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SHORT-TERM RESPIRATORY EFFECTS OF CLEANING EXPOSURES IN DOMESTIC CLEANING WOMEN

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ABSTRACT

Symptoms of obstructive lung disease in domestic cleaners have been related to the use of bleach and other irritant cleaning products. We investigated short-term effects of cleaning exposures on respiratory symptoms and peak expiratory flow (PEF) in domestic cleaners with respiratory disorders.

In a panel study, 43 domestic cleaning women with a recent history of asthma and/or chronic bronchitis completed a two-week diary collecting information on respiratory symptoms, PEF and cleaning exposures. Mixed regression models were used to assess daily changes in symptoms and PEF associated with specific cleaning exposures. The probability of having work-related asthma was individually assessed by a computerized diagnostic system (Oasys) and by an occupational asthma expert.

Lower respiratory symptoms were more common on working days (odds ratio (OR) 4.3; 95% confidence interval 1.7 to 11) and were predominantly associated with exposure to diluted bleach (OR 2.5; 1.1 to 5.8), degreasing sprays/atomizers (OR 2.6; 1.1 to 6.6) and air fresheners (OR 6.5; 2.1 to 20). Associations with upper respiratory symptoms and PEF were less apparent. Eleven subjects (30%) were positively scored for work-related asthma.

We conclude that exposure to certain irritant cleaning products aggravates lower respiratory symptoms in domestic cleaning women with asthma or chronic bronchitis.

INTRODUCTION

Recent studies have found an increased risk of asthma and other respiratory symptoms in cleaning workers [1-4], being particularly apparent in women employed in domestic cleaning [5, 6]. Surveillance studies for occupational asthma have also shown an increased incidence in cleaning workers [7-9], and cleaning materials, including bleach and ammonia, are among the most frequently reported causes of work-related asthma in the US [10]. In a previous nested case-control study among domestic cleaning women we found that regular use of bleach and possibly also other irritant cleaning products was associated with a higher risk of asthma and chronic bronchitis symptoms [11]. This was a cross-sectional study with prevalent cases, and therefore it was not possible to ascertain the time sequence between exposures and symptoms. Here we tested the hypothesis that exposure to irritant cleaning products may aggravate a pre-existing obstructive lung disease in domestic cleaning women. We conducted a panel study to evaluate short-term effects of transient cleaning exposures on respiratory symptoms and peak expiratory flow rate (PEF) in domestic cleaning women with a recent history of obstructive lung disease.

METHODS

Study design and population

Between June 2001 and April 2002 a two-week panel study was conducted among domestic cleaning women between 31 and 66 years of age with a history of obstructive lung disease. Subjects were recruited from participants of a case-control study [11] that had been nested within a large population-based cross-sectional survey conducted in Cornellà (Barcelona, Spain) in 2000-2001 [6]. Those reporting current asthma symptoms (i.e., having had an attack of asthma and/or being woken by an attack of shortness of breath in the last 12 months), chronic bronchitis symptoms (i.e., cough and/or bringing up phlegm on most days for at least three months each year), or both at the time of the population-based survey [6] were selected for the present panel study. Because symptomatic status for the selection of participants was determined approximately one year before the panel study, we will refer to participants as individuals with a *recent history of obstructive lung disease*. After excluding those who were illiterate or otherwise unable to complete a diary (n=7), a total of 80 women were invited to participate of which 51 (64%) returned a completed diary.

Diary

Each participant completed a two-week diary including information on cleaning exposures, respiratory symptoms and PEF. A trained research nurse instructed the participants on completing the diary and measuring the PEF using a mini-Wright peak

flow meter. All subjects performed a practice attempt of PEF measurement under supervision and were given detailed written instructions [12].

The exposure assessment was based on daily information about the use of cleaning products and performance of cleaning tasks. Participants were asked to mark in a checklist all cleaning exposures during the day, including exposures in their own home. Information about the number of hours cleaning in each home was also collected.

