Respiratory Symptoms, Atopy and Bronchial Hyperreactivity in Professional Firefighters

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ABSTRACT

A study to assess respiratory health in professional firefighters.

101 male professional firefighters from the city of Basel, Switzerland were included. The control group derived from the Basel sample of the Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) consisting of 735 male subjects of the general population. All subjects were administered a standardized questionnaire, spirometry, skin prick tests and bronchial challenge testing to methacholine.

Respiratory symptoms encountered during work were more frequent in firefighters compared to the general population including burning eyes (21% vs 3%), running nose (19% vs 2%), throat itching (26% vs 3%), cough (28% vs 3%), dyspnea (7% vs 2%) and headache (25% vs 3%) respectively (p<0.05 for all comparisons). Atopy was present in 51% of firefighters compared with 32% in the general population (p<0.001). Odds ratio for hyperreactivity to methacholine was 2.24, (95% CI 1.12-4.48) for firefighters compared with the general population.

Firefighters reported more respiratory symptoms at work and suffer more often from atopy compared to the general population. Bronchial hyperreactivity was more pronounced in firefighters, but not related to acute exposure or duration of employment. Whether these findings were present at recruitment or developed after joining the workforce is unclear.

Keywords: airway hyperresponsiveness, atopy, firefighter, respiratory symptoms
INTRODUCTION

According to the Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) 7% of the Swiss population have bronchial asthma and 19% suffer from allergic rhinitis. Studies from this cohort have shown that air pollution leads to increase in respiratory symptoms and decline in lung function. Firefighting is a physically demanding and hazardous occupation (1;2). During work, firefighters are at risk of exposure to various irritants or pollutants and hence wear self contained breathing apparatus (SCBA) during periods of visible smoke exposure (3).

An increased prevalence in respiratory symptoms (4), temporal decreases in lung function parameters (forced expiratory volume in one second (FEV1) and forced vital capacity (FVC)) (5;6) and an increase in airway hyperresponsiveness have been shown in members of municipal firefighting brigades in the US after firefighting (7;8). A season of wildland firefighting has been shown to increase airway hyperresponsiveness (9). Firefighters involved in rescue operations during the World Trade Center attack in 2001 had a greater annual reduction in FEV1 and FVC (10) and persistent airway hyperresponsiveness that was associated with intensity of exposure at the disaster site (11-14).

Exposure to air pollutants (combustion products) can lead to increased sensitization to airway allergens (11;15-18). There are no data regarding sensitization to common airway allergens and allergies in firefighters who are also at increased risk of exposure to air pollutants. Over the last decades the toxicity of smoke encountered at the scenes of fire has increased due to different synthetic products which have been introduced in various construction activities (1). Although the availability and effectiveness of the protective devices such as SCBA (1) has increased SCBA is insufficiently used by firefighters when smoke is not visible, during
phases of overhaul or work in the second line (drivers, pump manipulators) when important exposure to combustion products may persists because SCBA is heavy and its use inconvenient (19).

There is a lack of data about respiratory symptoms, lung function and airway hyperresponsiveness in full time municipal firefighters in Europe although firefighters in most countries undergo pre-employment screenings to rule out active diseases which might impair working ability or worsen diseases such as bronchial asthma when using respiratory protection devices. Firefighters undergo a pre-employment medical fitness check prior to enrolment in Switzerland (20). Therefore, one might perceive that firefighters might have a lower prevalence of respiratory symptoms, atopy, airway hyperresponsiveness and asthma. Hence, we undertook a cross sectional study to compare the prevalence of respiratory symptoms, atopy and airway hyperresponsiveness in full time municipal firefighters of the city of Basel with the general population from the same area. Some results have been previously presented in form of an abstract (21).

