Respiratory Function and Immunological Status in Paper-Recycling Workers

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The respiratory function and immunological status of workers employed in the paper recycling industry were studied. The mean age of the 101 studied workers was 41 years, and the mean duration of their exposure was 17 years. A group of 87 unexposed workers of similar age, duration of employment, and smoking history was studied for the prevalence of chronic respiratory symptoms. Lung function in the paper workers was measured by recording maximum expiratory flow volume (MEFV) curves and recording forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and maximum expiratory flow rates at 50% and the last 25% of the FVC (FEF_{50}, FEF_{25}). Immunological studies were performed in all 101 paper workers and in 37 control workers (volunteers). These included skin-prick tests with paper-dust extracts and other nonoccupational allergens, as well as the measurement of total serum immunoglobulin E. Significantly higher prevalences of all chronic respiratory symptoms were found in paper compared with control workers ($P < 0.01$). The highest prevalences were found for chronic cough (36.6%), chronic phlegm (34.7%), chronic bronchitis (33.7%), sinusitis (31.7%), and dyspnea (18.8%). Occupational asthma was diagnosed in four (4.0%) of the paper workers. A logistic regression analysis performed on chronic respiratory symptoms of paper workers indicated significant effects of smoking and exposure, with the smoking effect being the most important. Multivariate analysis of lung-function parameters indicate significant effects of exposure. For paper workers, the measured FEF_{50} and FEF_{25} were significantly decreased, compared with predicted values, suggesting obstructive changes located primarily in smaller airways. Among 101 tested paper workers, 16 (15.8%) had positive skin-prick tests to at least one of the paper extracts; none of the control workers reacted to these extracts. Increased serum IgE levels were found in 21% of the paper workers and in 5% of control workers ($P < 0.05$). Paper workers with positive skin-prick tests to any of the paper and/or other tested extracts had higher prevalences of chronic respiratory symptoms and lower measured lung-function tests compared with predicted than did those with negative skin-prick tests, but the differences were not statistically significant. The measured concentrations of total and respirable dust in this industry were higher than those recommended by Croatian standards. Our study suggests that work in the paper-recycling industry is associated with respiratory impairment and that sensitive workers employed in this industry may be at particular risk of developing chronic respiratory abnormalities.

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Substances of plant origin have been reported as a cause of airway disease in industrial workers.[1,2] Rylander[2] noted that animal, vegetable, and microbial aerosols (organic dusts) induce a variety of pulmonary diseases and subjective symptoms.

Atav and Spencer[3] suggested that the high prevalence of illness among paper workers might be due to the occupational environment. Toren et al[4–6] and Deprez et al[7] reported that employment in paper mills was associated with an increased risk of bronchial asthma and chronic obstructive pulmonary disease. Ericsson et al[8] found a dose-dependent increase of upper respiratory symptoms in paper workers. Toren et al[9] described increased prevalences of both upper and lower airway tract symptoms as well as asthma (but without lung-function impairment) in paper workers. Sigsgaard et al[10] described respiratory and mucosal symptoms (particularly chest tightness and itchy nose, throat, and eyes) as well as lung-function changes in garbage handlers and recycling workers, indicating an effect of this work environment on the respiratory system. Heederik et al[11] reported impaired lung-function tests in workers exposed to soft-paper dust, with positive intradermal reactions. Jarvholm et al[12] studied workers exposed to heavy concentrations of paper dust and found increased lung elastic recoil pressure, increased residual volume, and a significant frequency of lower respiratory tract symptoms. These authors suggested that the observed pulmonary function impairment was the result of a nonspecific

reaction to high levels of paper dust. Gautam et al[13] described multiple environmental exposures to respiratory irritants in paper mills in India, including those to wood dust, talc dust, caustic lime dust, irritating chlorine gas, and mercaptan odors.

In the study presented here, we investigated the effect of exposure to organic dust on respiratory function and immunological status in workers employed in a plant involved in the recycling of waste paper collected from households and industry.