The intensity of seven different respiratory symptoms was recorded daily using a five-category scale (0=none, 1=very mild, 2=mild, 3=moderate, 4=severe). A daily symptom severity score was calculated for upper respiratory tract symptoms (URS) summing the scores for blocked nose, throat irritation and watery eyes. Likewise, a daily symptom severity score for lower respiratory tract symptoms (LRS) was obtained summing the scores for chest tightness, wheezing, shortness of breath and cough.

PEF was recorded three times a day: in the morning (after rising), at lunchtime (between 1pm and 3pm) and before going to sleep. On each occasion, participants recorded three PEF measurements [12] and the highest was used in statistical analyses. Participants also provided daily information on usage of respiratory medication, presence of respiratory infection and number of cigarettes smoked.

Lung function and allergy testing

Clinical information was available from the case-control study [11]. Measurement of forced expiratory volume in one second (FEV_1) and methacholine challenge were performed following standard spirometry procedures [13, 14]. Bronchial hyperresponsiveness (BHR) was defined as a fall of ≥ 20% in FEV_1 associated with a methacholine dose ≤ 1 mg. Methacholine challenge was not performed in women with a baseline FEV_1 of either <1.5 L or <70% of the predicted value. Atopy was defined as a serum specific IgE level > 0.35 kU/L for at least one of these allergens: *Dermatophagoides pteronyssinus*, *D farinae*, cat, dog, *Cladosporium herbarum*, Timothy grass, *Parietaria judaica*, *Alternaria alternata* and latex.

Analyses

Of the 51 returned diaries, two were excluded from analyses because less than seven days had been completed. Plots of PEF series of the remaining 49 diaries (including a total of 693 days) were visually inspected to detect possible recording errors, outliers or a learning effect [15]. A total of 94 person-days were excluded from analyses due to these problems. Days reporting usage of respiratory medication were only included in the analyses if the same amount of medication was reported for at least five consecutive days, resulting in the exclusion of 17 person-days. Following this approach, we could assume that the reported medication predominantly referred to maintenance medication rather than bronchodilators. Six women had all recorded days affected by at least one of the previous circumstances. Thus, final analyses were based on 582 days from 43 women.

Statistical analyses were done using Stata version 7 (Stata Corporation, College Station, Texas, USA). Associations between daily cleaning exposures, respiratory symptoms and PEF were evaluated using logistic or linear mixed regression models, separately for each cleaning exposure. Exposure to a specific cleaning task or product was considered regardless whether this occurred at home or at work. Due to lack of statistical power, exposures present on less than 10% of the total person-days were not considered for analysis. The assessment of short-term effects of cleaning exposures on URS and LRS was based on binary outcomes obtained by dichotomising the respective symptom severity scores using a cut-off point of two [16]. Associations between each cleaning exposure and PEF were assessed using the PEF at night and the PEF in the morning of the following day as continuous variables. All models had a random intercept for each individual and were adjusted for presence of respiratory infection, use of maintenance medication and age. Some models were additionally adjusted for daily number of cigarettes smoked, years of employment in domestic cleaning and/or weekly working hours in domestic cleaning when the adjusting variable was significantly associated with the outcome or confounded the association with other covariates. In the analysis of URS and LRS, exposure variables that showed a P value less than 0.1 in the separate models were included in the same model to account for the simultaneous exposure to several products. Explanatory variables with a P value less than 0.1 were maintained in the final model and were subsequently evaluated for their association with respiratory symptoms during the following day.

Evaluation of peak flow patterns

Serial PEF charts were plotted for each individual using the Oasys programme (Occupational asthma system) [17] and the probability of having occupational asthma was scored by Oasys and also by an expert included in the authors list (PSB). Charts were plotted first by separating days at and away from work, then re-plotted separating days with and without exposure (either at work or at home) to bleach and/or degreasing sprays/atomizers (two of the cleaning products significantly associated with LRS in the previous analyses). The Oasys programme compares the PEF during an exposed period with the non-exposed periods before and after (a rest-work-rest complex). Likewise, each non-exposed period is compared with the two exposed periods before and after (a work-rest-work complex). The Oasys programme first scores complexes within a person's record, then gives an overall score from 1 to 4 (1 meaning occupational asthma is unlikely, 2 possible, 3 probable and 4 definite) [17]. The expert performed a similar procedure, but gave an integer score for the whole record. A total score of >2.50 was considered to be positive for occupational asthma when plotted by Oasys and a score of 3 or 4 positive when scored by the expert [17].