SUBJECTS AND METHODS

All full time municipal firefighters from inner city district of Basel (200,000 habitants), Switzerland were included. Hundred-two out of the 107 firefighters (95%) agreed to participate in the study. The study was approved by the local ethic committee and all subjects gave written informed consent. For purposes of analysis the only one female firefighter was excluded. Workers were involved in all types of work including responding to a call and hence all were exposed to similar conditions at the site of an incident on a rotation basis. The questionnaire from the SAPALDIA study was
administered (22). In the SAPALDIA study skin prick test (SPT) was done with Phazet allergen coated steel lancets (Pharmacia®) which were not available anymore when this study was performed. In this study steel lancets (ALK Abello, Denmark) and different aeroallergens (mixture of six grass mixture (Dactylis, Festuca, Lolium, Phleum, Poa, Avena), three trees mixture (birch, alder, hazel), Alternaria, Cladosporium, cat and dog epithelium and Dermatophagoides pteronyssinus and farinae) with histamine as positive and saline/glycerol solution as the negative control (ALK Abello, Denmark) were used. Reading and interpretation of the SPTs, spirometry, measurement of exhaled carbon monoxide and methacholine challenge testing was done as described earlier (22).

In the SAPALDIA study a random sample of 1491 subjects from the population of inner district of Basel was sampled and out of these all 735 male participants were included for comparison. The core questionnaire used in that study was identical to the one used in the study of the European Community Respiratory Health Survey (ECRHS) and the SAPALDIA Basel study center was a certified ECRHS center (23). These subjects also underwent skin prick testing (Parietaria, Birch pollen, Timothy grass pollen, Alternaria, Cladosporium, Dermatophagoides pteronyssinus, cat and dog epithelium), spirometry, methacholine challenge test and exhaled carbon monoxide measurement. Definitions for airway symptoms were used as described before (18;22;24-29). To characterize responsiveness to methacholine expressed as two-point dose-response slope, reference equations depending on individual characteristics (i.e. sex, age and baseline lung function) were used as described by Jayet and coworkers (30). Atopy was defined as a positive response to at least one of the allergens tested. Physician diagnosed asthma was defined as affirmative answer to the question “Do you have asthma?” and “Has this been confirmed by a
doctor?”. Seasonal rhinitis or conjunctivitis was defined as follows: Positive answer to at least one of the questions, “Did you ever experience a runny or stuffy nose or the urge to sneeze in the presence of pollen during spring or summer” and “Have you ever had itchy or watery eyes in the presence of pollen during spring or summer?”, were “in the presence of pollen” stands for “when you were close to trees, grass or flowers or when there was much pollen in the air” (29).

STATISTICS

Continuous variables are expressed as means ± standard deviation (SD), and categorical variables are expressed as relative frequencies and percentages. Fisher’s exact test was used for testing differences in the prevalence of respiratory symptoms, PD15 to methacholine and allergy between groups. Results of body measurements, ventilatory capacity tests, measurement of airway hyperresponsiveness to methacholine were analyzed by the unpaired t-test. Differences between the SAPALDIA general population and firefighters in dose response ratio (DDR) were assessed using Mann-Whitney U-test. To compare DRR to methacholine between firefighters and SAPALDIA, responsiveness to methacholine greater than the 90th percentile was calculated as an indicator variable for each subject according to Jayet and coworkers (30). Subsequent a logistic regression was performed with the indicator as dependent and potentially influencing factors (group firefighters vs SAPALDIA, age, physician diagnosed asthma, wheezing in the last 12 months, atopy, forced expiratory volume in one second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio) as independent variables. For all predictors odds ratios with corresponding 95% confidence intervals were calculated. A p-value
of less than 0.05 was considered to indicate statistical significance. All tests were
two-tailed and performed with use of SPSS Version 13 and Microsoft Excel 2002
software.

RESULTS

The mean age of firefighters was 41 years (± 11 years) compared to 40 years (± 12
years) in the SAPALDIA Basel sample (p=0.853). Firefighters have been appointed
for this job for a mean of 16 years (± 10 years). The number of current smokers was
similar in the firefighter and SAPALDIA Basel groups whereas the number of never
smokers was significantly higher in the firefighters (Table 1b). The mean amount of
daily cigarette consumption was five cigarettes per day in firefighters compared to 7
cigarettes in the general population (p=0.04).