Subjects and Methods

Paper Processing

The paper industry manufactures many types and qualities of paper. For economic and environmental reasons, it has become desirable to recycle the large quantity of paper that is discarded. The paper-recycling process creates a potential for exposure to organic dusts, particularly paper dust and water suspensions of microbial organisms, as well as to other respiratory irritants used in the recycling process (talc, chlorine gas, sulfur dioxide, chlorine dioxide, ammonia, and caustic soda).

In the plant that we studied, recycling begins with the sorting of waste paper, which is separated by hand into bulky (eg, cardboard) and fine (eg, newspaper, magazine paper, paper towels, etc) materials. The sorted paper is then treated mechanically in hot water under alkaline conditions. Most of the recycled material requires a special chemical cleaning process. Chemicals (eg, sodium hydroxide; alkaline soda; sulfur compounds such as neutral-sulfite, sodium sulfite, sodium sulfide, hydrogen sulfide, sulfate, and sulfur dioxide; chlorine; chlorine dioxide) and air are mixed with the paper in a custom-designed flotation cell. Chlorine dioxide can be used to bleach paper pulps in several stages to a high degree of brightness. Additional harmful exposures of the workers may involve mercaptan, talc dust, and caustic lime dust. After being bleached, the paper is sprayed onto paper machines, forming a sheet-like material. The paper sheets are then transferred to a large heated cylinder and then, once dry, scraped off. This process, as well as the initial hand-sorting, is particularly dusty. The paper is then rolled onto the cylinders and subsequently divided and folded in special re-rolling machines, after which it is cut. In between the mechanical processes and the time by which the paper pulp is fully cooked, varying amounts of different chemicals are added.

Subjects

This study investigated a group of 101 male paper-recycling workers employed in one paper processing plant in Zagreb, Croatia. The studied workers represented 96% of all employed workers in this plant. Workers frequently changed jobs in this industry, so they were all exposed to similar concentrations of respiratory irritants. The mean age of the men was 41 years (range, 19 to 65 years), their mean height was 171 centimeters (range, 167 to 181 centimeters), and their mean duration of exposure was 17 years (range, 2 to 27 years). A majority of these workers were smokers (54 of 101, or 53.5%), smoking on the average 20 cigarettes daily. In addition, a group of 87 nonexposed workers employed in packing food products in the food industry was studied as a control for the prevalence of chronic respiratory symptoms. The age, duration of employment, and smoking habits were not significantly different between the exposed and the control groups. For comparisons of the prevalence of acute symptoms, we used the reference group developed specifically for this purpose.[14]

Respiratory Symptoms

Chronic respiratory symptoms were recorded using the British Medical Research Council questionnaire on respiratory symptoms,[15] with additional questions on occupational asthma.[16–18] In all workers, a detailed occupational history, as well as questions about their smoking habits, were recorded. The following definitions were used:

Chronic cough or phlegm: cough and/or phlegm for a minimum of 3 months a year;

Chronic bronchitis: cough and phlegm for a minimum of 3 months a year and for not less than 2 successive years;

Dyspnea grades: grade 3, shortness of breath when walking with other people at an ordinary pace on level ground; grade 4, shortness of breath when walking at their own pace on level ground;

Occupational asthma: recurring attacks of dyspnea, chest tightness, and pulmonary function impairment of the obstructive type, diagnosed by physical examination and spirometric measurements during exposure to dust at or after work (decrease of 1-second forced expiratory volume [FEV_1] >15%) and confirmed by the medical records

Acute symptoms that developed during work shift were also recorded in all paper-processing workers. Symptoms included dry cough; dyspnea; irritation of the nose, throat and eyes; dryness of the throat; secretion, dryness, or bleeding of the nose; and headache. Frequency of acute symptoms were compared with those recorded in a group of 806 unexposed workers previously studied.[14]

Ventilatory Capacity

Ventilatory capacity measurements were performed by recording maximum expiratory flow-volume (MEFV) curves on a spirometer, the Pneumoscreen (Jaeger, Wurzburg, Germany). On these MEFV curves, the forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and maximum flow rates at 50% and the last 25% of the vital capacity (FEF_{50}, FEF_{25}) were read. Measurements were performed during the morning work shift. The spirometer was calibrated on a daily