RESULTS

No major differences were observed between responders and non-responders, except for a higher prevalence of BHR and a shorter duration of domestic cleaning employment among responders (table 1). The mean age of the study population was 49 years and most participants were lifetime non-smokers. Although all participants reported current respiratory symptoms during the population-based survey, six women did not report respiratory symptoms during the two-week panel study. Cough, reported at least once by 63% of the subjects, was the most common symptom, whereas wheezing and chest tightness, both reported at least once by 30% of the subjects, were the least common. The median of the average individual PEF was 395 L/min, which was slightly higher than the predicted value. A respiratory infection was reported on 20% of the person-days, the usage of maintenance medication on seven percent and smoking on 21%, with a median of 10.5 cigarettes smoked per day (data not shown).

Participants reported at least one cleaning activity/exposure on 98% of the days. As a median, participants went to clean other homes on 63% of the days. Cleaning the own home was performed on 76% of working days and 96% of days off work, which were not only weekends. The median number of hours cleaning (7.5 vs. 4), the median number of cleaning products used (5 vs. 3) and the median number of cleaning tasks performed (11 vs. 9) were higher on working days as compared to leisure days. Frequency of exposure varied across the different tasks and products. Some exposures, such as washing dishes or using bleach, were reported by most participants on the majority of the days; whereas other exposures, such as carpet/rug

beating or using stain removers, were reported by a minority of the participants and only on few days.

The associations between respiratory symptoms and cleaning exposures showed a different pattern for URS and LRS (Table 2). For URS there was no association with working days and only two specific cleaning exposures (vacuuming and using degreasing sprays/atomizers) showed a statistically significant association. In contrast, there was a strong and significant association between working days and LRS that increased with the daily number of working hours. Similarly, most of the tasks and products showed a statistically significant association with LRS. Having a respiratory infection, being older and working more hours per week increased the risk of both URS and LRS. Increased daily number of cigarettes smoked and taking maintenance medication were associated with presence of LRS.

Most associations between PEF and cleaning exposures were small and scattered around null (table 2). The only statistically significant decrease of the PEF at night was related to the use of ammonia. Older subjects showed significantly lower PEF levels, as did those with a respiratory infection when PEF was measured at night.

Multiple regression models including all potentially relevant exposure variables showed that vacuuming was the only cleaning exposure independently related to URS (Table 3). The use of diluted bleach, degreasing sprays/atomizers and air refreshing sprays/atomizers were independently associated with LRS and, in the case of diluted bleach, also with symptoms during the following day (OR 2.8 (1.2 to 6.6); data not presented). These associations were essentially the same for subjects

with asthma and subjects with chronic bronchitis and persisted when analyses were restricted to non-atopic subjects. Adjustment for working day or for daily hours cleaning resulted in similar estimations.

A total of 37 subjects had adequate PEF data for the individual evaluation of occupational asthma by either Oasys or the expert review. Eleven (30%) individuals were classified as having occupational asthma by at least one of the two assessments (Table 4). There was agreement between the expert and Oasys for five subjects in whom work-related changes were seen: four when all days at work were classed as exposed and a fifth only when exposure to bleach/degreaser was considered. The positive Oasys graph of cases #2 and #1 are shown in figures 1a-b, corresponding to the analysis of working and leisure days and of days with and without exposure to bleach/degreasers, respectively.

DISCUSSION

This panel study showed that women employed in domestic cleaning who had a recent history of obstructive lung disease experienced worsening of respiratory symptoms on working days and on days performing more hours cleaning. Although work-related PEF changes were not evident in the regression analysis, when PEF charts were individually assessed, 30% of women showed a pattern suggestive of occupational asthma. These results further support the relationship between working in domestic cleaning and asthma, although distinction between new-onset asthma and work-aggravated asthma is not possible at this point. In either case, our results suggest the existence of work-related respiratory symptoms and PEF decrements after exposure to certain cleaning products.

