Lack of combined effects of exposure and smoking on respiratory health in aluminium potroom workers

K Radon, D Nowak, D Szadkowski

Abstract

Objective—To investigate the combined influence on respiratory health of smoking and exposure in an aluminium potroom.

Methods—In a cross sectional study of 75 potroom workers (23 never smokers, 38 current smokers, 14 ex-smokers) and 56 controls in the same plant (watchmen, craftsmen, office workers, laboratory employees; 18 non-smokers, 21 current smokers, 17 ex-smokers), prevalences of respiratory symptoms and spirometric indices were compared.

Results—Smokers in the potroom group had a lower prevalence of respiratory symptoms than never smokers or ex-smokers, which was significant for wheezing (2.6% v 17.4% and 28.6% respectively, both p<0.01), whereas respiratory symptoms in controls tended to be higher in smokers (NS). No effects of potroom work on the prevalence of respiratory symptoms could be detected. In potroom workers, impairment of lung function due to occupational exposure was found only in non-smokers, with lower results for forced vital capacity (FVC) (98.8% predicted), forced expiratory volume in one second (FEV1) (96.1% predicted) and peak expiratory flow (PEF) (80.2% predicted) compared with controls (114, 109.9, and 105.9% predicted; each p<0.001). Conversely, effects of smoking on lung function were only detectable in non-exposed controls (current smokers v non-smokers: FVC 98.8% v 114.2% predicted; p<0.01; FEV1 95.5 v 109.9% predicted; p<0.05).

Conclusions—In a cross sectional survey such as this, the effects of both smoking and occupational exposure on respiratory health may be masked in subjects with both risk factors. This is probably due to strong selection processes which result in least susceptible subjects continuing to smoke and working in an atmosphere with respiratory irritants.

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Keywords: healthy smoker; healthy worker; spirometry

Workers in aluminium potrooms are exposed to various air pollutants—such as dusts (alumina, cryolite, and fluorides), fumes, and gases (mainly hydrogen fluorides and sulphur diox ide). Several studies have shown that working in the potroom may impair lung function, whereas others have not. There is some evidence that negative findings could be due to a healthy worker effect.

In adults, a dose-dependent effect of smoking on respiratory symptoms and level of lung function is well established. In several cross sectional studies performed in adolescents only minor effects could be detected for variables such as forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) assuming that never smokers and smokers entered adulthood with the same level of lung function. Therefore, longitudinal data were required to show that smoking caused a decline in lung function in older and younger people. It was speculated that the effects of smoking on lung function of young people, only detectable in longitudinal studies, could be due to an increased susceptibility to the effects of smoking in never smokers and a higher proportion of “unhealthy subjects” in never smokers than among a group of smokers drawn from the same population. This effect has been labelled the healthy smoker effect.

Given the well established healthy worker effect and the health selection called the healthy smoker effect, the hypothesis of the present study was that subjects occupationally exposed to airway irritants and smoking are the least susceptible subgroup to be affected by smoking and working exposure. Therefore a cross sectional study of respiratory symptoms and spirometry among smoking, ex-smoking, and non-smoking aluminium potroom workers and controls was carried out. The occupational exposure to hydrogen fluoride (HF) and inhalable dust at the potroom under study were below the German threshold limit value at the workplace (HF 2.5 mg/m³, total dust 4 mg/m³).

Subjects and methods

SUBJECTS

The cross sectional survey was carried out in summer 1997 on the plant site of a German prebake aluminium smelter. All smelter employees were invited to participate in the study. Seventy eight workers registered as potroom employees participated in this study (23 never smokers, 38 current smokers, 17 ex-smokers). Never smokers were lifelong non-smokers, ex-smokers were those who stopped smoking for at least 1 year before the study. Therefore three ex-smokers who had stopped smoking during the preceding year were excluded. Fifty seven employees in the office, laboratory, workshop, and gate served as control subjects (18 non-smokers, 22 current smokers, 17 ex-smokers). One pipe smoker was excluded.
ASSESSMENT OF EFFECTS ON RESPIRATORY HEALTH

Questionnaires
Respiratory symptoms (dyspnoea, wheezing, and cough) during the preceding year, smoking habits, medical and occupational history, personal characteristics, and current duties were recorded in a standardised interview by two physicians. The interview was based on a questionnaire of Kongerud et al., and most of the questions were translations derived from the British Medical Research Council questionnaire.

Lung function measurements
Spirometry was performed in all subjects as recommended by the American Thoracic Society. Inspiratory vital capacity (IVC), FVC, FEV₁, midexpiratory flow rates (MEF₅₀, MEF₁₂, MMEF₂₅₋₇₅), and peak expiratory flow (PEF) were measured with a transportable spirometer (Flowscreen II, Jaeger, Würzburg, Germany). The equipment was volume calibrated before every testing procedure. Lung function tests were performed before the morning shift with the subject in a sitting position with a noseclip. At least three technically satisfactory manoeuvres were used for analysis. Midexpiratory flow rates were taken from the curve with the highest sum of FVC and FEV₁. The measurements were electronically converted to BTPS (body temperature and pressure saturated) conditions.