TABLE 1
Prevalence of Chronic Respiratory Symptoms in Paper-Recycling Workers and Control Workers

Group	Mean Age (years)	Mean Height (cm)	Mean Exposure (years)	Chronic Cough	Chronic Phlegm	Chronic Bronchitis	Dyspnea Grades 3 and 4	Occupational Asthma	Sinusitis	Nasal Catarrh
Paper (n = 101)	41 ± 11	171 ± 6	17 ± 11	37 (36.6%)	35 (34.7%)	34 (33.7%)	17 (16.8%)	4 (4.0%)	32 (31.7%)	30 (29.7%)
				<0.01	<0.01	<0.01	<0.01	NS†	<0.01	<0.01
Control (n = 87)	42 ± 10	173 ± 5	18 ± 11	16 (18.4%)	14 (16.1%)	12 (13.8%)	4 (4.6%)	0 (0%)	2 (2.3%)	3 (3.4%)

* Unless otherwise indicated, all values are shown as n (%).
† NS, difference statistically not significant ($P > 0.05$).

basis. Lung function testing was performed according to the recommendations of Quanjer et al.[19] At least three MEFV curves were recorded for each subject, and the best value of the three technically satisfactory MEFV curves was used as the result of the test. The measured values of ventilatory capacity were compared with the predicted normal values for the Croatian population.[20]

Immunological Study

In the immunological study, we tested all 101 paper workers and 37 out of 87 control workers (volunteers who agreed to immunologic testing). Skin-prick tests were performed with aqueous extracts of two types of paper dust (paper dust collected at the beginning of the recycling process—"dry paper"—and paper collected during the wet processing—"wet paper") in a concentration of 1:20 w/v. Paper extracts were prepared using a standard immunological technique, employing the material collected in the workroom where workers were examined.[21] Skin-prick testing was performed according to the recommendations of Dreborg,[22] using a lancet with a 1-mm tip. In addition, workers were skin-tested with molds, histamine base (1 mg/mL), and a buffer (as a control solution), wood extract, *Dermatophagoides pteronyssinus*, house dust, and molds. Skin reactions were evaluated after 20 minutes. A test was considered positive if the diameter of the observed wheal was 3 mm greater than that of the control solution.

The serum level of total immunoglobulin E (IgE) was determined by a reference laboratory (PRIST Pharmacia Diagnostics AB, Uppsala, Sweden), using the direct radioimmunologic "sandwich" technique. A level of IgE below 125 IU/mL was considered normal.

Environmental Measurements

The dust concentrations in the work environment were measured by the two-stage Hexhlet apparatus (Casella, London, England), which collects total and respirable dust particles. Dust samples were collected during the entire 8-hour work shift in the actual work areas. Two Hexhlet monitors were used for these measurements. The samples were placed in two separate areas of the plant: the first in the initial processing areas where papers are separated by grade and weight, and the second in the cleaning and brushing areas, where chemicals are added to soften the paper. Dust measurements were made on 5 separate days in each of these areas. Dust concentrations are recorded as the average of these measurements in mg/m^3 and expressed as arithmetic means and ranges.

Statistical Analysis

The results of ventilatory capacity measurements were analyzed by the paired t test when comparing baseline to predicted values. Odds ratios were calculated by using logistic procedures for each respiratory symptom, with age, exposure, and smoking as predictors.[23] Results of ventilatory capacity tests were analyzed by applying a multiple regression analysis with age, exposure, and smoking as predictors, and FVC, FEV_1, FEF_{50}, and FEF_{25} as criteria variables.[24] The chi-square test (or, when appropriate, Fisher's exact test), was used for testing differences in the prevalence of respiratory symptoms between groups. A level of $P < 0.05$ was considered statistically significant.

Results

Respiratory Symptoms

Table 1 presents the prevalences of chronic respiratory symptoms in the recycling paper-processing workers and in the control workers. There were significantly higher prevalences for all chronic symptoms in exposed, compared with control, workers ($P < 0.01$), except for occupational asthma, which was recorded in four (4.0%) of the paper workers and none of the controls (not statistically significant [NS]).

