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# The Prevalence of Pulmonary and Upper Respiratory Tract Symptoms and Spirometric Test Findings Among Newspaper Pressroom Workers Exposed to Solvents

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The Prevalence of Pulmonary and Upper Respiratory Tract Symptoms and Spirometric Test Findings Among Newspaper Pressroom Workers Exposed to Solvents

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Abstract

To investigate the relationship between exposure to organic solvents and the presence of pulmonary and upper respiratory tract mucous membrane symptoms, we conducted a cross-sectional study of 215 newspaper pressroom workers who were occupationally exposed to organic solvent and lubricant mixtures. Thirty-four compositors, who were not occupationally exposed to the solvents or lubricants, served as controls. Pressroom workers and compositors underwent spirometric testing and were also asked about the presence of cough, phlegm, hemoptysis, dyspnea, wheezing, chest tightness, nose or throat irritation, eye irritation, and sinus trouble. The spirometric results did not significantly differ between the two groups. However, the pressroom workers were significantly more likely to report pulmonary or upper respiratory tract mucous membrane symptoms than were compositors ( $P < 0.005$ ). An exposure-response relationship could be demonstrated when comparing the number of solvents exposed with the total number of symptoms ( $P < 0.001$ ). Similarly, an exposure-response relationship could be demonstrated when comparing the frequency of use of each of the seven solvents with the total number of symptoms ( $P < 0.002$ ). Each

of these findings was supported in a multivariable linear regression model that adjusted for potential confounders such as age, smoking history, and number of years in the industry. A high prevalence of these symptoms was reported even though the degree of exposure to solvents and lubricants was within the current permissible exposure limits.

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Many occupational health hazards have been described among newspaper pressroom workers. Numerous studies have reported an increased mortality rate among newspaper trades-people, usually resulting from malignancy or vascular disease. [1-3](#) The most often cited hazard is an increased risk of malignancy, including lung cancer, [1,3-5](#) bladder cancer, [5](#) cancer of the renal pelvis, [5](#) hepatic cancer, [5](#) oropharyngeal cancer, [3,4](#) and melanoma. [6,7](#) However, the relevance of these earlier mortality studies to modern pressworkers in industrialized countries is not clear because the newspaper printing process has evolved significantly since the time of these reports. The older letterpress printing process involved the use of lead plates, generated significant amount of "ink fly," and used relatively few solvents. In contrast, the modern offset lithographic process no longer uses lead plates, generates a minimal amount of "ink fly," but uses a wider variety of solvents. In addition, new industrial regulations have been implemented since the time of these reports and have decreased the allowable amount of worker's exposure to various irritants, toxins, and carcinogens.

Furthermore, there have been relatively few morbidity studies among pressworkers. Several studies have reported a high prevalence of dermatitis resulting from exposure to organic solvents, inks, or paper. [8-12](#) Other reported conditions include glomerulonephritis, [13](#) and proteinuria, hematuria, or leukocyturia. [14](#) The prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among newspaper pressroom workers have not been reported previously, especially for those using the modern offset lithographic process. Because of perceived health and safety concerns among employees of a large printing press in northeastern United States, a cross-sectional health survey was conducted to investigate the prevalence of dermatologic conditions, genitourinary abnormalities, and pulmonary or upper respiratory tract mucous membrane symptoms. The prevalence of the dermatologic conditions [12](#) and genitourinary abnormalities [14](#) have previously been reported. We now report the prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among press workers.

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Methods

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Subjects

The eligible study population consisted of 284 full-time pressroom workers from a large newspaper printing plant located in the northeastern United States. Newspapers are printed at two plants: a main printing facility and a satellite plant. At the time of this survey, 203 individuals worked at the main printing facility, which also houses the administrative and composition offices (plant 1), and 81 were employed at the second plant (plant 2). All workers, who were members of the International Printing and Graphic Communications Union, were given the opportunity to participate in the study and were encouraged to do so by both union and management. A descriptive pamphlet was developed by the investigators and mailed to the workers before the commencement of the study to provide an understanding of what was involved and how the study results would be used. Two hundred fifteen of the 284 pressroom workers (76%) chose to participate. In addition, 34 of the 262 compositors (13%), who worked at plant 1 but not in the pressroom, agreed to participate in the study as referents.