In our study, presence of LRS was predominantly associated with use of diluted bleach, degreasing sprays/atomizers and air refreshing sprays/atomizers. Decrements in PEF at night were associated with exposure to ammonia in the regression models, and with the use of bleach and degreasing sprays/atomizers when PEF charts were analysed individually. These results are consistent with the case-control study, where regular exposure to these products was related to asthma and chronic bronchitis symptoms in this population when compared to symptom-free controls [11]. In addition, the results here presented support our previous reasoning that occupational asthma in domestic cleaning job is probably irritant-induced or irritant-aggravated. This is supported by the fact that atopy neither was associated with LRS nor modified the associations between cleaning products and LRS; as well as by the observation that only two out of the eleven women with possible

occupational asthma were atopic. However, sensitisation to substances such as pinene [19] or limonene [20] that are present in air refreshing sprays/atomizers was not tested and thus cannot be ruled out. Finally, the fact that PEF variability was relatively small even in subjects with a pattern suggestive of occupational asthma is consistent with the possibility that airway obstruction is less pronounced in those with irritant-induced asthma than in sensitized workers.

Bleach, a chlorine-releasing agent, can also liberate moderate amounts of chloramines when combined with products containing traces of nitrogen compounds (e.g., dishwashing liquids). In our population, average levels of airborne chlorine during cleaning activities (including use of bleach) ranged up to 0.4 ppm with peaks up to 1.3 ppm [11]. In agreement with our results, an experimental study reported that two out of seven individuals with BHR experienced respiratory symptoms following a 60-minute exposure to 1 ppm chlorine [21]. Furthermore, low-level exposure to chlorine has been related to immediate decrements in lung function, including PEF [21], whereas inhalation of moderate levels of chloramines has been related to both immediate and late asthmatic reactions [22].

The association between LRS and exposure to air refreshing sprays/atomizers is consistent with the known susceptibility of asthmatic subjects to odours, which have been related to respiratory complaints including tightness of chest, shortness of breath, wheeze and cough [23]. In addition, cleaning products and cologne/perfume are among the most common triggers reported by asthmatics reacting to odours [24].

The effect of daily cleaning exposures on the PEF level was very subtle when assessed using regression models that averaged the changes in all individuals. The most relevant change observed in PEF using regression analysis was a mean decrease of 10.3 L/min (2.6% of the population median PEF) in PEF at night associated with use of diluted ammonia. Although this average change was within the normal range of PEF reproducibility [25, 26], it is noteworthy that two women experienced a decrease >5% and one woman >10% after exposure to diluted ammonia. This suggests that, although present in few individuals, most of the exposure-related changes in PEF were probably moderate. This could partly be due to the substantial proportion of subjects in the study population with a history of chronic bronchitis symptoms and/or to a mild BHR, since daily variations in airway calibre are less pronounced in subjects with chronic bronchitis or mild asthma [27]. In addition, PEF measurements were only done three times a day, resulting in a somewhat low sensitivity and involving the possibility that some changes in PEF remained undetected.

In spite of the subtle changes in PEF observed in the regression analysis, the evaluation of individual PEF charts by both the Oasys program and the expert revealed the existence of important exposure-related changes in at least five women. It is important to keep in mind, however, that Oasys is less sensitive when measurements are made less than four times a day, less than three consecutive days at work and/or have a duration of less than three weeks [28]. For that reason, with the type of records obtained in our study, Oasys had a sensitivity of 64% and a specificity of 83% in the detection of occupational asthma patterns. In addition, the analysis of specific exposures using Oasys was often difficult due to short periods of consecutive days with exposure and had to be restricted to bleach/degreasers exposure.

Our study has several limitations that should be taken into account. First of all, the lack of within-individual variability for infrequent cleaning exposures forced us to exclude from analyses several cleaning agents such as waxes, oven sprays or hydrochloric acid, precluding the recognition of potentially existing associations. Secondly, the limited number of daily PEF readings could have biased the results against detecting immediate reactions with a rapid recovery. This type of reaction was probably only captured by reported respiratory symptoms, as they referred to the whole day period rather than to a precise moment. Thirdly, exposure assessment in our study was based on presence/absence of exposure, which minimized exposure misclassification but precluded the investigation of a dose-response relationship. Given the paucity of previous studies on the short-term effects of cleaning exposures, our study placed the priority on examining a wide range of exposures rather than on characterizing a few in detail. Finally, as a result of examining multiple exposures, some of the associations found here could be spurious. Nevertheless, the agreement between the regression models and the individual diagnostic and the consistence with results from the case-control study do not support this hypothesis.