Table 2 presents the logistic regression analysis for individual symptoms. Regression coefficients for symptoms were all statistically significant for smoking ($P < 0.001$), with the exception of asthma. Regression coefficients for symptoms were also significant for exposure, but as can be appreciated by the odds ratio, the effect was much less important.

There was a high prevalence of acute symptoms which developed during the work shift (Table 3). Among the 101 paper-recycling workers, the highest symptom preva-

TABLE 2
Respiratory Symptoms in Relation to Age, Exposure, and Smoking in 101 Paper-Recycling Workers—Logistic Procedures*

Respiratory Symptoms	Logistic Regressions	Odds Ratio, Smoking	Odds Ratio, Exposure
Chronic cough	$-5.8293 + 0.1118 \times \text{age} - 0.0516 \times \text{exposure} + 2.1233 \times \text{smoking}$	8.359	1.053
Chronic phlegm	$-7.1141 + 0.1378 \times \text{age} + 0.0567 \times \text{exposure} + 2.6093 \times \text{smoking}$	13.590	1.058
Chronic bronchitis	$-6.2822 + 0.1189 \times \text{age} - 0.0480 \times \text{exposure} + 2.4406 \times \text{smoking}$	11.480	1.049
Asthma	$10.360 - 0.1733 \times \text{age} + 0.0155 \times \text{exposure} + 11.7438 \times \text{smoking}$	10.000	1.016

* Regression coefficients are statistically significant for smoking ($P < 0.001$) and exposure ($P < 0.01$), except for asthma.

TABLE 3
Prevalence of Acute Symptoms During Working Shift in Paper-Recycling Workers by Smoking Habit

Smoking Habit	*n*			Throat		Nose			Eye	
		Cough	Dyspnea	Irritation	Dryness	Secretion	Dryness	Bleeding	Irritation	Headache
Smokers	54	22 (40.7%)	17 (31.5%)	18 (33.3%)	27 (50.0%)	15 (27.8%)	15 (27.8%)	7 (12.9%)	8 (14.8%)	22 (40.7%)
		<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	NS	NS	<0.01
Non-smokers	47	7 (14.8%)	7 (14.8%)	5 (10.6%)	5 (10.6%)	4 (8.5%)	3 (6.4%)	2 (4.3%)	9 (19.1%)	7 (14.9%)

* Unless otherwise indicated, all values are shown as *n* (%).

lences were found for dryness of the throat (31.7%), followed by dry cough (28.7%), headache (28.7%), dyspnea (23.7%), excess nasal secretion (18.8%), irritation of the throat (17.8%), dryness of the nose (17.8%), eye irritation (16.8%), and bleeding of the nose (8.9%). There were significantly higher prevalences for most of the acute symptoms in smokers, compared with nonsmokers ($P < 0.01$). Older smokers (>40 years) and those with longer employment (>10 years) had higher prevalences of acute symptoms than did younger (≤40 years) nonsmokers and those with shorter employment (≤10 years), but the differences were not significant (NS).

Ventilatory Capacity

We studied the effects of smoking habit, age, and duration of employment on lung function in these workers. Table 4 shows the findings of our multiple regression analysis with exposure and smoking as predictors, and lung function parameters as outcome variables. This table shows exposure to be a highly significant predictor of FEV_1, FEF_{50}, and FEF_{25}. Smoking was not significant for any of the parameters, except for a marginal significance for FEF_{25}. When age is added to the regression analysis, the importance of smoking is reduced and the effect of exposure is no longer significant. This finding is due to the high degree of correlation between age and exposure ($r = 0.88631$).

By analyzing individual data on lung function as a percentage of predicted in paper workers, the values less than 70% of predicted were found in 9.9% of the workers for FVC, in 3.0% for FEV_1, in 27.7% for FEF_{50}, and in 47.5% for FEF_{25}. Those four workers with symptoms of occupational asthma had decreased FEV_1, FEF_{50}, and FEF_{25} in comparison to predicted, varying from 81% to 63% of predicted.

