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Short-term respiratory effects of cleaning exposures in female domestic cleaners

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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. The short-term effects of cleaning exposures on respiratory symptoms and peak expiratory flow (PEF) were investigated in domestic cleaners with respiratory disorders.

In a panel study, 43 female domestic cleaners with a recent history of asthma and/or chronic bronchitis completed a 2-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 computerised diagnostic system and an occupational asthma expert.

Lower respiratory tract symptoms were more common on working days and were predominantly associated with exposure to diluted bleach, degreasing sprays/atomisers and air fresheners. Associations with upper respiratory tract symptoms and PEF were less apparent. Eleven (30%) subjects scored positively for work-related asthma.

It is concluded that exposure to certain irritant cleaning products aggravates lower respiratory tract symptoms in female domestic cleaners with asthma or chronic bronchitis.

KEYWORDS: **Asthma, chronic bronchitis, cleaning, irritants, occupational, peak expiratory flow**

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Recent studies have found an increased risk of asthma and other respiratory symptoms in cleaning workers [1–4], being particularly apparent in females 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 USA [10]. In a previous nested case–control study among female domestic cleaners, it was 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. In the present study, the hypothesis that exposure to irritant cleaning products may aggravate a pre-existing obstructive lung disease in female domestic cleaners was tested. A panel study was conducted in order to evaluate the short-term effects of transient cleaning exposures on respiratory symptoms and peak expiratory flow (PEF) in female domestic cleaners with a recent history of obstructive lung disease.

METHODS

Study design and population

Between June 2001 and April 2002, a 2-week panel study was conducted among female domestic cleaners aged 31–66 yrs 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 (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 3 months each year) or both at the time of the population-based survey [6] were selected for the present panel study. Since symptomatic status for the selection of participants was determined ~1 yr before the panel study, participants are referred to 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 females were invited to participate, of whom 51 (64%) returned a completed diary.

Diary

Each participant completed a 2-week diary including information on cleaning exposures, respiratory symptoms and PEF. A trained research nurse instructed the participants on completing the diary and measuring PEF using a mini-Wright peak flow meter (Clement Clarke, Harlow, UK). All subjects performed a practice attempt at 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 on a checklist all cleaning exposures during the day, including exposures in their own home. Information about the number of hours of 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 (URTSs) by summing the scores for blocked nose, throat irritation and watery eyes. Likewise, a daily symptom severity score for lower respiratory tract symptoms (LRTSs) was obtained by 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 (13:00–15:00 h) and before going to sleep. On each occasion, participants recorded three PEF measurements [12] and the highest was used in 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 spirometric procedures [13, 14]. Bronchial hyperresponsiveness (BHR) was defined as a fall in FEV_1 of $\geqslant 20\%$ associated with a methacholine dose of $\leqslant 1$ mg. Methacholine challenge was not performed in subjects with a baseline FEV_1 of either <1.5 L or $<70\%$ of the predicted value. Atopy was defined as a serum-specific immunoglobulin E level of >0.35 $kU \cdot L^{-1}$ for at least one of the following allergens: *Dermatophagoides pteronyssinus*, *D. farinae*, cat, dog, *Cladosporium herbarum*, timothy grass, *Parietaria judaica*, *Alternaria alternate* and latex.

Analyses

Of the 51 returned diaries, two were excluded from analyses because <7 days had been completed. Plots of PEF series from the remaining 49 diaries (a total of 693 days) were visually inspected in order 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 $\geqslant 5$ days consecutively, resulting in the exclusion of 17 person-days. Following this approach, it could be assumed that the reported medication predominantly referred to maintenance medication rather than bronchodilators. Six of the subjects had all recorded days affected by at least one of the previous circumstances. Thus, final analyses were based on 582 days from 43 participants.

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 of whether this occurred at home or at work. Owing to lack of statistical power, exposures present on <10% of the total person-days were not considered for analysis. The assessment of short-term effects of cleaning exposures on URTSs and LRTSs 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 on the morning of the following day as continuous variables. All models had a random intercept for each individual and were adjusted for the 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 URTSs and LRTSs, exposure variables that showed a p-value of <0.1 in the separate models were included in the same model in order to account for the simultaneous exposure to several products. Explanatory variables with a p-value of <0.1 were maintained in the final model and 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 program (occupational asthma system) [17], and the probability of having occupational asthma was scored by Oasys and also by an expert (P.S. Burge). Charts were plotted first by separating days at and away from work, and then replotted separating days with and without exposure (either at work or at home) to bleach and/or degreasing sprays/atomisers (two of the cleaning products significantly associated with LRTSs in previous analyses). The Oasys program compares PEF during an exposed period with the preceding and following nonexposed periods (a rest-work-rest complex). Likewise, each nonexposed period is compared with the preceding and following exposed periods (a work-rest-work complex). The Oasys program scores complexes within a person's record and gives an overall score of 1–4 in respect of the likelihood of occupational asthma (1: unlikely; 2: possible; 3: probable; and 4: definite) [17]. The expert performed a similar procedure but gave an integral 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 nonresponders, except for a higher prevalence of BHR and shorter duration of domestic cleaning employment among responders (table 1).