In conclusion, professional domestic cleaners with a history of obstructive lung disease may suffer a short-term increase in lower respiratory symptoms on working days and on days using irritant cleaning products, including sprays. A clear effect of these exposures on PEF, however, was only evident in few individuals. Our findings suggest that asthma and chronic bronchitis in domestic cleaners may be, at least partly, irritant-aggravated. Further research is needed to disentangle new-onset and work-aggravated asthma in domestic cleaning workers and to investigate the

short- and long-term effects of irritant cleaning products in other cleaning workers and in the general population, especially in those with chronic respiratory disorders. International studies are needed to evaluate the impact of qualitative and quantitative differences in cleaning products and procedures across countries [29].

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Table 1. Descriptive characteristics of the study population and of those who did not complete the diary.

	Participants*	Non-responders	P-value†
Number of subjects	43 (100)	29 (100)	
Age (years)	49 (34 to 65)	53 (31 to 66)	0.14
Smoking status			
. Never	27 (63)	23 (79)	
. Ex-smokers	6 (14)	0 (0)	0.09
. Current smokers	10 (23)	6 (21)	
Symptoms reported in the population-based survey			
. Asthma symptoms‡ only	11 (26)	13 (45)	
. Chronic bronchitis symptoms§ only	21 (49)	11 (38)	0.23
. Both asthma‡ and chronic bronchitis† symptoms	11 (26)	5 (17)	
Symptoms reported in the diary‖			
. Upper respiratory tract symptoms	24 (56)	-	
. Lower respiratory tract symptoms	16 (37)	-	
FEV_1 (% of predicted¶) (N=43, 25)	96 (68 to 127)	101 (77 to 123)	0.08
Mean Peak Expiratory Flow per person (L/min)	395 (212 to 525)	-	
Peak Expiratory Flow (% of predicted¶)	113 (61 to 136)	-	
Bronchial hyperresponsiveness** (N=26, 17)	8 (31)	1 (6)	0.05
Atopy†† (N=40, 28)	7 (18)	3 (11)	0.44
Total number of houses currently employed in	2 (1 to 7)	2 (1 to 4)	0.53
Weekly working hours in domestic cleaning	16 (3 to 52)	18 (3 to 48)	0.99
Years of employment in domestic cleaning	17 (2 to 53)	22 (2 to 56)	0.05

Median (minimum to maximum) or n (%) are given.

* Not including the eight women that were excluded from analyses (see *analyses* section for further details on exclusion criteria).

† P-value for Mann-Whitney test (continuous variables) or Chi^2 test (categorical variables)

‡ Reported an asthma attack and/or a nocturnal attack of shortness of breath in the last two years or reported ever having been diagnosed of asthma.

§ Reported regular cough and/or regularly bringing up phlegm

‖ Persons with a severity score ≥2 at least on one day

¶ Prediction equation from Roca *et al.[18]*

** Fall of at least 20% in FEV_1 associated with a methacholine dose of ≤1mg

†† Specific serum IgE (level > 0.35 kU/L) to at least one out of nine common allergens

- Information not available.

Table 2. Associations* between cleaning exposures, daily reported symptoms and PEF