General respiratory symptoms based on the SAPLADIA questionnaire and the
incidence of physician diagnosed asthma was similar in both groups (Table 2a). When
specifically asked for respiratory symptoms encountered during work, burning
eyes, running nose, throat itching, cough, dyspnoea and headache were significantly
more prevalent in firefighters compared to the SAPALDIA Basel sample (Table 2b).
Overall, 51 (51%) firefighters were atopic compared to 215 (32%) of the SAPALDIA
Basel population (p<0.001) (Table 1). Duration of employment did not account for the
differences in prevalence of respiratory symptoms and atopy (Table 4).

Comparing firefighters with the SAPALDIA Basel population, the mean FEV1%
predicted were 103% (± 12%) and 100 % (±19%) (p=0.053), the FVC% predicted
were 97% (±14%) and 91% (±13%) (p<0.001) and the FEV1/FVC ratio were 0.77
(±0.07) and 0.75 (±0.09) respectively (p=0.078). Methacholine was done in 96 (96%)
firefighters and 558 (76%) subjects in of the SAPALDIA Basel population. Methacholine testing was not done in four firefighters because they missed the scheduled appointment. One subject did not undergo methacholine challenge as he had a FEV1/FVC ratio of 0.59, which increased greater than 15% after inhaling a short acting bronchodilator. Fifteen firefighters (16%) had a positive methacholine challenge test based on a fall in FEV1 greater or equal to 20% compared to 52 (9%) from the SAPALDIA Basel population (p=0.06). The mean reactivity to methacholine expressed as the continuous dose response ratio (DRR) was 4.29 (±15.68) %decrease/µmol for firefighters and 5.44 (± 39.30) %decrease/µmol in the SAPALDIA Basel population (p<0.001)

The odds ratio to have responsiveness to methacholine greater than the 90th percentile compared to the male SAPALDIA Basel population was 2.24 (95% CI 1.12-4.48). In logistic regression analysis the following factors influencing greater methacholine responsiveness were identified: Being a firefighter (OR 2.39, 95% CI 1.17-4.89, p<0.05), FEV1/FVC ratio <0.7 (OR 2.70, 95% CI 1.69-4.35, p<0.01), history of wheezing in the last 12 months (OR 2.17, 95% CI 1.2-3.94, p<0.01) and doctors diagnosed asthma (OR 3.46, 95% CI 1.63-7.33, p<0.01).

DISCUSSION

A high incidence of respiratory symptoms has been reported in firefighters (4;5;31). In Croatian firefighters, Mustajbegovic and co-workers have reported a prevalence of chronic cough, chronic phlegm and chronic bronchitis in more than 20% of subjects. (4). These symptoms were less frequent in our study population; however, cough was regularly encountered at work in 28% of firefighters (Table 2a and 2b). The
increased prevalence in the Croatian firefighters might be attributed to the higher prevalence of current smokers (53%) compared to the Basel firefighters (32%). An increase in upper and lower airway symptoms was reported in New York firefighters engaged in rescues operations during the world trade center attack in 2001(14). These firefighters had a low prevalence of cough (2%) prior to responding to this incident, which might be related to low prevalence of smoking (3%) in their study population (14). Chronic symptoms were similar in the Basel firefighters when compared with the SAPALDIA Basel population (Table 2a). However, several respiratory symptoms regularly encountered during work were significantly more often reported in the Basel firefighters (Table 2b). Therefore, the general respiratory symptoms questionnaire used in epidemiological studies might be inadequate to assess respiratory symptoms of firefighters.