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Job and Process Descriptions

Plant 1 has been in operation since 1955, and plant 2 has been in operation since 1984. Approximately 500,000 newspapers are printed each weekday, and over 750,000 are printed for the Sunday edition. Before 1977, plant 1 used the letterpress (raised-surface) printing process, which included the handling of lead plates. Workers were exposed to inks as well as to ink mist thrown off by inking rollers. Cleanup involved the use of solvents, such as kerosene. The letterpress operation was phased out in 1976, and plant 1 was converted to the di-litho (lithographic)

process. With the advent of di-litho operations, the use of lead plates ceased. Di-litho printing involves the use of a plate treated chemically so that ink adheres only to the print image. Although generation of "ink fly" from high-speed litho presses is reportedly minimal, workers are exposed to di-litho and a wider variety of wash-up solvents than are workers in the letterpress operation. Di-litho operations were gradually phased out of plant 1 between 1979 and 1987 and replaced by the offset process. Plant 2 opened in December 1983 as an offset operation. In the offset process, also a lithographic operation, a plate cylinder is sprayed by a fountain solution then inked by an ink roller. The print image repels the solution and retains the ink for transfer to a blanket cylinder. The blanket cylinder then offsets the image to continuous printing stock.

Exposures among pressroom workers vary depending on the task performed. Workers progress through a series of positions on the working press. Entry-level positions include the paper handler, who feeds paper to the press, and the plate handler, who delivers and removes plates. Apprentice job responsibilities include oiling and greasing the press, splicing new paper rolls to old, and paper folding and alignment. Pressworkers run the presses and set the ink adjustment. The floor supervisors (foremen) check the quality of the newspaper and may perform any of the other operators' tasks as necessary. All apprentice and pressman positions become involved in "plating up" the press (putting plates on printing cylinders). Job duties also vary by shift. Typically, the day crew "makes ready" the presses by performing cleanup and maintenance and changing blankets and rollers, and the night crew operates the presses for newspaper production. An inventory of products regularly used in these pressrooms is listed in [Table 1](#). By contrast, the compositors are responsible for composing the printed page, do not have contact with ink or lubricants, and rarely have contact with cleaning solvents.

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#### Work Environment Evaluation

The work environment was assessed by a certified industrial hygienist (T.S.) via plant walk-through surveys, informal discussions with workers, observations of work practice during both production and maintenance shifts, and measurements of personal breathing zone and general-area air concentrations of organic solvents and several glycol ethers. All substances used during the printing process or during maintenance and cleaning activities were identified, and material safety data sheets (MSDS) reviewed for each. Further analysis of several process solutions and cleaning solvents was performed using gas chromatography with mass spectrometry detection (GC-MSD) according to published National Institute for Occupational Safety and Health (NIOSH) methods [15](#) to further characterize the samples and identify components not specified on the MSDS.

A preliminary analysis of the major printing solutions (fountain solutions, blanket wash) and cleaning agents (mixed cleaning solvent, kerosene, all-purpose cleaner, solvent type 1) indicated that these organic solvents contain a blend of naphthas, and for some solutions, small amounts of glycol ethers. A list of products used in newspaper printing and their major constituents are presented in [Table 1](#). Naphtha is a general term that refers to a nonuniform blend of petroleum hydrocarbons containing aliphatic and aromatic components, with the predominant hydrocarbon species and aromatic content varying among individual products.

Gas chromatographic analysis of bulk air samples were performed by an industrial hygienist according to published NIOSH methods. [15](#) The representative bulk air samples obtained in the pressroom resulted in complex chromatograms containing primarily C<sub>9</sub> to C<sub>14</sub> aliphatic hydrocarbons, with small amounts of C<sub>9</sub> to C<sub>10</sub> aromatics, toluene, and xylene. Based on this preliminary information, full-shift personal breathing zone and general-area air samples to assess organic solvent exposure were quantified for total naphthas because it was not feasible to quantify the individual peaks present in each chromatogram. Air samples were collected on activated charcoal tubes, using calibrated SKC Model 222 personal sampling pumps (SKC Inc., Eighty Four, PA), operating at flow rates of 50 or 100 cc/minute. The charcoal-tube samples were desorbed with carbon disulfide and analyzed by gas chromatography with flame ionization detection (GC-FID). Total naphtha levels were determined using either Stoddard (Super Industrial Products, Springfield, MA) solvent (which had a chromatogram similar to representative bulk air samples) or dodecane as standards.

