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Respiratory symptoms and ventilatory capacity in workers in a vegetable pickling and mustard production facility

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Summary. A group of 117 women occupationally exposed in a pickling factory were studied for the prevalence of acute and chronic respiratory symptoms and lung function changes. Workers were studied by task which included (1) pickling, (2) mustard making, and (3) packing. Similar prevalences for all respiratory symptoms were seen for the three worker groups, with all groups having significantly higher prevalences of chronic cough ($P < 0.05$), chest tightness, nasal catarrh, and sinusitis ($P < 0.01$) than a nonexposed control group from a bottling plant. Prevalences of acute symptoms were greater for pickling than for mustard or packing workers. Measured forced expiratory volume in 1 s and maximum flow rates at 50% and the last 25% of the control vital capacity were in general significantly lower than predicted values for the worker subgroups. Pickling workers exposed for more than 1 year in the industry had greater across-shift reductions for all spirometric parameters tested than those workers exposed for 1 year or less. Our data suggest that extended occupational exposure in the pickling industry results in acute exposure-related respiratory effects and ultimately may lead to the development of chronic respiratory symptoms and changes in baseline lung function.

Key words: Acid air pollution – Pickling workers – Respiratory symptoms – Lung function – Spices

Introduction

Systematic studies of workers in the pickling industry have not previously been performed. Individual cases of respiratory reactions to agents used in the pickling process have, however, been reported by several investigators. Many of these responses suggest sensitization-mediated reactions; however, nonspecific irritation may also occur since acid aerosols are present.

Recently, Rajan and Davies (1989) described reversible airways obstruction and interstitial pneumonitis due to acetic acid inhalation. Allergy to mustard and vinegar has been described by Speer (1975). Other publications describing the consequences of vinegar or acetic acid are concerned with the effects of these agents following the ingestion of wine and other alcoholic beverages (Hicks 1968; Geppert and Boushey 1978; Gong et al. 1981; Gershwin et al. 1985; Dahl et al. 1986). These authors reported predominantly bronchospastic or hypersensitivity reactions in subjects exposed to these agents. Przybilla and Ring (1983) described the effect of exposure to acetic acid and vinegar in a woman who developed itching, facial flushing, dizziness, and dyspnea after ingesting wine, beer, rum, or vinegar. Positive skin prick reactions were obtained to vinegar and acetic acid. Oral challenge testing with acetic acid in this subject provoked severe anaphylaxis, with urticaria, facial flushing, itching of the mucosal membrane, hoarseness, and dyspnea. Acetic acid is implicated in reactions to ethanol since acetic acid is a metabolite of ethanol. Zuskin et al. (1981) showed that the inhalation of ethanol causes respiratory symptoms and lung function changes.

Exposure to aerosols in the pickling industry may have important common features with exposure of the general population to acid air pollutants. Such exposures have been associated with respiratory effects, particularly in subjects with underlying respiratory disease (Raizenne et al. 1989; Linn et al. 1989). There exist, however, significant gaps in our knowledge of the human health effects resulting from the inhalation of acid air pollutants in all settings. Finally, we have previously shown that spice workers are susceptible to respiratory effects (Zuskin et al. 1988a, b).

In the present study we investigated the prevalence of respiratory symptoms and ventilatory capacity abnormalities in workers employed in a pickling factory in Varazdin, Croatia, where workers were employed preserving different vegetables and producing mustard. The study protocol was reviewed and approved by the Institutional Review Board of the Andrija Stampar School of Public Health, Zagreb, Croatia.

Materials and methods

Working process. During the pickling process, workers were exposed to the vapors of vinegar (4% acetic acid). In addition the so-

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lution used for pickling contained salt, alum, different natural flavors including turmeric, xantham gum, corn syrup, dehydrated onion, and citric acid. The pH of the pickling solution varied from 3.47 to 3.75. Workers who pickle usually preserve paprika, cucumbers, cabbage, and beets. The workers engaged in pickling are located in one large open work area.