Immunological Studies

Among the 101 tested paper workers, 55 (54.5%), and among 37 tested control workers, 15 (40.5%) demonstrated positive skin-prick tests to one or more of the test antigens (NS). All tested workers reacted to histamine and none to the buffer control solution. Among paper workers, 16 of 101 (15.8%) reacted to paper extracts (9, or 8.9%, to dry paper; and 7, or 6.9%, to wet paper). Among the control workers, none reacted to dry- or wet-paper extract ($P < 0.01$). None of the paper workers reacted to paper extract alone without a positive reaction to at least one of the other tested allergens.

Figure 1 presents the data on prevalence of positive skin-prick tests to these extracts in paper and in control workers. The highest prevalence was found for *D. pteronyssinus* (22%), followed by wood (11%), house dust (11%), dry paper (9%), molds (8%), and wet paper (7%).

Increased serum IgE levels were found in 21 (21.0%) of 101 paper workers and in 2 (5.4%) of 37 controls ($P < 0.05$). Among the 16 paper workers with positive skin-prick tests to either of the paper extracts, 10 (62.5%) had an increased serum IgE level. By contrast, only 6 of 74 (8.1%) of the skin test–negative paper workers had elevated serum IgE levels ($P < 0.01$). All of these four paper workers with symptoms of occupational asthma had positive skin-prick tests to one of the paper extracts and increased serum IgE levels.

The prevalences of chronic respiratory symptoms in the 101 paper

TABLE 4
Regression Analysis of Ventilatory Capacity Tests in 101 Paper-Recycling Workers—Age Excluded*

Test	Variable	DF	Parameter Estimate	Standard Error	T for Ho (Parameter = 0)	Probability > (%)	F	DF1	DF2	P	R^2
FVC	Intercept	1	4.636617	0.28583972	16.221	0.0001					
	Exposure	1	−0.013598	0.00770269	−1.756	0.0806					
	Smoking	1	−0.040136	0.18004934	−0.223	0.8241					
							5.176	2	98	0.0073	0.0771
FEV_1	Intercept	1	3.960174	0.23348658	16.961	0.0001					
	Exposure	1	−0.020113	0.00629190	−3.197	0.0019					
	Smoking	1	0.031295	0.14707230	0.213	0.8319					
							5.176	2	98	0.0073	0.0073
FEF_{50}	Intercept	1	4.462917	0.42360375	10.536	0.0001					
	Exposure	1	−0.031510	0.01141509	−2.760	0.0069					
	Smoking	1	0.232558	0.26682636	0.872	0.3856					
							3.883	2	98	0.0238	0.0545
FEF_{25}	Intercept	1	1.915809	0.24381873	7.858	0.0001					
	Exposure	1	−0.025136	0.00657032	−3.826	0.0002					
	Smoking	1	0.284337	0.15358047	1.851	0.0671					
							8.021	2	98	0.0006	0.1231

* DF, degrees of freedom; T, *t* statistic for null hypothesis (Ho) that parameter in question is equal to 0; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; FEF_{50} and FEF_{25}, flow rates at 50% and the last 25% of the FVC.