STATISTICAL ANALYSIS
Standard methods for statistical analyses were used—such as cross tabulation, Fisher’s test, t test for independent variables, multiple analysis of variance (ANOVA), with final comparison by Newman-Keuls test and multiple regression. All statistical tests were done at α=0.05 significance level.

In this report all references of the lung function are given as percentage of predicted.

Results
STUDY POPULATION
Table 1 presents the distribution of personal data of potroom and control employees by smoking habit. In both groups, smokers were significantly younger than never smokers. Ex-smoking control employees were employed significantly longer than smokers and had a significantly lower number of pack-years than potroom workers. The control group included significantly more women and fewer foreign subjects.

RESPIRATORY SYMPTOMS
Prevalences of the main respiratory symptoms wheezing, dyspnoea, and cough are given in figure 1. Currently potroom workers who did not smoke had a slightly but not significantly higher prevalence of respiratory symptoms than the control subjects with the same smoking habit. Wheezing was reported by a significantly lower proportion of smokers in the potroom group than in the control group (p<0.05, v the same control group who smoked). Among potroom workers, the highest prevalences of respiratory symptoms were found in ex-smokers, whereas among control subjects, smokers complained most often of wheezing, dyspnoea, and cough (NS).

LUNG FUNCTION TESTS
No difference was found between mean lung function results of German and foreign

<table>
<thead>
<tr>
<th>Table 1 Characteristics of the subjects by exposure group and smoking</th>
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<tbody>
<tr>
<td>Potroom worker</td>
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<tr>
<td></td>
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<tr>
<td>Females (n)</td>
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<td>Foreign subjects (n)</td>
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<tr>
<td>Age (y)</td>
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<td>Duration of employment (y)</td>
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<td>Pack-years</td>
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<td>Duration of non-smoking (y)</td>
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</tbody>
</table>

*p<0.05 ; **p<0.01 v smokers; †††p<0.001 v the same smoking group of controls; n=total number.
employees. Thus, the average results of spirometry for all subjects regardless of nationality are shown in figure 2.

When compared with unexposed workers, only non-smokers in the potroom group had significant lower results for FVC (96.3% v 114.2%; p<0.001), FEV$_1$ (92.3% v 109.9%; p<0.01), and PEF (80.2% v 105.9%; p<0.001). Conversely, in ex-smokers only FVC was significantly lower (100.4% v 109.9%; p<0.05) and in current smokers only the PEF was significantly decreased (80.7% v 93.2%; p<0.05).

Among potroom workers, no significant differences could be found between groups of differing smoking habits. Smokers had slightly but not significantly better values of FVC, FEV$_1$, and MMEF$_{25/75}$ than never smokers. In controls significantly lower results in FVC (98.8% v 114.2%; p<0.01) and FEV$_1$ (95.5% v 109.9%; p<0.05) were found in smokers compared with never smokers.

Table 2  Multiple regression analysis of VC and FEV$_1$ as dependent variables and exposure, pack-years, interaction term, and duration of employment as the predictor variables

<table>
<thead>
<tr>
<th>Dependent variable (% predicted)</th>
<th>Exposure (potroom (+1) v control group (-1))</th>
<th>Pack-years</th>
<th>Interaction term (exposure × pack-years)</th>
<th>Duration of employment (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SEM of β</td>
<td>β</td>
<td>SEM of β</td>
</tr>
<tr>
<td>IVC</td>
<td>-0.39***</td>
<td>0.11</td>
<td>-0.25**</td>
<td>0.08</td>
</tr>
<tr>
<td>FVC</td>
<td>-0.36**</td>
<td>0.11</td>
<td>-0.24**</td>
<td>0.09</td>
</tr>
<tr>
<td>FEV$_1$</td>
<td>-0.28*</td>
<td>0.12</td>
<td>-0.21*</td>
<td>0.09</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001.

Although in potroom workers the highest spirometric values were found in ex-smokers, in controls the spirometric results were lower in ex-smokers than in never smokers and lowest in smokers.

In a multiple regression model with adjustment for duration of employment, pack-years, and exposure group were shown to be significantly negatively associated with VC and FEV$_1$ (table 2). Also, the interaction between exposure and number of pack-years was positively correlated with VC and FEV$_1$, which was significant only for IVC (p<0.05).

Discussion

The present cross sectional study on respiratory health in aluminium potroom workers and controls indicates an adverse health effect of both potroom work and smoking. Our main findings are that (a) the effect of workplace exposure was only detectable in subjects who did not smoke, and (b) the consequence of smoking was only found in non-exposed subjects. Therefore, a combined effect of smoking and occupational exposure was not found.