In processing mustard the usual ingredients include vinegar, mustard seeds, salt, various spices, natural flavoring, and turmeric. Workers who process mustard are only incompletely separated from the room where pickling takes place. Workers who pickle and those who process mustard rotate their jobs so that they have similar exposures to environmental pollution. Those workers who package the pickled vegetables are located adjacent to the pickling area.

Subjects. The study examined respiratory findings in 117 women in one pickling and mustard-producing factory in Croatia. They represented 95% of all the workers in the plant. The mean age was 31 years (range: 16–57 years), the mean height 161 cm (range: 152–177 cm), and the mean duration of exposure 10 years (range: 1–35 years). Thirty-three percent of the pickling and packing workers were regular smokers, smoking on the average 15 cigarettes daily. Only 5% of the mustard workers were regular smokers. Workers were divided into three groups: (1) pickling workers ($n = 36$), (2) workers employed in making mustard ($n = 44$) and (3) workers who packaged and bottled final products ($n = 37$). The third group, the packers, consisted primarily of workers who had been previously employed in pickling vegetables but because of their sensitivity (symptoms) to the atmospheric pollution had been transferred to the packaging area. A control group for chronic respiratory symptoms comprised 65 female non exposed workers in another industry (bottling fruit juice) who were of similar age (mean age 31 years; range 19–50 years) and smoking habit (on the average 15 cigarettes daily) to the entire studied cohort.

Respiratory symptoms. Chronic respiratory symptoms were recorded in exposed and in control workers by using the British Medical Research Council Committee questionnaire on respiratory symptoms (1960) with additional questions on occupational asthma (World Health Organization 1986). A detailed occupational history was recorded for all workers, together with information about their smoking habit. The following definitions were used:

1. Chronic cough or phlegm: cough and/or phlegm production for at least 3 months per year
2. Chronic bronchitis: cough and phlegm for a minimum of 3 months a year and for not less than 2 successive years
3. 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
4. Occupational asthma: recurring attacks of dyspnea, chest tightness, and pulmonary function impairment of the obstructive type diagnosed by physician examination and spirometric measurments during exposure to dust at or following work

In all workers, acute symptoms present during the work shift, such as cough, dyspnea, chest tightness, irritation or dryness of the throat, secretion, dryness and bleeding of the nose, and headache, were specifically recorded.

Asthma, sinusitis, or nasal catarrh were defined as by physician-diagnosed conditions, the diagnosis having been established by the time of the survey.

Ventilatory capacity. Ventilatory capacity was measured in all exposed workers by recording maximum expiratory flow-volume (MEFV) curves using a portable flow-volume spirometer (Autospiror Hi-498, Chest Co., Tokyo, Japan). The instrument was calibrated for volume on a daily basis. Measurements were performed on the first working day of the week (Monday). For pickling workers measurements were performed before (6 a.m.) and after the work shift (2 p.m.). In the two other worker groups, ventilatory capacity was measured only before the shift. The forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), and maximum flow rates at 50% and the last 25% of the control vital capacity (FEF_{50} and FEF_{25}) were recorded from these MEFV curves. Testing was performed in accordance with the American Thoracic Guidelines (Ferris 1978). At least three MEFV curves were performed and the one with the greatest FEV_1 was used. The measured Monday preshift values of ventilatory capacity were compared with the expected normal values of Quanjer (1983).

Statistical analysis. The results of ventilatory measurements were analyzed by using the paired *t*-test comparing baseline (preshift) lung function to predicted values, and pre- to postshift lung function (across shift changes). The $\chi 2$ test (or, when appropriate, Fisher's exact test) was used for testing differences in the prevalence of respiratory symptoms. $P < 0.05$ was considered statistically significant.