The mean age of the study population was 49 yrs and most participants were lifetime nonsmokers. Although all participants reported current respiratory symptoms during the population-based survey, six of them did not report respiratory symptoms during the 2-week panel study. Cough, reported at least once by 63% of subjects, was the most common symptom, whereas wheezing and chest tightness, both reported at least once by 30% of subjects, were the least common. The median of the mean individual PEF was 395 $L \cdot min^{-1}$, which was slightly higher than the predicted value. A respiratory infection was reported on 20% of person-days, usage of maintenance medication on 7% and smoking on 21%, with a median of 10.5 cigarettes smoked daily (data not shown).

Participants reported at least one cleaning activity/exposure on 98% of days. Participants went to clean other homes on a median of 63% of days. Cleaning their own home was performed on 76% of working days and 96% of days off work, which were not only at weekends. The median time cleaning (7.5 *versus* 4.0 h), number of cleaning products used (five *versus* three) and number of cleaning tasks performed (11 *versus* nine) were higher on working days compared with leisure days. The 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 days, whereas other exposures, such as carpet/rug beating or using stain removers, were reported by a minority of the participants and only on a few days.

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

	Participants#	Nonresponders	p-value¶
Subjects	43 (100)	29 (100)	
Age yrs	49 (34–65)	53 (31–66)	0.14
Smoking status			
Never-smoker	27 (63)	23 (79)	
Ex-smoker	6 (14)	0 (0)	0.09
Current smoker	10 (23)	6 (21)	
Symptoms reported in survey			
Asthma+ only	11 (26)	13 (45)	
Chronic bronchitis§ only	21 (49)	11 (38)	0.23
Asthma+ and chronic bronchitis§	11 (26)	5 (17)	
Symptoms reported in diaryƒ			
Upper respiratory tract	24 (56)	NA	
Lower respiratory tract	16 (37)	NA	
FEV1 % pred##,¶¶	96 (68–127)	101 (77–123)	0.08
Mean PEF per person L·min-1	395 (212–525)	NA	
PEF % pred##	113 (61–136)	NA	
Bronchial hyperresponsiveness++,§§	8 (31)	1 (6)	0.05
Atopyƒƒ,###	7 (18)	3 (11)	0.44
Houses currently employed in n	2 (1–7)	2 (1–4)	0.53
Weekly domestic cleaning work h	16 (3–52)	18 (3–48)	0.99
Domestic cleaning employment yrs	17 (2–53)	22 (2–56)	0.05

Data are presented as median (range) or n (%). FEV1: forced expiratory volume in one second; % pred: percentage of the predicted value; PEF: peak expiratory flow. NA: information not available. #: not including the eight females excluded from analyses (see Analyses section); ¶: Mann–Whitney test (continuous variables) or Chi-squared test (categorical variables); +: asthma attack and/or nocturnal attack of shortness of breath in the last 2 yrs or ever having been diagnosed with asthma; §: regular cough and/or regularly bringing up phlegm; ƒ: persons with a severity score of ≥2 on ≥1 day; ##: ROCA *et al.* [18]; ¶¶: n=43; n=25; ++: fall of ≥20% in FEV1 associated with a methacholine dose of ≤1 mg; §§: n=26; n=17; ƒƒ: specific serum immunoglobulin E level of >0.35 kU·L-1 to at least one of nine common allergens; ###: n=40; n=28.

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

Most associations between PEF and cleaning exposures were small and scattered around null (table 2). The only significant decrease in PEF at night was related to use of ammonia. Older subjects showed significantly lower PEFs, 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 URTSs (table 3). The use of diluted bleach, degreasing sprays/atomisers and air refreshing sprays/atomisers were independently associated with LRTSs and, in the case of diluted bleach, also with symptoms during the following day (odds ratio 2.8 (95% confidence interval 1.2–6.6); data not shown). These associations were essentially the same for subjects with asthma and subjects with chronic bronchitis, and persisted when analyses were restricted to nonatopic subjects. Adjustment for working day or for daily hours cleaning resulted in similar estimations.

There was adequate PEF data for the individual evaluation of occupational asthma in a total of 37 subjects by either Oasys or the expert reviewer. 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 one and two are shown in figure 1, corresponding to the analysis of working and leisure days and of days with and without exposure to bleach/degreasers.

