The International Labor Organization’s International System (ILO system) for Classification of Radiographs for Pneumoconiosis has been accepted by the scientific community for use in studies of pneumoconiosis. The National Institute for Occupational Safety and Health (NIOSH) recommends using multiple ILO trained readers to increase accuracy and precision. The difference of between-reader agreement on the estimates of prevalence of ILO abnormalities in medical screening in general and screenings of former nuclear weapons workers in particular has not been studied extensively. We screened over 2,650 workers from two sites in Iowa with a chest x-ray, spirometry and questionnaire to identify beryllium disease of the U.S. Department of Energy (DoE) funded Former Nuclear Weapons Worker Medical Screening Program (DoE-FNW). The films were scored according to ILO (rev. 2000) guidelines by three occupational medicine physicians (clinician readers) and the prevalence of parenchymal abnormalities (median profusion score \( \geq 1 / 0 \)) on one site was found to be up to twice as high as in other DoE populations with higher potential for exposure to parenchymal lung disease hazards reported to date (Demet et al., 2003; Makio et al., 2005). Other than suggestion of asbestos for isolated pleural fibrosis no occupational etiology was identified (Mikulski et al., 2011) but age was statistically associated with prevalence of isolated parenchymal and pleural abnormalities. The agreement between the readers ranged from moderate to substantial for dichotomous parenchymal and pleural abnormalities and was also substantial for ordinal profusion scoring. This pattern of ILO readings could reflect an effect of age, or a true high rate of pneumoconiosis but increased sensitivity by non-B clinician readers cannot be ruled out. A sample of 500 films was reviewed by independent ILO B-reader for quality assurance purposes and results are reported.

DoE Former Worker Medical Screening Programs

The University of Iowa College of Public Health medical screening program recruited former nuclear weapons workers from the state of Iowa starting in 2001 and 2006.

Part of the nationwide screening program funded by DoE under Public Law 102-484 Section 3162 of the 1993 Defense Authorization Act

Goal: Identifying, locating, and providing former Iowa Army Ammunition Plant (AAMP) and Ames Lab DoE workers employed in research and manufacture of nuclear weapons with medical evaluation of long term health effects that might have resulted from employment.

DoE Former Worker Medical Screening Programs

Site 1 – Iowa Army Ammunition Plant Located in Middletown, Iowa - primarily manufacture of conventional munitions for Department of Defense (DoD) but nuclear weapons dismantled and repaired between 1949 and mid-1975 on Line 1 under Atomic Energy Commission (AEC, pre-DoE) contractual agreements with Fisk-Mason Company.

Workplace approximations 2000

Exposures (expanded list available at http://www.epd.gov/index.cfm)
- Ionizing radiation
- High Explosives incl. Barium
- Beryllium
- Asbestos
- Silica
- Solvents

Exposures (expanded list available at http://www.epd.gov/index.cfm)
- Long duration (uranium, plutonium, thorium)
- Beryllium
- Asbestos
- Silica
- Solvents

Participants for the FWP screenings were recruited by mail, telephone, press releases, town-hall meetings and word of mouth. All participating in the medical screenings were offered CXR, spirometry and testing for Beryllium sensitization (BeLPT) and occupational history.

Postero-Anterior (PA) films were reviewed by three occupational medicine clinicians using the ILO system, blinded to radiologist’s reports and each other’s readings but not to the industry and its exposures. The most recent CXR with three ILO readings was used for analysis. Abnormal profusion scoring defined as \( \geq 1 / 0 \).

A sample of 500 films (read by three readers), including all those read as consistent with work-related parenchymal and/or pleural disease by ILO standards were reviewed by an external ILO B-reader blinded to exposure history, personal characteristics, radiologist’s reports and other readings.

Spirometry was performed according to American Thoracic Society (ATS) guidelines using Third National Health and Nutrition Examination Survey (NHANES III) reference population and American College of Occupational and Environmental Medicine (ACOEM) recommended lower limit of normal (LLN) algorithm for interpretation.

Beryllium Sensitization (BeLPT) was defined as two abnormal blood Beryllium Lymphocyte Proliferation Tests (BeLPT) or one abnormal + one borderline BeLPT result from any accredited laboratory. Non-normal initial BeLPT were repeated with a split test sent to two laboratories within 6-12 months of the initial testing. Normal results offered repeat testing within three to five years.

Highest ever exposure potential to beryllium and asbestos was estimated by industrial hygienists based on job codes/job titles in subprograms for former nuclear weapons workers and plant employment records, interviews. Jobs with highest exposure potential to beryllium (frequent, direct exposure); millwright, tool and die maker, machinist. Jobs with occasional exposure potential to beryllium: production operator, engineer/scientist, pipetiper, plumber, electrician, laundry operator. Jobs with highest exposure potential to asbestos (frequent, direct exposure): pipetiper, plumber, carpenter. Jobs with occasional exposure potential to asbestos: power plant operators, auto/equipment mechanics.

Analysis

Multivariate logistic regression was used to validate ILO readings in models with known predictors of parenchymal and/or pleural disease. Modeling was done separately for each reader and with ILO abnormalities as a dependent variable 1 grouped together i.e. ever abnormal (Y/N) and 2) modeled separately i.e. isolated parenchymal abnormalities (PA) in a separate model from pleural (PL) and coincident parenchymal pleural abnormalities (PA+PL). Model fit assessed by AIC.

No smokers were defined as those with less than 20 pack smoking history during lifetime or less than one cigarette smoked per day for one year. Ex-smokers were defined as those who quit smoking \( \geq 1 \) month before the survey. Pack-years were calculated according to pack-years smoked formula; cigarette conversion for other types of tobacco use - 1 small cigar = 3 cigarettes; 1 regular cigar = 5 cigarettes; 1 pipe + 4 cigarettes.

Inter-reader concordance was assessed by calculating simple and weighted kappa statistic according to Fleiss (1971) and Cohen (1960), separately for each ILO clinical reader compared to the B-reader. Generalized kappa (generalized Pi, Scott 1955) was calculated for all four readers together. Concordance was assessed separately for 1) ever-abnormal film incl. PA and PA+PL and PL (Y/N); 2) ILO type of abnormality i.e. PA vs. PA+PL vs. PL vs. NL; and 3) for ILO profusion scoring grouped according to (modified) Miller et al. 1996, Group D: 0/0, 0/1; Group 1: 1/0, Group 2: 1/1, Group 3: 2/1; Group 4: 2/2+3/3.

Clinician readers were significantly more likely to report chronic granulomatous disease and emphysema and less likely to report effusion than the B-reader.

Clinic and ILO B-readings showed a similar pattern of increased likelihood of abnormal spirometry results associated with abnormal ILO readings. There was a suggestion of some degree of specifying the association between abnormal ILO readings consistent with pneumoconiosis and restrictive and or mixed pulmonary disease. Clinician and ILO B-readings were also similar as regards associations between increased age and likelihood of ILO abnormality consistent with pneumoconiosis, with odds ratios ranging from 1.03 to 1.08 for increased in abnormal ILO reading associated with each year increase in age.

Concordance between clinician non-B readers and the ILO B-reader was the highest for films with the highest and lowest profusion scores.

The increase in sensitivity of clinician readers has been reported before (Gilth et al., 2004) and cannot be fully explained by this study. The association between abnormal spirometry and abnormal ILO reading characterization suggest some degree of validation, however without a true Gold Standard sensitivity and specificity cannot be calculated. Use of standardized, quantifiable methods of interpretation of interstitial opacities and patterns using CAT scan technologies may be assist in addressing such questions.