Because the presence of naphthas interfered with the analysis of glycol ethers by gas chromatography with flame

ionization detection, the technique of multidimensional gas chromatography was used to minimize interferences and maximize selectivity. Air samples were collected on activated charcoal tubes using calibrated SKC Model 222 personal sampling pumps operating at flow rates of 50 to 100 cc/minute. The charcoal-tube samples were desorbed with 5% methanol in methylene chloride as outlined in NIOSH 1403.[16](#) Quantitation of the individual glycol ether compounds was done using multidimensional gas chromatography/mass spectrometry.

Full-shift personal and area air sampling was conducted for measurement of particulate concentrations (primarily paper dust) during the newspaper production shifts. Five-micron pore size polyvinyl chloride filters and calibrated, battery-operated sampling pumps operating at flow rates of 2 liters/minute and 1.7 liters/minute were used to collect total and respirable particulates, respectively. A total of 68 air samples were collected, including 38 personal breathing zone air samples and 30 general-area air samples. Samples were obtained from the paper-handlers (high expected particulate exposure) working primarily in the lower deck of the plant as well as from the pressman (low expected particulate exposure) working primarily on the first or the second deck of the plant.

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### Questionnaire

A comprehensive health questionnaire was developed and mailed to all pressworker and compositor participants. Collection of data on job processes and job description was intended to help provide an exposure assessment based on the employee's work history. Exposure questions included both recent and long-term use of solvents and other substances at work, at home, or as part of a hobby. In particular, information was obtained about the frequency of use of seven solvents, cleaners, and lubricants that were known to have been used at the time of the present study at plants 1 and 2 ([Table 1](#)). The seven compounds were specifically included as a result of preliminary industrial hygiene evaluation and assessment of the workplace. This survey indicated that these materials were most prevalent, most intensely used, and/or most commonly cited by workers as potential causes of problems. The medical history assessed the prevalence of symptoms referable to the pulmonary or upper respiratory tract systems that were of specific interest in this survey. Specifically, subjects were asked about the presence of chronic cough, phlegm, wheezing, dyspnea, hemoptysis, chest tightness (pulmonary symptoms), and nose or throat irritation, eye irritation, or sinus trouble (upper respiratory tract mucous membrane symptoms). The total number of these symptoms was recorded for each subject and used as the primary outcome of the study.

Finally, information concerning medications, habits, and hobbies was collected for evaluation as potential confounders. A trained interviewer reviewed the questionnaire for completeness.

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### Pulmonary-Function Testing

Study subjects underwent spirometric testing while in a seated position, using an 8-liter water-sealed field spirometer (W.E. Collins, Co., Braintree, MA) according to the American Thoracic Society performance criteria.[17](#) Trained technicians and physicians performed the spirometric tests without knowledge of the subject's exposure status or questionnaire data. Forced expiratory volume in one second (FEV<sub>1</sub>), forced vital capacity (FVC), peak expiratory flow rate (PEFR), and the ratio of FEV<sub>1</sub> to FVC were recorded. The best values for each parameter were used in analysis. The percentage of predicted value for each spirometric value was calculated according to Knudson,[18](#) which takes into consideration the subject's race, age, sex, and height.

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### Statistical Methods

A statistical analysis was performed using the two-tailed t test for unpaired data to compare the means of the demographic statistics; categorical data were analyzed using Fisher's exact test. The FEV<sub>1</sub>, FVC, and PEFR were compared using the two-tailed t test for unpaired data. Because of non-normality of the data, the ratio of FEV<sub>1</sub> to FVC was compared using the Wilcoxon rank sum test. A crude comparison of the prevalence of each symptom in the two groups was performed using Fisher's exact test. The effects of age, smoking history, number of years in the printing industry, and the duration of average work-week were each examined for potential confounding. Each of



these variables was dichotomized at the median value, based on the actual distribution of data, so that the subjects were categorized as <47 years of age ("younger") vs ≥47 years of age ("older"); ≤15 pack-years (no significant smoking history) vs >15 pack-years of tobacco history (significant smoking history); those who had worked >28 years in the industry vs ≤28 years; and those who worked <45 hours per week vs ≥45 hours per week. The median values were chosen and the subjects dichotomized before the data was analyzed.

Linear regression models were constructed to account for the effects of potential confounders on results of the spirometric testing. The models adjusted for age, height, smoking history, and number of years in the printing industry. The study population was already limited to white men.