Results

Respiratory symptoms

The prevalence of chronic respiratory symptoms in exposed and in control workers is presented in Table 1. There were significantly higher prevalences of chronic

Table 1. Prevalence of chronic respiratory symptoms in pickling, packing, mustard, and control workers

Group	Mean age (years)	Mean exposure (years)	Chronic cough	Chronic phlegm	Chronic bronchitis	Asthma	Dyspnea	Chest tightness	Nasal catarrh	Sinusitis
Pickling	30	10	8[a]	4	4	4	0	10[b]	17[b,c]	12[b]
($n = 36$)			22.2%	11.1%	11.1%	11.1%	0%	27.8%	47.2%	33.3%
Packing	33	10	8[a]	5	4	5	3	8[b]	13[b]	7[b]
($n = 37$)			21.6%	13.5%	10.8%	13.5%	8.1%	21.6%	35.1%	18.9%
Mustard	32	10	10[a]	6	5	10	3	7[b]	8[b,c]	10[b]
($n = 44$)			22.7%	13.6%	11.4%	22.7%	6.8%	15.9%	18.2%	22.7%
Controls	31	9	4	3	3	0	0	0	1	1
($n = 65$)			6.2%	4.6%	4.6%	0%	0%	0%	1.5%	1.5%

[a,b] Differences between exposed and control workers statistically significant. a: $P < 0.05$; b: $P < 0.01$
[c] Difference between pickling and mustard workers statistically significant ($P < 0.05$)

cough ($P<0.05$), chest tightness, nasal catarrh, and sinusitis ($P<0.01$) in all three exposed groups of workers compared to controls. The prevalence of all chronic respiratory symptoms was similar in the three exposed groups, except for nasal catarrh, which was significantly higher for pickling (47,2%) than for mustard workers (18.2%) ($P<0.01$). Occupational asthma was recorded in three (8.1%) of the packing workers and in three (6.8%) of the mustard workers. They described their asthma symptoms beginning several years after employment in the pickling industry. All had worked initially as pickling workers but because of progressive symptoms had been transferred to the packing and mustard-making areas. Their ages ranged from 42 to 50 years, with the duration of employment in the pickling factory varying from 26 to 33 years. They were all nonsmokers.

In comparing the prevalence of chronic respiratory symptoms in exposed workers by their smoking habit, we found no significant differences. This lack of a "smoking effect" may be related to the small cell sizes.

Pickling workers exposed for more than 1 years had significantly higher prevalences of chest tightness (71.1%), nasal catarrh (63.6%), and sinusitis (45.5%) than did pickling workers exposed for 1 year or less (40.5%; 21.4%; 14.2%) ($P<0.01$).

Table 2 presents the prevalence of acute symptoms which developed during the work shift in exposed workers. These data were not available for control workers. The highest prevalences were recorded for cough, followed by dyspnea, irritation or dryness of the throat, eye irritation, and headache. Pickling workers had a significantly higher prevalence of cough, dyspnea, irritation

Table 2. Prevalence of acute symptoms during work whift in pickling, packing, and mustard workers

Group	Cough	Dyspnea	Throat		Eye irritation	Nose			Headache
			Irritation	Dryness		Secretion	Dryness	Bleeding	
Pickling	21[a]	19[b]	19[b]	17[b]	17	14[b]	6	4	19[a]
($n=36$)	58.3%	52.8%	52.8%	47.2%	47.2%	38.9%	16.7%	11.1%	52.8%
Packing	17	15	12	15	15	7	5	5	15
($n=37$)	45.9%	40.5%	32.4%	40.5%	40.5%	18.9%	13.5%	13.5%	40.5%
Mustard	9	13	9	11	15	7	5	2	10
($n=44$)	20.5%	29.5%	20.5%	25.0%	34.1%	15.9%	11.4%	4.5%	22.7%

[a,b] Difference statistically signifcant between pickling and mustard workers. a: $P<0.01$; b: $P<0.05$