	OR (95% CI)		Coeff. (95% CI)	
	URS†	LRS‡	PEF at night	PEF following morning
Working day§	1.1 (0.6 to 2.3)	3.1 (1.4 to 7.1)	-3.2 (-8.3 to 1.9)	0.5 (-4.6 to 5.5)
Daily number of hours cleaning‖				
Between 4 and 8 hours	1.0 (0.4 to 2.5)	2.0 (0.7 to 5.6)	-0.9 (-7.5 to 5.6)	1.0 (-5.4 to 7.5)
More than 8 hours	2.0 (0.7 to 6.1)	5.6 (1.7 to 19)	-5.1 (-14 to 3.5)	-1.4 (-9.9 to 7.1)
Cleaning tasks¶				
Dusting	1.2 (0.4 to 3.3)	4.2 (1.5 to 12)	-3.6 (-10 to 2.9)	2.0 (-4.5 to 8.5)
Vacuuming	2.0 (1.0 to 4.2)	2.0 (1.0 to 4.0)	-3.9 (-8.6 to 0.7)	1.1 (-3.8 to 5.9)
Cleaning the toilet bowl	0.9 (0.4 to 2.1)	4.2 (1.9 to 9.5)	5.9 (0.0 to 12)	1.1 (-5.0 to 7.2)
Cleaning the bathroom	1.5 (0.6 to 3.6)	3.4 (1.3 to 8.8)	-0.8 (-7.0 to 5.4)	4.0 (-2.4 to 10)
Cleaning the kitchen	1.8 (0.8 to 4.0)	2.3 (1.1 to 4.9)	0.1 (-5.8 to 6.0)	6.5 (0.6 to 12.4)
Washing dishes	1.0 (0.4 to 2.7)	1.3 (0.4 to 4.4)	-5.4 (-12 to 1.0)	0.9 (-5.7 to 7.5)
Ironing	1.9 (0.9 to 3.9)	1.4 (0.7 to 2.8)	0.1 (-4.7 to 4.9)	3.5 (-1.4 to 8.5)
Cleaning products¶				
Bleach (total)	1.8 (0.8 to 4.2)	3.5 (1.4 to 8.5)	3.5 (-1.9 to 8.9)	1.7 (-3.9 to 7.2)
. Only undiluted	1.4 (0.2 to 8.4)	1.7 (0.3 to 10)	9.0 (0.4 to 18)	3.2 (-5.8 to 12)
. Only diluted	1.6 (0.7 to 3.9)	4.4 (1.8 to 11)	1.4 (-4.6 to 7.3)	1.4 (-4.8 to 7.6)
. Both diluted & undiluted	1.4 (0.5 to 3.9)	4.4 (1.4 to 14)	4.3 (-4.0 to 13)	0.5 (-8.1 to 9.1)
Ammonia (total)**	1.8 (0.7 to 4.9)	1.6 (0.6 to 4.4)	-9.4 (-17 to -2.3)	-1.2 (-8.5 to 6.2)
. Diluted	1.3 (0.3 to 5.0)	3.0 (1.0 to 9.1)	-10.3 (-18 to -2.7)	-2.9 (-11 to 5.1)
Liquid multi-use cleaners	1.3 (0.6 to 2.9)	2.2 (0.9 to 5.0)	-3.6 (-9.2 to 1.9)	-1.4 (-7.1 to 4.3)
Decalcifiers	0.5 (0.2 to 1.5)	3.6 (1.6 to 8.4)	-5.2 (-11.8 to 1.5)	-0.4 (-7.4 to 6.7)
Stain removers	0.9 (0.3 to 2.8)	2.2 (0.8 to 5.7)	-2.2 (-12.3 to 7.8)	6.4 (-3.4 to 16.3)
Furniture sprays/atomizers	0.7 (0.3 to 1.5)	2.2 (0.9 to 5.4)	-0.2 (-5.7 to 5.3)	-0.8 (-6.5 to 5.0)

Glass cleaning sprays/atomizers	1.1 (0.6 to 2.4)	2.9 (1.3 to 6.4)	0.2 (-5.1 to 5.5)	-0.3 (-5.7 to 5.2)
Degreasing sprays/atomizers	2.2 (1.0 to 4.8)	6.9 (2.9 to 16)	6.0 (-0.1 to 12)	-2.9 (-9.2 to 3.4)
Air refreshing sprays/atomizers	1.2 (0.4 to 3.8)	7.8 (2.6 to 24)	7.9 (-1.5 to 17)	-4.1 (-14 to 5.5)

* A separate logistic/lineal mixed model with random intercept was fitted for each exposure. All models were adjusted for presence of respiratory infection, use of maintenance medication and age. Models for upper respiratory symptoms were additionally adjusted for years of employment in domestic cleaning and weekly working hours in domestic cleaning. Models for lower respiratory symptoms were additionally adjusted for daily number of cigarettes smoked, years of employment in domestic cleaning and weekly working hours in domestic cleaning,

† Upper respiratory tract symptoms: blocked nose, watery eyes and throat irritation.