The total number of pulmonary and upper respiratory tract mucous membrane symptoms was recorded for each subject (possible range of 0 to 9 symptoms). A Mantel-Haenszel test for trend was performed to compare the total number of symptoms as a function of job classification. Subjects were also classified according to the number of solvents and lubricants exposed: use of 0 to 1, 2 to 3, 4 to 5, or 6 to 7 types of the seven solvent and lubricant mixtures. A Mantel-Haenszel test for trend was performed to compare the total number of symptoms as a function of exposure to solvents and lubricants. In addition, subjects were classified according to the frequency of use of a given solvent or lubricant as follows: none, <once per week, and ≥once per week. A Mantel-Haenszel test for trend was performed to compare the prevalence of each symptom as a function of the frequency of use of a given solvent or lubricant. Linear regression models were constructed to account for the effects of potential confounders on each of these relationships. The models adjusted for age, smoking, history, and the number of years in the printing industry. All statistical analyses were performed on SAS® software (SAS Institute Inc., Cary, NC).

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## Results

Of the 249 workers who chose to participate in the survey, one press-room worker did not return the questionnaire and was removed from the study. In addition, two nonwhite pressroom workers and one female compositor were removed from the analysis. As a result, 245 white male workers were analyzed. The descriptive characteristics of the total cohort are summarized in [Table 2](#). The compositors were, on average, 10 years older than the pressroom workers and had spent more years in the trade. The participating pressroom workers were representative of the total pressroom workers in age and years employed in printing.

The industrial hygiene evaluation revealed the concentration of total naphthas in 54 personal breathing zone air samples obtained on pressroom workers to be 0.5 to 105 mg/m<sup>3</sup>. Personal exposures to total naphthas were well below the applicable environmental evaluation criteria established by the Occupational Safety and Health Administration,[19](#) the American Conference of Governmental Industrial Hygienists,[20](#) and NIOSH.[15](#)

Of the five personal air samples quantified for five specific glycol ethers (butyl cellosolve, butoxypropanol, diethylene glycol monobutyl ether, dipropylene glycol monomethyl ether, and butoxyethoxyethanol), only one sample contained a detectable level of any of the glycol ethers. This sample, obtained on a worker performing maintenance and cleaning activities, had a concentration of 2.6 mg/m<sup>3</sup> butyl cellosolve. Although the number of personal air samples was small, results from the analysis of 12 area air samples obtained in areas expected to have the greatest potential glycol ether concentrations, were also quite low. Area air concentrations of individual glycol ethers or glycol ethers combined were less than 4 mg/m<sup>3</sup>, with the exception of one area air sample collected during the maintenance shift that had a concentration of 13 mg/m<sup>3</sup> butyl cellosolve. All personal breathing zone and general air samples for glycol ethers were below the existing environmental evaluation criteria for butyl cellosolve and dipropylene glycol methyl ether. Occupational exposure standards have not been established for the other glycol ethers analyzed during this evaluation.

The spirometric pulmonary-function test results were not significantly different between the compositors and pressworkers ([Table 2](#)). A multivariable linear model taking into consideration the effects of age, height, smoking history, and number of years in the industry did not change the results of the crude analysis. The model did not adjust for race or sex because the study population was already limited to white men.

Although the airborne concentrations of naphthas and glycol ethers were all quite low, the prevalence of pulmonary and upper respiratory tract mucous membrane symptoms was generally higher among press-workers than compositors, as shown in [Table 3](#). Eight of the nine symptoms were more prevalent among pressworkers than compositors, but the differences were statistically significant only for wheezing ( $P < 0.03$ ; relative risk [RR], 2.9; 95% confidence interval [CI], 1.1 to 7.7) and eye irritation ( $P < 0.03$ ; RR, 1.7; 95% CI, 1.1 to 2.5). Hemoptysis was more prevalent among compositors than pressworkers, but the difference was not statistically significant. Older subjects (age  $\geq 47$  years) were more likely to experience dyspnea, compared with younger subjects (age  $< 47$  years,  $P < 0.04$ ); compared with those without a significant smoking history ( $\leq 15$  pack-years), those with significant smoking history ( $> 15$  pack-years) were more likely to experience coughing ( $P = 0.003$ ), wheezing ( $P < 0.04$ ), chest tightness ( $P < 0.02$ ), and dyspnea ( $P = 0.002$ ); and those who had worked  $\geq 28$  years in the printing industry were more likely to experience phlegm, compared with those who had worked  $< 28$  years. The duration of the average work-week ( $< 45$  hours/week vs  $\geq 45$  hours/week) did not significantly affect the prevalence of any pulmonary or upper respiratory tract mucous membrane symptom.