In the current study, firefighters had a significantly higher rate of atopy compared to the SAPALDIA Basel population (Table 3). This increased rate of atopy in firefighters might be due to the exposure to pollutants encountered at fire station or scenes of incidents and/or due to the exposure to motor vehicle exhaust fumes as the Basel fire station is centrally located at a busy street. Firefighters are known to be at risk of exposure to diesel emissions and combustion products (32). Self contained breathing apparatus which are recommended to be routinely used at scenes of incidents, are heavy, increase energy cost, lower work performance and impair postural and functional balance (33;34) and therefore may not consequently be used by firefighters especially if there are no visible flames or smoke on the scene (19). The appropriate equipment is often not used during the overhaul and clean-up phase after visible flames are extinguished despite the possible high concentration of combustion products even during this phase (19;35). Air pollution has been shown to
increase and exacerbate respiratory symptoms or reduce the dose of allergen needed to provoke an allergic response in atopic subjects (36-38). It has been hypothesized that air pollutants may promote airway sensitisation by altering the allergenic content of airborne particles that are containing different allergens (36;39-43). Air pollution may damage the airway mucosa and may affect the mucociliary clearance and this may ease the penetration and access of inhaled allergens to the cells of the immune system (36;42;44). Pollen grains or allergen bearing particles may interact with nitrogen dioxide and carbon particles leading to an increased allergenicity (15-17;45). In an experimental human study challenge with diesel exhaust particles and ragweed induced markedly higher ragweed-specific IgE when compared with a challenge with ragweed alone (46). An increased sensitization to outdoor allergens has been shown in subjects living in streets with high volume traffic (18;36;47-49). Compared to the SAPALDIA study we tested for more allergens (3 tree mixture compared to birch pollen alone and 6 grass mixture compared to timothy grass pollen and Parietaria in the SAPALDIA study) and this may at least partially explain the higher rate of atopy in the population of firefighters when using the definition of atopy to having at least one positive SPT to an allergen. But when limiting the analysis only to the allergens that were tested in both groups the difference still exists. The highest rate of atopic (defined as at least one positive SPT to one of the allergens tested) were seen in firefighters aged 40 to 50 years (data not shown). It can be argued that younger firefighters have had less exposure to pollutants due to shorter duration of service whereas in firefighters with longer duration of service there might be a selection of healthy worker and therefore workers with atopy and respiratory disease might change their profession. In addition it has been shown that atopy prevalence is decreasing with age (29;50) and that
smoking is negatively related to atopy (29). In our population of firefighters the smoking prevalence was lower than in the SAPALDIA Basel male population and therefore we would expect an atopy rate below the SAPALDIA Basel population. As skin prick tests are not routinely performed during the medical exam at conscription we do not know if atopic subjects were selected for this profession. If this would be the case it seems that atopy does not influence the performance of the subject in the fitness test every firefighter candidate has to pass prior to hiring. It seems that atopy alone does only marginally limit performance in physical activity. Katelaris has shown a high prevalence of atopy to at least one aeroallergen in athletes taking part at Olympic Summer Games (51). SPTs are not included in the pre-employment and routine medical examination of firefighters and hence the exact impact of firefighting on the atopy status cannot be determined in the current study. Thus, SPTs could be included in the routine medical examination of firefighters.

Firefighters in the current study had a significantly higher vital capacity compared to the SAPALDIA Basel population (Table 1a). This might be due to the selection of healthy workers for this profession. In professional divers a similar effect has been attributed to the natural selection for diving rather than a training effect (52). Spirometry is routinely included in the pre-employment medical assessment of potential firefighting recruits in Switzerland and those with impairment of lung function are declared unfit for service (20). Subjects having asthma are also refused enrolment in the fire fighting brigade (20). Airway challenge tests are not routinely performed in firefighters and reserved for specific subjects by the examining physician (20). A response to methacholine based on a fall in FEV1 greater or equal to 20% (PD 20) was similar in firefighters as well as the SAPALDIA Basel population. However, the dose response ratio to methacholine is argued to be a better predictor
of bronchial hyperreactivity, particularly for epidemiologic studies as it avoids censoring (53). Furthermore, the response to methacholine based on a fall in FEV1 greater or equal to 20% varies depending on the maximum dose administered. In the current study, airway hyperresponsiveness based on the dose response ratio (53) to methacholine was significantly lower in the firefighters compared to the SAPALDIA Basel population. As different factors may influence the value of the dose response ratio, Jayet and co-workers calculated reference equations for relevant percentiles of the methacholine two-point dose response slope taking into account individual characteristics like sex, age and pre-test airway calibre. Jayet and co-workers suggested the 90th percentile as a “cut-off” level for identifying asthmatics in a sample of subjects with self reported physician diagnosed asthma yielding a sensitivity of 51% (30). By using these percentile equations who take into account pre-test lung volume the proportion of subjects with methacholine reactivity above the 90th percentile is higher in firefighters than in the male SAPALDIA population (26% vs 13%, p=0.001). The risk of having reactivity to methacholine above the 90th percentile is double for the firefighters compared to the male SAPALDIA population (odds ratio 2.24, 95% CI 1.12-4.48). Self reported physician diagnosed asthma, wheezing in the last 12 months and a FEV1/FVC ratio <0.7 were factors contributing to a reactivity to methacholine of above the 90th percentile. A positive association between the degree of bronchial hyperresponsiveness and the level of FEV1 have been described before (54) whereas wheezing in the last 12 months is a cardinal symptom of asthma and is often used in epidemiological studies to define asthma in patients with a positive bronchial challenge test (55-57).