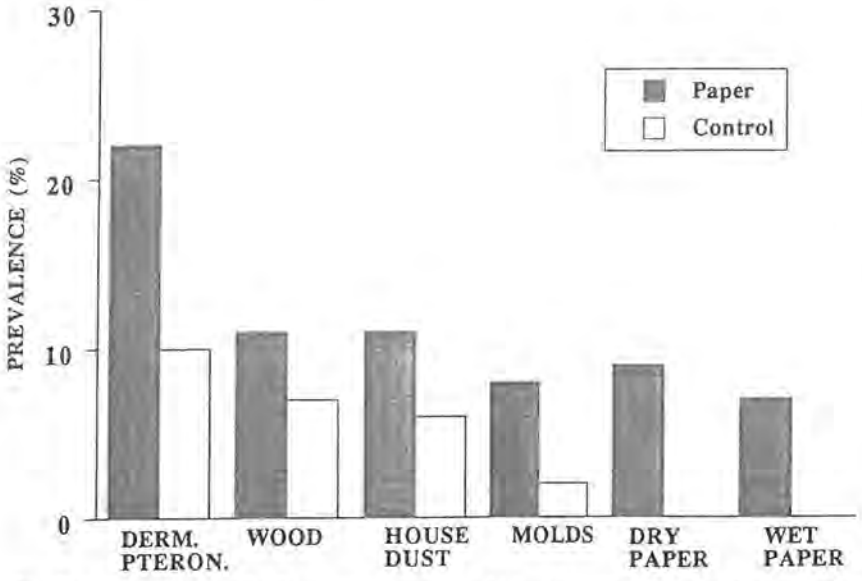

Fig. 1. A comparison of the frequency of positive skin-prick tests to paper and other extracts in both paper-recycling workers and controls.

workers and in the 37 control workers (volunteers) are presented separately for those with positive and negative skin-prick tests in Table 5. A significant difference in the prevalence between workers with positive and negative skin tests was found for sinusitis ($P < 0.05$). The prevalences of acute symptoms that developed during work shift were slightly higher in those with positive skin-prick tests than in those with negative skin-prick tests, but the differences were not statistically significant (NS).

Data on ventilatory capacity measured separately in paper workers and controls with positive and negative skin-prick tests are presented in Table 6. Paper workers with positive skin-prick tests had lower FVC, FEV_1, FEF_{50}, and FEF_{25} as a percentage of predicted than those with negative skin-prick tests, but the differences were not statistically significant (NS). Similar findings were obtained in control workers. A separate analysis of ventilatory capacity data in 16 paper workers who reacted with positive skin-prick test to one of the paper extracts demonstrated reduced values of FEF_{50} and FEF_{25} in relation to predicted values (FEF_{50} range, 75% to 69%; FEF_{25} range, 73% to 62%).

Environmental Measurements

In the paper-processing area, the mean total dust level was 9.1 mg/m^3 (range, 2–17 mg/m^3) and the mean respirable fraction was 1.9 mg/m^3 (range, 0.9–2.8 mg/m^3). The dust concentrations were the highest at the initial stage of the processing, in which separation of papers occurred. These measured mean total and respirable dust concentrations were higher than those allowed by the Croatian Federal standards for organic dust (total dust, 3 mg/m^3; respirable dust fraction, 1 mg/m^3).

Discussion

Our study demonstrates that employment in a paper-recycling plant is associated with the development of acute and chronic respiratory symptoms related to smoking and

TABLE 5
Prevalence of Chronic Respiratory Symptoms in Paper-Recycling Workers and Control Workers, by Skin Test*

Group	Skin Test†	Mean Age‡ (years)	Mean Exposure‡ (years)	*n*	Chronic Cough	Chronic Phlegm	Chronic Bronchitis	Dyspnea Grades 3 and 4	Occupational Asthma	Sinusitis	Nasal Catarrh
Paper (*n* = 101)	+	39 ± 12	15 ± 11	31	11 (35.5%)	11 (35.5%)	10 (32.3%)	5 (16.1%)	2 (6.5%)	14 (45.2%)	10 (32.3%)
					NS	NS	NS	NS	NS	<0.05	NS
	−	42 ± 11	17 ± 12	70	26 (37.1%)	24 (34.3%)	24 (34.3%)	12 (17.1%)	2 (2.9%)	18 (25.7%)	20 (28.6%)
Control (*n* = 87)	+	45 ± 10	20 ± 10	14	3 (21.4%)	3 (21.4%)	3 (21.4%)	2 (14.3%)	0 (0%)	3 (21.4%)	2 (14.3%)
					NS	NS	NS	NS	NS	NS	NS
	−	39 ± 10	16 ± 10	23	4 (17.4%)	3 (13.0%)	3 (13.0%)	2 (8.7%)	0 (0%)	2 (8.7%)	1 (4.3%)