The distribution of the total number of pulmonary and upper respiratory tract mucous membrane symptoms (chronic cough, phlegm, wheezing, dyspnea, hemoptysis, chest tightness, nose or throat irritation, eye irritation, or sinus trouble) among compositors and pressworkers is displayed in [Fig. 1](#). Compared with compositors, pressworkers were more likely to experience these symptoms (Mantel-Haenszel test for trend,  $P = 0.005$ ). The multivariable linear model that accounted for age, number of years in the printing industry, and pack-years of smoking history found job classification (compositors vs pressworkers) to be a significant predictor of total number of symptoms ( $[\beta] = 0.9513$ ,  $P = 0.01$ ).

When the analysis was limited just to the pulmonary symptoms (chronic cough, phlegm, wheezing, dyspnea, hemoptysis, or chest tightness), pressworkers were also more likely to experience these symptoms than were compositors (Mantel-Haenszel test for trend,  $P = 0.04$ ). However, the multivariable linear model that accounted for age, number of years in the printing industry, and pack-years of smoking history no longer found job classification (compositors vs pressworkers) to be a significant predictor of the number of pulmonary symptoms ( $[\beta] = 0.4640$ ,  $P = 0.09$ ).

When the analysis was limited just to the upper respiratory tract mucous membrane symptoms (nose or throat irritation, eye irritation, or sinus trouble), pressworkers were again more likely to have such symptoms than were compositors (Mantel-Haenszel test for trend,  $P = 0.01$ ). The multivariable linear model that accounted for age, number of years in the printing industry, and pack-years of smoking history found job classification (compositors vs pressworkers) to be a significant predictor of the number of symptoms ( $[\beta] = 0.4898$ ,  $P < 0.01$ ).

To test for an exposure-response relationship, subjects were classified according to the number of solvents and lubricants used: use of 0 to 1, 2 to 3, 4 to 5, or 6 to 7 types of the seven solvent and lubricant mixtures. Using subjects with 0 to 1 solvent exposure as the standard population, the relative prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among pressworkers as a function of solvent exposure is displayed in [Fig. 2](#). A clear "exposure-response" can be demonstrated where subjects with higher degree of solvent or lubricant exposure tend to experience a higher number of total symptoms (Mantel-Haenszel test for trend,  $P = 0.001$ ). The multivariable linear model that accounted for age, number of years in the printing industry, and pack-years of smoking history found the degree of solvent and lubricant exposure to be a significant predictor of the number of symptoms ( $[\beta] = 0.3578$ ,  $P < 0.002$ ).

As another way to test for exposure-response, subjects were classified according to the frequency of use of a given solvent or lubricant: "none," "occasional" ( $< \text{once per week}$ ), and "frequent" ( $\geq \text{once per week}$ ). The prevalence of chest tightness, wheezing, eye irritation, and nose-throat irritation as a function of individual solvent or lubricant exposure is summarized in [Table 4](#). In a multivariable logistic model that accounted for age, number of years in the printing industry, and pack-years of smoking history, the frequency of use of isopropanol and solvent type 1 were significantly correlated with the prevalence of chest tightness ( $P < 0.03$  and  $P < 0.05$ , respectively). A similar model found the frequency of use of Mobil (Fairfax, VA) Oil® 600 W ( $P < 0.05$ ), isopropanol ( $P = 0.0003$ ), and plate



cleaner ( $P < 0.04$ ) to be significantly associated with the prevalence of wheezing. The frequency of use of kerosene ( $P = 0.001$ ), solvent type 1 ( $P = 0.05$ ), and all-purpose cleaner ( $P = 0.001$ ) were significantly associated with the prevalence of eye irritation. The frequency of use of Mobil Oil® 600 W ( $P < 0.01$ ), kerosene ( $P = 0.001$ ), all-purpose cleaner ( $P < 0.05$ ), and isopropanol ( $P = 0.002$ ) were significantly associated with prevalence of nose and throat irritation. Finally, multivariable linear models that accounted for age, number of years in the printing industry, and pack-years of smoking history found the frequency of use of each of the seven solvents or lubricants to be significantly correlated with the total number of pulmonary and upper respiratory tract mucous-membrane symptoms ([Table 5](#)).