‡ Lower respiratory tract symptoms: tightness of chest, wheezing, shortness of breath and cough.

§ Reference category consist of all leisure days, including 188 days cleaning the own home and 8 days without cleaning exposure.

|| Hours cleaning include cleaning at work and at home. Reference category are days cleaning 0 to 4 hours.

¶ Reference category consists of all days not exposed to the cleaning task/product (either leisure or working day). Only exposures with a p-value ≤ 0.1 for any of the outcomes are shown. Cleaning exposures analysed but not shown in the table include sweeping, carpet/rug beating, mopping the floor, cleaning windows/mirrors, cleaning the stove/hob, washing clothes by hand, washing clothes by machine, cooking, using detergents and using sprays for mopping the floor.

** Undiluted ammonia was excluded from analyses because it was used on less than 10% of the days.

Table 3. Independent associations* between specific cleaning exposures and daily reported symptoms (N=582)

	Exposed days N (%)	Upper respiratory tract symptoms† OR (95% CI)	Lower respiratory tract symptoms‡ OR (95% CI)
Cleaning tasks			
Vacuuming	227 (39)	2.0 (1.0 to 4.2)	-
Cleaning products			
Diluted bleach	345 (59)	-	2.5 (1.1 to 5.8)
Degreasing sprays or atomizers	206 (35)	-	2.6 (1.1 to 6.6)
Air refreshing sprays or atomizers	79 (14)	-	6.5 (2.1 to 20)

* A single logistic mixed model that included all exposures presented in the table and a random intercept was fitted for each outcome. All models were adjusted for presence of respiratory infection, use of maintenance medication, age, years of employment in domestic cleaning and weekly working hours in domestic cleaning. Models for lower respiratory symptoms were additionally adjusted for daily number of cigarettes smoked.

† Blocked nose, watery eyes and throat irritation

‡ Tightness of chest, wheezing, shortness of breath and cough

- Not included in the model.

Table 4: Expert and Oasys scores of individual peak flow record outcome. Eleven records (out of 37 analysed) scored positively for occupational asthma by at least one measure are shown.

Case #	Age	Smoking Status	Years in domestic cleaning work	Recent history of respiratory symptoms*	Symptoms reported in the diary†		Improvement of respiratory symptoms on holidays‡	Atopy‖	BHR¶	Home/work analysis		Bleach/degreaser analysis	
					URS	LRS				Expert	OASYS	Expert	OASYS
1	50	Never	25	A, CB	No	No	Yes§	Yes	Yes	3	2.67	3	2.67
2	43	Current	22	CB	No	Yes	No	No	.	3	3	3	1.25
3	44	Former	22	CB	No	No	No	No	No	2.5	2.75	1	3
4	54	Never	40	A, CB	Yes	Yes	No	No	.	3	4	ID	ID
5	48	Never	17	A, CB	Yes	No	No	No	No	1	1.25	3	3
6	54	Never	32	A, CB	Yes	Yes	No	No	.	ID	3	ID	3.67
7	41	Former	8	A	Yes	No	No	No	Yes	ID	3	ID	3
8	39	Former	8	A, CB	Yes	Yes	Yes	Yes	Yes	ID	3	ID	ID
9	41	Current	12	A, CB	Yes	Yes	Yes	No	.	ID	3.25	ID	ID
10	40	Former	13	A, CB	No	No	No	No	No	1	1.2	ID	3
11	55	Never	26	CB	Yes	No	No	No	Yes	ID	ID	ID	3

ID=inadequate data.

* Respiratory symptoms reported either at the time of population-based cross-sectional study or the case-control study (A= asthma, CB= chronic bronchitis).

† Severity score ≥ 2 at least on one day (URS= upper respiratory symptoms, LRS= lower respiratory symptoms).

‡ Self-reported improvement in asthma attacks, wheezing, shortness of breath, cough, phlegm, runny/blocked nose and watery eyes during holiday periods (information from the case-control study).