Unlike studies done before, this hyperreactivity was not related to an acute exposure to combustion products or a polluted environment as our study was
performed in a cross sectional manner and those who had responded to an incident and were exposed to combustion products within the last 24 hours were rescheduled (8;9;14;58). Due to the preemployment screening, one might expect the prevalence of asthma to be lower in the firefighters compared to the general population. However, in our study, the diagnosis of current physician diagnosed asthma was similar in the firefighters and the SAPALDIA Basel population. Out of the six firefighters with current physician diagnosed asthma, only two had a record with a confirmatory diagnosis of asthma by the board physician. Therefore, there is a possibility of under reporting symptoms during medical screening of firefighters. Potential under reporting of symptoms and the current diagnosis of asthma has been reported in US air force recruits (59). The findings of our study underline the value of performing objective tests prior to enrolment and also during routine medical examination of firefighters.

Working under respiratory protection with a self containing breathing apparatus (SCBA) or diving with a self-containing underwater breathing apparatus (SCUBA) will lead to an increase in workload and therefore minute ventilation. When filling the bottle, air is compressed and dehumified to avoid corrosion of the metal parts of the breathing apparatus. When the air is released and decompressed during use of the apparatus it is cooling down (Boyle’s law). This dry cold air could be a trigger for an acute bronchoconstriction when airway inflammation is present (60). Indirect bronchial challenge tests like mannitol powder, Adenosine 5’-Monophosphate, hypertonic saline or exercise eucapnic voluntary hyperpnoea act via osmotic stimuli on inflammatory cells who then release mediators like histamine, leukotrienes and prostaglandins who act on smooth muscle cells (61). As an acute impairment of lung function can influence work performance and therefore put the
subject and co-workers in danger we suggest that individuals with a positive indirect challenge test should be declared unfit to work under respiratory protection and should be treated until airway inflammation has resolved. The status fit for duty should not be restored until these subjects have a negative indirect challenge test.

According to the study by Sistek et al. (26) wheezing was the most sensitive single symptom of current active asthma. Based on our current findings, firefighters either develop asthma as a consequence of their job or the initial screening using questionnaire and spirometry is insufficient.

Further studies are needed to determine the impact of professional firefighting on sensitization to aeroallergens and on bronchial hyperreactivity. To answer this question skin prick tests and bronchial challenge tests should be done at conscription and in regular intervals when active in the workforce. Exposure to airway irritants should be estimated by recording work duties (eg. number of operations with exposure to airway irritants, type of work done at the site and type of respiratory protection worn), by using personal air and dust sampling devices (19;35) or measuring biological indicators of exposure (62). Furthermore studies assessing the impact of atopy and bronchial hyperreactivity on work performance and medical leaves are needed.