To account for the potential effect of airborne particulates on the prevalence of these symptoms, the particulate concentrations in 38 personal breathing zone air samples were measured. In the samples obtained from employees working primarily in the lower deck of the plant (ie, paper handlers), the total particulate concentration ranged from 0.05 to 6.60 mg/m<sup>3</sup>. For employees working primarily on the first or the second deck (ie, pressmen), the total particulate concentrations in the personal breathing zone air samples ranged from zero to 0.58 mg/m<sup>3</sup>, with the exception of one person whose level was 9.93 mg/m<sup>3</sup>. In general, paper handlers were exposed to a higher level of particulates than pressmen. The spirometric pulmonary function test results and prevalence of pulmonary and upper respiratory tract mucous membrane symptoms were compared between the paper handlers ( $n = 23$ ) and pressmen ( $n = 133$ ) to test whether particulate exposure was a confounder in this analysis. The percentage predicted FEV<sub>1</sub> (98.9% vs 95.6% for paper handlers and pressmen, respectively), FVC (99.3% vs 99.1%), PEFR (97.4% vs 96.2%), and the ratio of FEV<sub>1</sub>/FVC (99.9% vs 96.3%) did not differ significantly between the two groups. A multivariable linear model taking into consideration the effects of age, height, smoking history, and number of years in the industry did not change the results of the crude analysis (data not shown). Similarly, the prevalence of cough (39.1% vs 34.8% for paper handlers and pressmen, respectively), phlegm (36.8% vs 39.1%), hemoptysis (3.8% vs 0%), wheezing (24.4% vs 26.1%), chest tightness (23.3% vs 21.7%), dyspnea (20.3% vs 13.0%), eye irritation (58.7% vs 56.6%), nose-throat irritation (51.1% vs 34.8%), or sinus trouble (18.3% vs 13.0%) did not differ statistically between the two groups. A multivariable logistic model adjusting for age, smoking history, and number of years in the industry did not change the results of the crude analysis. Finally, the total number of pulmonary and upper respiratory tract mucous membrane symptoms (chronic cough, phlegm, wheezing, dyspnea, hemoptysis, chest tightness, nose or throat irritation, eye irritation, or sinus trouble) among paper handlers and pressmen did not differ significantly (multivariable linear model [ $\beta$ ] = 0.086,  $P = 0.90$ ). Thus exposure to particulates was not a significant confounder in this study.

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## Discussion

We and other researchers have previously demonstrated that modern newspaper pressroom workers using the offset lithographic printing process are at increased risk of dermatitis,[8-12](#) leukocyturia, hematuria, and proteinuria.[14](#) The results of this study demonstrate a high prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among modern pressroom workers who use the offset lithographic printing process. We believe that these symptoms were associated with the use of numerous solvents and lubricants during the printing process. In support of this conclusion are the exposure-response effects that could be demonstrated between the number of symptoms and the number of solvents and lubricants used and between the number of symptoms and the frequency of use of each individual solvent or lubricant. Multiple linear regression models that adjusted for the effects of age, smoking status, and number of years in the trade still found the relationships to be statistically valid. These health hazards were observed even though the industrial hygiene evaluation revealed the concentration of total naphthas and glycol ethers to be within regulatory standards established by the Occupational Safety and Health Administration,[19](#) the American Conference of Governmental Industrial Hygienists,[20](#) and NIOSH.[15](#) In our prior study,[12](#) we had demonstrated that the solvents and lubricants routinely used in the modern newspaper printing process can have an irritant effect on the skin. Similarly, the higher prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among pressworkers is also likely a result of an irritant effect of these solvents and lubricants on the mucous membranes of the pulmonary and upper respiratory tract system.

Despite the higher prevalence of pulmonary and upper respiratory tract mucous membrane symptoms among pressworkers, the spirometric test results were not significantly different between pressworkers and compositors. However, a lack of a difference in spirometric tests does not imply that the higher prevalence of symptoms should be regarded simply as a nuisance to the workers. Large, population-based longitudinal studies [21,22](#) have suggested that the presence of chronic respiratory symptoms is a significant independent risk factor for accelerated decline in lung function. For example, in a community-based 12-year study involving 3948 randomly selected subjects, [22](#) the presence of chronic cough or phlegm identified individuals at risk for accelerated decline in FEV<sub>1</sub> even when adjusted for sex, height, age, and smoking. Thus further studies that address the long-term respiratory health consequences of newspaper pressworkers appear to be warranted.