§ Information only available for nose and eye symptoms.

|| Specific serum IgE (level > 0.35 kU/L) to at least one out of nine common allergens.

¶ Fall of at least 20% in FEV_1 associated with a methacholine dose of ≤1mg

Figure 1a. Positive Oasys graph for the analysis of work and leisure days corresponding to case # 2 in table 4 (Oasys overall score 3). Daily maximum, mean and minimum peak expiratory flow plotted against time. Shaded days correspond to working days.

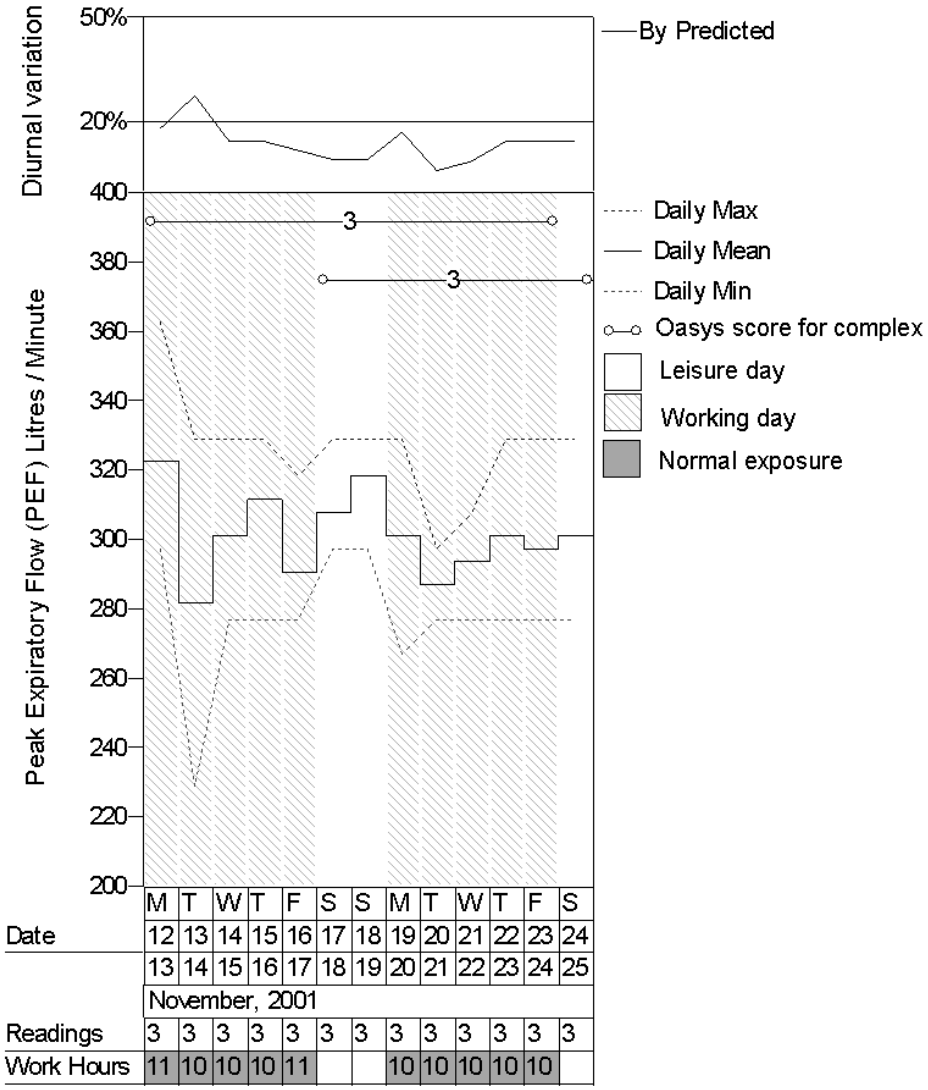

Figure 1b. Positive Oasys graph for the analysis of days with and without exposure to bleach/degreasers corresponding to case # 1 in table 4 (Oasys overall score 2.67). Daily maximum, mean and minimum peak expiratory flow plotted against time. Shaded days correspond to those days exposed to bleach/degreasers.