Due to various air pollutants, work in a potroom is suspected of causing deterioration of respiratory symptoms and reduced lung function in exposed workers even in modern aluminium plants.6–8 28 Other reports, even from the same authors, diverge from these findings.12 14 Particularly in cross sectional studies, it cannot be ruled out that negative findings may be due to a healthy worker effect. Heavy exposure to inhaled irritants may lead to a selection of comparatively resistant people in the workplace whereas more susceptible people have to leave the jobs. There are also some indications for a healthy worker effect in this study. Comparison of the prevalences of respiratory symptoms in potroom workers with those in the general population,39 shows that wheezing occurred significantly less often among potroom workers. Because of the cross sectional design of the study, no exact data were available on workers who left the job due to airway symptoms or disease and other potential factors related to respiratory function. However, it is known that in the years before the study some workers had claimed compensation for suspected occupational airway disease. Also, duration of employment did not show any effect on lung function results.

Comparing the subjects of this study by working categories, a trend towards higher prevalences of respiratory symptoms were found only among non-smokers working in the

Figure 2 Mean (SD) spirometry.
No combination of exposure and smoking on respiration in aluminium potroom workers

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1990, Becklake and Lalloo found in an early cross sectional study in 1962 a progressive decrease of FEV/FVC with increasing pack-years of smoking. Dockery et al reported an irreversible loss of FVC and FEV1 for each pack-year smoked. This finding is consistent with several epidemiologi-
centre health often failed to take both healthy smoker and healthy worker effects into ac-

Angeles. A later prospective study on 200 teenagers in Los

ted by inhaled pollutants including tobacco smoke. Also it would be interesting to
determination of the lung function before

teresting to identify people at risk of being affected by inhaled pollutants including tobacco smoke. Also it would be interesting to
determine the level of the lung function before and some years after starting smoking and work in a contaminated environment in a pro-

In conclusion, there are two different health selection processes among aluminium potroom workers. The magnitude of each effect is diffi-
culate when investigating the effects of smoking as well as of occupational exposure by suitable controls or longitudinal studies. Further re-

smoke than among smokers, whereas the health worker effect, a higher proportion of unhealthy subjects is expected among non-smokers than among smokers. Thus, in

In this survey these earlier reports were confirmed for control employees by a loss in lung function by smoking habit (highest among smokers, least among never smokers) and the highest prevalence of symptoms among non-
exposed smokers.

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to either of both. Taking into account the

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ters had a decrease in FEV1 than did people who

In a longitudinal study, Chan-Yeung et al showed a smaller annual decline in young (< 30 years), highly exposed potroom workers who smoked than in ex-smokers or never smokers of the same age group. Although most of the investigations on smoking and respiratory health did not focus on work related exposure, studies on work related impairment of respira-

years after starting smoking and work in a contaminated environment in a pro-

perspective study.

This study indicates that the combined exposure to potroom dust in the work place and private cigarette smoke leads to a selection of workers with comparatively low susceptibil-

In that survey spirometric indices of lung function were shown to be predictors of future smoking. The higher the lung function values of the adolescents were, the higher was the probability that they started to smoke. Due to the voluntary character of smoking, a person may be less likely to take up the smoking habit if it caused discomfort or unpleasant sensa-
tions. Thus, it can be assumed that non-

Comparing the results with more recent studies on respiratory health among alu-
mium potroom workers, there is some evidence for a similar health selection among smokers. Alessandri et al found a significantly higher proportion of subjects with impaired FVC only in potroom employees who did not smoke compared with controls. In the control group, a significantly higher number of smokers had a decrease in FEV1 than did people who never smoked. Akbar-Khanzadeh et al reported a significantly higher prevalence of shortness of breath among potroom workers who did not smoke than among smokers, whereas in the control group the opposite relation was found. In a longitudinal study, Chan-Yeung et al showed a smaller annual decline in young (< 30 years), highly exposed potroom workers who smoked than in ex-smokers or never smokers of the same age group. Although most of the investigations on smoking and respiratory health did not focus on work related exposure, studies on work related impairment of respira-

The hypothesis is supported by the absence of effects of smoking on younger people and by a prospective study on 200 teenagers in Los Angeles. In that survey spirometric indices of lung function were shown to be predictors of future smoking. The higher the lung function values of the adolescents were, the higher was the probability that they started to smoke. Due to the voluntary character of smoking, a person may be less likely to take up the smoking habit if it caused discomfort or unpleasant sensa-
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9. Akbar-Khanzadeh F. Exposure to particulates and fluorides and the workers for their participation. Also thank the management for their cooperation and support in organising the study, and A Schottky for language assistance. We thank A Riess for her medical support, E Nern for her help organizing the study, and A Schröder for language assistance. We also thank the management for their cooperation and support and the workers for their participation.