As demonstrated in [Table 5](#), each of the seven solvents was associated with a higher prevalence of pulmonary and upper respiratory tract mucous membrane symptoms. However, individual symptoms were associated with exposure to some solvents and lubricants but not others. For example, chest tightness was associated with the use of isopropanol ( $P < 0.03$ ) and solvent type I ( $P < 0.05$ ) but not with the use of the other substances. In contrast, wheezing was associated with the use of Mobil Oil® 600 W ( $P < 0.05$ ), kerosene ( $P = 0.05$ ), plate cleaner ( $P < 0.04$ ), and isopropanol ( $P < 0.001$ ) but not with the use of the other substances. Similarly, eye irritation was associated with the use of kerosene ( $P < 0.001$ ), all-purpose cleaner ( $P < 0.001$ ), or solvent type I ( $P = 0.05$ ), and nose-throat irritation was associated with the use of Mobil Oil® 600 W ( $P < 0.01$ ), kerosene ( $P = 0.001$ ), all-purpose cleaner ( $P < 0.05$ ), and isopropanol ( $P = 0.002$ ). Thus each solvent or lubricant appears to have a different effect on the prevalence of various symptoms.

We chose the total number of pulmonary and upper respiratory tract mucous membrane symptoms as the primary outcome of the study because the power to detect a 25% difference in the prevalence of any individual symptom (ie, 20% vs 15%) would have been only 6%, using  $[\alpha]$  of 0.05 and the available sample size. In addition, because nine symptoms and four spirometric results would have been compared, the need to account for multiple comparisons would have reduced the power even further.

Exposure to airborne particulates may have been a potential confounder in this study. However, the levels of particulate exposure were generally low in this group of workers. Furthermore, spirometric results or the prevalence of symptoms did not differ significantly between paper handlers (higher particulate exposure) and pressmen (lower particulate exposure). Thus it is unlikely that particulate exposure was a significant confounder in the study.

In our analysis, each symptom was given the same weight regardless of the severity of the symptom. For example, an individual with a mild eye irritation was given the same weight as someone who had severe chest tightness. Although a more refined analysis that adjusts for the severity of each symptoms would have been informative, our questionnaire lacked the detailed severity data that would permit such an analysis. Regardless, given the strong exposure-response effects that could be demonstrated between the number of symptoms and the number of compounds used and between the number of symptoms and the frequency of use of each compound, it is unlikely that an analysis that adjusts for the severity of symptoms would significantly alter the final conclusion of the study.

Another potential limitation of the study is that only 13% of the eligible compositors chose to participate in the study as referents. It is conceivable that those who chose to participate in the study were not representative of the entire nonexposed population. Compositors were chosen as controls for the study because all other potential control populations in the plant were exposed to these solvents to some extent. In contrast, none of the compositors had ever worked in the pressroom nor were they exposed to any hazardous chemicals. However, the compositors were significantly different from the study subjects in some demographic features. The compositors were, on average, 10 years older than the pressroom workers and had spent 6 more years in the trade. Nevertheless, both older age and more years in the trade would have biased the analysis toward null because it would be expected that these factors would have been associated with more symptoms rather than fewer symptoms. Furthermore, the multivariable linear regression analysis that adjusted for age and number of years in the trade as well as for smoking still found a strong association between the prevalence of pulmonary and upper respiratory tract mucous membrane symptoms and the use of these compounds.

In summary, our study suggests that actively working newspaper pressworkers are more likely to experience pulmonary and upper respiratory tract mucous membrane symptoms than control subjects. The higher prevalence of symptoms appears to be a result of exposure to various solvents and lubricants used in the modern offset lithographic printing process, even though the degree of exposure was within the current permissible exposure limits.

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## Demographics of Suicide

April may indeed be the "cruellest month," at least with respect to suicide rates. Suicides peak not during the Christmas holidays or the winter as a whole, as one might expect, but during the spring, usually April. Speculation as to why focuses on both biological factors (depression and suicide have been associated with fluctuations in levels of the neurotransmitter serotonin, which may occur as hours of daylight increase) and behavioral factors (those experiencing depression may expect it to lift when spring arrives and may become even more depressed when it doesn't). A geographic pattern to suicide is also evident: rates in the western mountain states are twice as high as the national average of 12 per 100,000 people. Isolation undoubtedly plays a role; in addition, these are among the states with the greatest proportions of new residents, a fact that bolsters a long-postulated link between mobility, which weakens a person's social supports, and suicide.

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