* Unless otherwise indicated, all values are shown as *n* (%).
† +, positive skin prick test; −, negative skin prick test.
‡ Age and exposure are presented as mean ± SD.

working conditions. While both smoking and exposure were associated with excess of chronic respiratory symptoms, the effect was due primarily to smoking. Toren et al[4,5] reported that exposure to high levels of paper dust (>5 mg/m^3), as well as to other respiratory irritants, is an important occupational risk among paper workers. Chan-Yeung et al[25] studied workers in a pulp and paper mill and were unable to demonstrate an increased prevalence of respiratory symptoms and pulmonary function abnormalities among workers exposed to gases and chemicals in this environment. By contrast, a high prevalence of acute work-related symptoms during the work shift was recorded in our paper workers. The highest prevalences were found for cough, dryness of the throat and dryness of the nose, and eye irritation. Marttila et al[26] reported that long-term exposure to ambient air contaminated with sulfur compounds released from pulp mills carries the risk of producing nasal symptoms, cough, eye irritation, and headache. Haahtela et al[27] and Jaakkola et al[28] described the acute health effects of sulfur-containing pollutants released by a pulp mill in South Karelia, Finland. The symptoms included eye irritation, nasal symptoms, cough, pharyngeal irritation, breathlessness, nausea, and headache.

The multivariate analysis of lung function indicates a significant effect of exposure on these variables. The distinction between age and exposure is difficult in view of the high degree of correlation between these two variables. Our study demonstrated a significant reduction for FEF_{50} and FEF_{25} in comparison to predicted values for the paper recycling workers. These findings suggest that obstructive changes probably localized in smaller airways. Ferris et al[29,30] suggested that exposure to chlorine and sulfur dioxide in paper mills might have an adverse effect on pulmonary function. Sigsgaard et al[31] reported that among recycling workers in a paper production mill, exposure to organic dust caused a fall in FEV_1 over the workshift. Interestingly, no significant association was found between endotoxin exposure levels and lung function decrements in this study. Cortes et al[32] studied paper-mill workers exposed to gases during the industrial processing of paper products and did not find evidence of occupationally induced bronchospasm.

Heederik et al[11] studied workers exposed to soft-paper dust and found that these exposures regularly exceeded the Dutch maximal allowable concentrations. They found lower FEV_1, MMEF, MEF_{50}, and MEF conducted among the exposed workers. These same workers showed a decline in pulmonary function over the week, compared with the associated controls. These authors suggested an obstructive airway reaction with an immunologic mechanism resulting from dust exposure in the paper mill. Henneberger et al[33,34] reported that in pulp and paper mill workers, FVC and FEV_1 were lower than in unexposed subjects who had never worked in the pulp or paper production areas. The authors described a cumulative interaction effect between smoking, mill exposure, and gassing. In their study changes in pulmonary function appeared to be chronic and persisted beyond the actual exposure. Dahlqist[35] suggested that a low level of exposure to paper dust in bookbinders employed for more than 10 years might cause a slight lung function deterioration without clinical relevance.

Our study indicates a low but significant prevalence of positive skin-prick tests to dry- or wet-paper dust extracts in paper workers. Among the workers with positive skin tests to paper dust extracts, more than half had elevated IgE levels. Papa et al[36] administered immunologic tests to 275 workers employed in a paper-making and printing factory and found that 24.4% of the subjects had allergic reactions. They suggested that exposure to these industrial pollutants is associated with a high prevalence of allergic respiratory diseases.

