abnormalities were common. Lower indium air concentrations were found in the grinding area (GM=0.2 mg/m<sup>3</sup>), where clinical abnormalities were less common, and the ITO department (GM=0.1 mg/m<sup>3</sup>), where abnormalities were common.

### **Conclusions:**

Lung function abnormalities consistent with recognized health effects of indium were common. Traditional measures of exposure and response had discrepancies, which could be due to misclassification of exposure or response, or may reflect a more complex relationship. Alternative measures of exposure (peak concentrations, physicochemical characterization of aerosols) and response (biomarkers of early lung effects, more sensitive imaging) may be more informative.

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