Table 3. Ventilatory capacity in pickling, packing, and mustard workers

Group	Mean age (years)	Mean height (cm)	Mean exposure (years)	Measurement	FVC		FEV_1		FEF_{50}		FEF_{25}	
					Before shift L	% predicted	Before shift L	% predicted	Before shift L/s	% predicted	Before shift L/s	% predicted
Pickling	30	160	10	Measured	3.44 ± 0.59	94.8 ± 11.2	2.81 ± 0.54	96.2 ± 10.5	3.87 ± 0.99	90.2 ± 15.7	1.78 ± 0.77	88.5 ± 16.3
($n=36$)					NS		NS		<0.01		<0.05	
				Predicted	3.63 ± 0.51		2.92 ± 0.49		4.29 ± 0.42		2.01 ± 0.37	
Packing	33	160	10	Measured	3.29 ± 0.59	100.6 ± 9.7	2.65 ± 0.51	93.3 ± 9.6	3.80 ± 0.91	90.4 ± 17.2	1.68 ± 0.78	86.1 ± 16.4
($n=37$)					NS		<0.01		<0.01		<0.01	
				Predicted	3.27 ± 0.50		2.84 ± 0.48		4.20 ± 0.41		1.95 ± 0.44	
Mustard	32	161	10	Measured	3.38 ± 0.59	104.5 ± 10.8	2.70 ± 0.53	92.2 ± 11.5	3.53 ± 0.13	82.5 ± 15.2	1.71 ± 0.78	85.5 ± 17.5
($n=44$)					NS		<0.01		<0.01		<0.01	
				Predicted	3.34 ± 0.58		2.93 ± 0.51		4.28 ± 0.45		2.00 ± 0.38	

Data are presented as mean ± SD

NS, Difference not statistically significant ($P>0.05$)

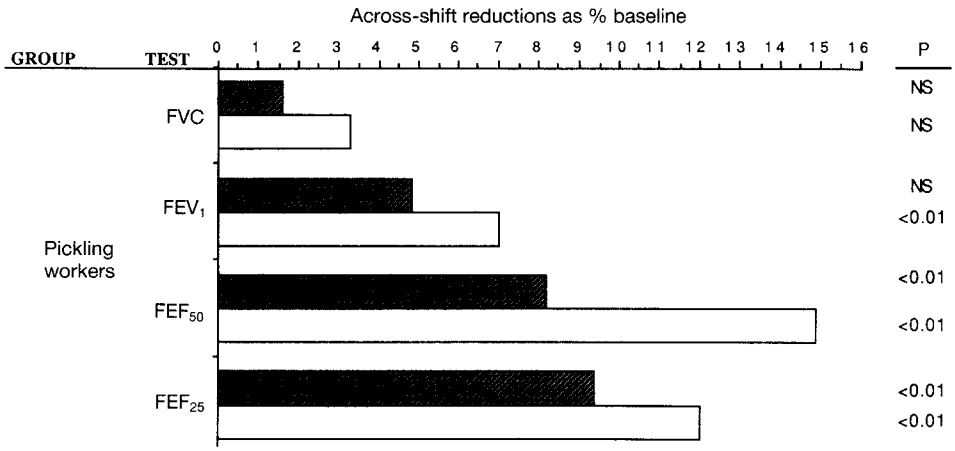

Fig. 1. Relative across-shift reductions in 14 pickling workers exposed for less than 1 year and in 22 pickling workers exposed for more than 1 year. ▨ ≤ 1 year exposure; □ > 1 year exposure

and dryness of the throat, nasal secretion, and headache than did mustard workers ($P < 0.01$).

In comparing the prevalence of acute symptoms between smokers and nonsmokers, pickling workers who were nonsmokers had higher prevalences for all symptoms than did pickling workers who were smokers, the differences being significant for dryness of the throat (smokers: 20.0%; nonsmokers: 57.7%; $P < 0.05$) and nasal secretions (smokers: 0%; nonsmokers: 53.8%; $P < 0.003$). This unexpected finding may reflect the fact that in this cohort nonsmokers may be more sensitive to such atmospheric pollutants.

Pickling workers employed for more than 1 year had significantly higher prevalences of all acute symptoms than did pickling workers exposed for 1 year or less ($P < 0.01$), except for dyspnea and bleeding of the nose.

Ventilatory capacity

Table 3 shows the measured and predicted ventilatory capacity data for pickling, packing, and mustard workers. For pickling workers the FEF_{50} was significantly less than the predicted value ($P < 0.01$), as was the FEF_{25} ($P < 0.05$). Packing and mustard workers had significantly decreased FEV_1, FEF_{50}, and FEF_{25} when compared to expected values ($P < 0.01$). Smoking workers showed lower values (as compared to predicted) than nonsmoking workers; this was particularly so for FEF_{25} in mustard workers (smokers: 64.5%; nonsmokers: 86.0%; $P < 0.01$). Among pickling workers, 27.8% had an FEF_{50} and an FEF_{25} lower than 80% of predicted. Among packing workers, 29.7% had an FEF_{50} and 54.0% an FEF_{25} lower than 80% of predicted, and among mustard workers, 43.2% had an FEF_{50} and 45.5% had an FEF_{25} lower than 80% of predicted. For the six workers with occupational asthma symptoms the ventilatory capacity data were in general lower than 80% of predicted (FVC: 91%–79%; FEV_1: 79%–76%; FEF_{50}: 56%–45%; FEF_{25}: 63%–25%).