Exposures during the initial phase of paper processing, ie, hand-sorting of waste paper, may be similar to exposures of sanitation and sewage

TABLE 6
Ventilatory Capacity* in Paper-Recycling Workers by Skin Test

Group	Skin Test	Mean Age† (years)	Mean Exposure† (years)	Mean Height (cm)	n	FVC Measured (L)	FVC Predicted (L)	FVC Difference, Measured-Predicted %	FVC Difference, Measured-Predicted P	FEV_1 Measured (L)	FEV_1 Predicted (L)	FEV_1 Difference, Measured-Predicted %	FEV_1 Difference, Measured-Predicted P	FEF_{50} Measured (L/s)	FEF_{50} Predicted (L/s)	FEF_{50} Difference, Measured-Predicted %	FEF_{50} Difference, Measured-Predicted P	FEF_{25} Measured (L/s)	FEF_{25} Predicted (L/s)	FEF_{25} Difference, Measured-Predicted %	FEF_{25} Difference, Measured-Predicted P
Paper (n = 101)	+	39 ± 12	15 ± 11	171 ± 6	31	4.40 ± 0.88	4.66 ± 0.51	94.4	NS	3.67 ± 0.64	3.72 ± 0.47	98.7	NS	4.15 ± 1.27	5.24 ± 0.53	79.2	<0.01	1.87 ± 0.76	2.56 ± 0.38	73.0	<0.01
	−	42 ± 11	17 ± 12	172 ± 8	70	4.33 ± 0.91	4.59 ± 0.67	94.3	<0.05	3.63 ± 0.58	3.67 ± 0.81	98.9	NS	4.33 ± 1.39	5.10 ± 0.60	84.9	<0.01	1.93 ± 0.84	2.44 ± 0.40	79.1	<0.01
Control (n = 37)	+	45 ± 10	20 ± 10	173 ± 7	14	3.98 ± 0.83	4.54 ± 0.64	87.7	NS	3.35 ± 0.61	3.56 ± 0.56	94.1	NS	4.68 ± 1.39	4.98 ± 0.56	93.9	NS	1.96 ± 0.75	2.36 ± 0.35	83.1	<0.05
	−	39 ± 10	16 ± 11	174 ± 5	23	4.53 ± 0.93	4.84 ± 0.50	93.6	NS	3.79 ± 0.81	3.85 ± 0.60	98.4	NS	5.10 ± 0.91	5.30 ± 0.49	96.2	NS	2.41 ± 0.65	2.58 ± 0.35	93.4	NS

* Ventilatory capacity data are presented as mean ± SE.
† Age and exposure are presented as mean ± SD.

workers who handle different kinds of refuse containing paper products and microbiologically contaminated material.[37,38] This process in the paper industry is very dusty, and the environment contains—in addition to paper dust—molds, yeast and bacterial aerosols. Niemela et al[39] studied the incidence of microbial contaminants in the upper respiratory tract of workers in the paper industry. The nasal cavities of many workers were colonized by *Klebsiella pneumoniae*, coliforms, yeast, and molds. However, the same authors did not find any association between nasopharyngeal symptoms and microbial contamination, suggesting the effectiveness of host defenses. Deprez et al[7] suggested nevertheless that occupational exposure in paper and pulp mills may be a significant factor in the hospitalizations of workers for respiratory infections, bronchitis, and asthma. Toren et al[5,40] found a significantly increased mortality for asthma, chronic obstructive pulmonary disease, and lung cancer among paper mill workers. Other authors have also suggested that workers employed in pulp and paper mills may have an increased mortality from specific cancers.[41–43] The medical records in the industry that we studied showed no case of cancer related to occupation, but follow-up for retired workers was not available.

Recently, Kauppinen et al[44] published an international database of exposure measurements in the pulp, paper, and paper product industries. The authors described various agents that are often present in the paper-recycling industry, such as organic dust (paper dust), formaldehyde, ammonia, perchloroethylene, ethyl acetate, ethanol, butanol, and toluene. All of these pollutants exceeded current occupational exposure limits. Exposure to dust and other different irritants in these industries therefore present an important potential occupational hazard for paper workers in a wide variety of settings.[45]

In order to prevent respiratory and immunological disorders among paper-recycling workers, we suggest that reducing dust concentrations and encouraging smoking cessation are important for the primary prevention of acute and chronic respiratory symptoms and lung function impairment. In addition, medical surveillance, including pre-employment and periodic medical examinations, should be performed and should include lung function and immunological testing. This medical screening can protect workers from developing chronic respiratory or allergic disorders by allowing the early detection and possibly the removal of sensitive workers from the industry before chronic impairment develops.

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