To summarize, firefighters have more respiratory symptoms at work compared to the general population and these have to be asked specifically. Firefighters seem to have more atopy compared to the general population, which might be related to the greater exposure to a polluted environment. Firefighters also have more bronchial hyperreactivity, which is not related to an acute exposure to a firefighting incident. Whether these findings were present at recruitment or developed after joining the workforce is unclear.
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Table 1a
Comparison of lung function, exhaled carbon monoxide measurement in firefighters compared with the the SAPALDIA Basel sample

<table>
<thead>
<tr>
<th></th>
<th>FIREFIGHTERS</th>
<th>SAPALDIA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at examination</td>
<td>41 yrs (range 23-64 yrs)</td>
<td>40 yrs (range 18-62 yrs)</td>
<td>P=0.853</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>178 (SD 6)</td>
<td>176 (SD 7)</td>
<td>P=0.026</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>83 (SD12)</td>
<td>77 (SD11)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.2 (SD 3.4)</td>
<td>24.7 (SD 3.5)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>FEV1%predicted</td>
<td>103 (SD 12)</td>
<td>100 (SD 19)</td>
<td>P=0.053</td>
</tr>
<tr>
<td>FVC%predicted</td>
<td>97 (SD 14)</td>
<td>91 (SD 13)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>FEV1/FVC ratio</td>
<td>0.77 (SD 0.07)</td>
<td>0.75 (SD 0.09)</td>
<td>P=0.078</td>
</tr>
<tr>
<td>Exhaled carbon monoxide (ppm)</td>
<td>4 (SD 7)</td>
<td>15 (SD 16)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Subjects with CO &gt;10 ppm</td>
<td>11 %</td>
<td>37 %</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

BMI body mass index
FEV1 forced expiratory volume in one second
FVC forced vital capacity
DRR dose response rate, expressed as geometric mean
Table 1b
Smoking status and second hand smoke (SHS) exposure in firefighters compared with the control group

<table>
<thead>
<tr>
<th></th>
<th>FIREFIGHTERS N=101</th>
<th>SAPALDIA N=735</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current smoker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cigarettes per day</td>
<td>32 (32%)</td>
<td>294 (40%)</td>
<td>P=0.128</td>
</tr>
<tr>
<td></td>
<td>5 (SD11)</td>
<td>7 (SD 12)</td>
<td>P=0.044</td>
</tr>
<tr>
<td>Never smoker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- SHS in Never smoker</td>
<td>44 (44%)</td>
<td>241 (33%)</td>
<td>P=0.034</td>
</tr>
<tr>
<td></td>
<td>25 (57%)</td>
<td>67 (28%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Former smoker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- SHS in Former smoker</td>
<td>23 (23%)</td>
<td>197 (27%)</td>
<td>P=0.470</td>
</tr>
<tr>
<td></td>
<td>8 (35%)</td>
<td>50 (25%)</td>
<td>P=0.327</td>
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</table>
Table 2a

Respiratory Symptoms in firefighters and the control group

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Firefighters N=101</th>
<th>SAPALDIA N=735</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheezing</td>
<td>15 (15%)</td>
<td>141 (19%)</td>
<td>P=0.342</td>
</tr>
<tr>
<td>Wheezing with dyspnoea</td>
<td>12 (12%)</td>
<td>72 (10%)</td>
<td>P=0.483</td>
</tr>
<tr>
<td>Wheezing without cold</td>
<td>10 (10%)</td>
<td>91 (12%)</td>
<td>P=0.625</td>
</tr>
<tr>
<td>Nocturnal chest tightness</td>
<td>13 (13%)</td>
<td>100 (14%)</td>
<td>P=1.000</td>
</tr>
<tr>
<td>Rest dyspnoea</td>
<td>4 (4%)</td>
<td>48 (7%)</td>
<td>P=0.386</td>
</tr>
<tr>
<td>Exercise dyspnoea</td>
<td>12 (12%)</td>
<td>139 (19%)</td>
<td>P=0.098</td>
</tr>
<tr>
<td>Nocturnal cough</td>
<td>19 (19%)</td>
<td>194 (26%)</td>
<td>P=0.114</td>
</tr>
<tr>
<td>Nocturnal dyspnoea</td>
<td>5 (5%)</td>
<td>46 (6%)</td>
<td>P=0.824</td>
</tr>
<tr>
<td>Chronic cough</td>
<td>7 (7%)</td>
<td>54 (7%)</td>
<td>P=1.000</td>
</tr>
<tr>
<td>Chronic phlegm</td>
<td>4 (4%)</td>
<td>69 (9%)</td>
<td>P=0.088</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>18 (18%)</td>
<td>133 (18%)</td>
<td>P=1.000</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>8 (8%)</td>
<td>74 (10%)</td>
<td>P=0.595</td>
</tr>
<tr>
<td>Physician diagnosed Asthma</td>
<td>6 (6%)</td>
<td>60 (8%)</td>
<td>P=0.556</td>
</tr>
</tbody>
</table>
Table 2b