Figure 1 illustrates the mean across-shift reductions in lung function for pickling workers exposed for 1 year or less and for more than 1 year. Workers exposed for more than 1 year showed greater across-shift reductions than did those with shorter exposures, although the differences between short- and long-term employees were statistically significant only for FEF_{50} ($P < 0.01$).

Discussion

Our data suggest that occupational exposures in pickling and mustard manufacturing, particularly over long periods of time, may cause the development of acute and/or chronic respiratory as well as other symptoms. Such symptoms were particularly pronounced for pickling workers. However, the group of packing workers, who were for the most part previous pickling workers who had developed sensitivity to their work environment, also experienced high prevalences of respiratory symptoms as well as occupational asthma. Most of the studied workers complained of cough, dyspnea, and chest tightness particularly pronounced at the beginning of the work shift. These respiratory symptoms were accompanied by significant across-shift decrements in lung function in packing workers, particularly those employed for more than 1 year in the industry. These workers also developed changes in their baseline preshift lung function.

The environmental pollutants in this industry are multiple; hence it is not possible, based on an epidemiologic assessment, to determine which one (or group) of the pollutants was responsible for these effects. Two known groups of contaminants, namely acid aerosols and spice dust, may play a prominent role in the findings of our study.

Hackney et al. (1989) demonstrated that both normal and asthmatic subjects showed statistically significant dose-related increases in respiratory symptoms during exposure to acid concentrations attained in ambient air. Asthmatics also showed dose-related decrements in FEV_1. Jedrychowski and Krzynowski (1989) showed that subjects who lived in areas with higher sulfate levels had a lower FEV_1 than did residents in other areas. The same authors also demonstrated that the FEV_1 decline rate over the 13-year period of the study was significantly more pronounced (by 11 ml/year) in the area with higher levels of acid aerosols than in the area of low pollution.

In acute challenge studies, by contrast, no changes in pulmonary function resulted from exposure to H_2SO_4 in

healthy subjects (Horstman et al. 1982; Kerr et al. 1981; Chaney et al. 1980). Aris et al. (1991) suggested that short-term inhalation of concentrations of H_2SO_4 higher than those encountered in polluted outdoor air does not cause significant bronchoconstriction in subjects with mild asthma. The same authors stated that any adverse respiratory health effects of sulfuric acid air pollution are likely to be effects other than bronchoconstriction. In their occupational setting, pickling workers are exposed over long periods of time to acid aerosols on a daily basis. Hence it is probable that if the acid aerosols do contribute to the respiratory findings, their effects are cumulative, as in the population studies.

Exposures in the pickling and mustard industry were not limited to acid pollution. Our previous studies in spice workers indicate that sensitivity to different spices may result in the development of chronic respiratory symptoms and obstructive lung function changes (Zuskin et al. 1988a, b). In this cohort of 92 female workers, high prevalences of chronic symptoms were also documented as well as across-shift and baseline (preshift) lung function changes. A majority of these workers exhibited skin test reactivity to mixed spice dust allergen and this sensitivity correlated with lung function changes and shift-related symptoms. In the current study, workers were also exposed to spices (in addition to the acid vapors and aerosols) since spices are added to the pickling solution.

In the present study we have documented that workers employed for more than 1 year in the pickling and mustard industry both suffered from an excess of respiratory symptoms and from abnormal lung function. The presence in this environment of acid aerosols as well as spice dusts suggests two potential occupational agents causing these changes. The high prevalences of chronic symptoms, of functional changes, and of occupational asthma warrant close medical and environmental surveillance of this industry.

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