Symptoms regularly encountered during work in firefighters and the control group

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Firefighters</th>
<th>SAPALDIA</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health disturbance</td>
<td>9 (9%)</td>
<td>63 (9%)</td>
<td>P=0.851</td>
</tr>
<tr>
<td>Burning eyes</td>
<td>21 (21%)</td>
<td>20 (3%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Running nose</td>
<td>19 (19%)</td>
<td>17 (2%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Throat itching</td>
<td>26 (26%)</td>
<td>21 (3%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Cough</td>
<td>28 (28%)</td>
<td>20 (3%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Dyspnoea</td>
<td>7 (7%)</td>
<td>13 (2%)</td>
<td>P&lt;0.006</td>
</tr>
<tr>
<td>Wheezing</td>
<td>2 (2%)</td>
<td>9 (1%)</td>
<td>P=0.632</td>
</tr>
<tr>
<td>Fever</td>
<td>1 (1%)</td>
<td>2 (&lt;1%)</td>
<td>P=0.321</td>
</tr>
<tr>
<td>Headache</td>
<td>25 (25%)</td>
<td>22 (3%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>2 (2%)</td>
<td>7 (&lt;1%)</td>
<td>P=0.298</td>
</tr>
</tbody>
</table>
Table 3
Sensitisation and atopy

<table>
<thead>
<tr>
<th>Allergen</th>
<th>Firefighter</th>
<th>SAPALDIA general population</th>
<th>p-value (when applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-grass mixture</td>
<td>25/101 (25%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thimothy</td>
<td></td>
<td>132/699 (19%)</td>
<td></td>
</tr>
<tr>
<td>Paretaria</td>
<td></td>
<td>5/693 (1%)</td>
<td></td>
</tr>
<tr>
<td>3-tree mixture</td>
<td>26/101 (26%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birch</td>
<td></td>
<td>86/699 (12%)</td>
<td></td>
</tr>
<tr>
<td>Alternaria</td>
<td>13/101 (13%)</td>
<td>9/679 (1%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Cladosporium</td>
<td>7/100 (7%)</td>
<td>1/673 (1%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Cat dander</td>
<td>13/101 (13%)</td>
<td>28/669 (4%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Dog dander</td>
<td>14/101 (14%)</td>
<td>23/699 (3%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>D. pteronyssinus</td>
<td>28/101 (28%)</td>
<td>83/680 (12%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>D. farinae</td>
<td>31/101 (31%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atopy (same allergens)</td>
<td>36/100 (36%)</td>
<td>112/ 652 (17%)</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Atopy (wider definition)</td>
<td>51/100 (51%)</td>
<td>215/ 663 (32%)</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

Atopy (same allergens): at least one SPT positive to the following antigens:
Alternaria, Cladosporium, D. pteronyssinus, Cat and Dog dander.

Atopy (wider definition): at least one SPT positive to one of the tested antigens
Table 4: 
Wheezeing, respiratory symptoms at the workplace, hay fever and atopy according to duration of work as a firefighter

<table>
<thead>
<tr>
<th></th>
<th>≤10 years (n=38)</th>
<th>&gt;10 years (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheezing in the last 12 months</td>
<td>6 (16%)</td>
<td>9 (14%)</td>
</tr>
<tr>
<td>Respiratory symptoms at the workplace</td>
<td>14 (37%)</td>
<td>20 (32%)</td>
</tr>
<tr>
<td>Atopy</td>
<td>21 (55%)</td>
<td>29 (46%)</td>
</tr>
</tbody>
</table>