DISCUSSION

The present panel study showed that females employed in domestic cleaning who had a recent history of obstructive lung

TABLE 2 Associations between cleaning exposures, daily reported symptoms and peak expiratory flow (PEF)

	OR (95% CI)		Coefficient (95% CI)	
	URTSs#	LRTSs¶	PEF at night	PEF following morning
Working day+	1.1 (0.6–2.3)	3.1 (1.4–7.1)	-3.2 (-8.3–1.9)	0.5 (-4.6–5.5)
Daily time cleaning§				
4–8 h	1.0 (0.4–2.5)	2.0 (0.7–5.6)	-0.9 (-7.5–5.6)	1.0 (-5.4–7.5)
>8 h	2.0 (0.7–6.1)	5.6 (1.7–19)	-5.1 (-14–3.5)	-1.4 (-9.9–7.1)
Cleaning tasks^f				
Dusting	1.2 (0.4–3.3)	4.2 (1.5–12)	-3.6 (-10–2.9)	2.0 (-4.5–8.5)
Vacuuming	2.0 (1.0–4.2)	2.0 (1.0–4.0)	-3.9 (-8.6–0.7)	1.1 (-3.8–5.9)
Cleaning toilet bowl	0.9 (0.4–2.1)	4.2 (1.9–9.5)	5.9 (0.0–12)	1.1 (-5.0–7.2)
Cleaning bathroom	1.5 (0.6–3.6)	3.4 (1.3–8.8)	-0.8 (-7.0–5.4)	4.0 (-2.4–10)
Cleaning kitchen	1.8 (0.8–4.0)	2.3 (1.1–4.9)	0.1 (-5.8–6.0)	6.5 (0.6–12)
Washing dishes	1.0 (0.4–2.7)	1.3 (0.4–4.4)	-5.4 (-12–1.0)	0.9 (-5.7–7.5)
Ironing	1.9 (0.9–3.9)	1.4 (0.7–2.8)	0.1 (-4.7–4.9)	3.5 (-1.4–8.5)
Cleaning products^f				
Bleach				
Total	1.8 (0.8–4.2)	3.5 (1.4–8.5)	3.5 (-1.9–8.9)	1.7 (-3.9–7.2)
Only undiluted	1.4 (0.2–8.4)	1.7 (0.3–10)	9.0 (0.4–18)	3.2 (-5.8–12)
Only diluted	1.6 (0.7–3.9)	4.4 (1.8–11)	1.4 (-4.6–7.3)	1.4 (-4.8–7.6)
Diluted and undiluted	1.4 (0.5–3.9)	4.4 (1.4–14)	4.3 (-4.0–13)	0.5 (-8.1–9.1)
Ammonia##				
Total	1.8 (0.7–4.9)	1.6 (0.6–4.4)	-9.4 (-17– -2.3)	-1.2 (-8.5–6.2)
Diluted	1.3 (0.3–5.0)	3.0 (1.0–9.1)	-10.3 (-18– -2.7)	-2.9 (-11– -5.1)
Liquid multi-use cleaners	1.3 (0.6–2.9)	2.2 (0.9–5.0)	-3.6 (-9.2–1.9)	-1.4 (-7.1–4.3)
Decalcifiers	0.5 (0.2–1.5)	3.6 (1.6–8.4)	-5.2 (-12–1.5)	-0.4 (-7.4–6.7)
Stain removers	0.9 (0.3–2.8)	2.2 (0.8–5.7)	-2.2 (-12–7.8)	6.4 (-3.4–16)
Furniture sprays/atomisers	0.7 (0.3–1.5)	2.2 (0.9–5.4)	-0.2 (-5.7–5.3)	-0.8 (-6.5–5.0)
Glass cleaning sprays/atomisers	1.1 (0.6–2.4)	2.9 (1.3–6.4)	0.2 (-5.1–5.5)	-0.3 (-5.7–5.2)
Degreasing sprays/atomisers	2.2 (1.0–4.8)	6.9 (2.9–16)	6.0 (-0.1–12)	-2.9 (-9.2–3.4)
Air refreshing sprays/atomisers	1.2 (0.4–3.8)	7.8 (2.6–24)	7.9 (-1.5–17)	-4.1 (-14–5.5)

OR: odds ratio; CI: confidence interval; URTSs: upper respiratory tract symptoms; LRTSs: lower respiratory tract symptoms. #: blocked nose, watery eyes and throat irritation; ¶: tightness of chest, wheezing, shortness of breath and cough; +: reference category consists of all leisure days, including 188 days cleaning their own home and 8 days without cleaning exposure; §: includes cleaning at work and at home; reference category is days cleaning 0–4 h; ^{f}: reference category consists of all days without exposure to the cleaning task/product (either leisure or working day); ##: undiluted ammonia was excluded from analyses because it was used on <10% of days. A separate logistic/lineal mixed model with random intercept was fitted for each exposure. All models were adjusted for the presence of respiratory infection, use of maintenance medication and age. Models for URTSs were additionally adjusted for years of employment in domestic cleaning and weekly working hours in domestic cleaning. Models for LRTSs were additionally adjusted for the daily number of cigarettes smoked, years of employment in domestic cleaning and weekly working hours in domestic cleaning. Only exposures with a p-value of ⩽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;

disease experienced worsening of respiratory symptoms on working days and on days on which they spent more time cleaning. Although work-related PEF changes were not evident in the regression analysis, when PEF charts were individually assessed, 30% of the females 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, the present results suggest the existence of work-related respiratory symptoms and PEF decrements after exposure to certain cleaning products.

In the present study, the presence of LRTSs was predominantly associated with the use of diluted bleach, degreasing sprays/atomisers and air refreshing sprays/atomisers. Decrements in PEF at night were associated with exposure to ammonia in the regression models, and with the use of bleach and degreasing sprays/atomisers when PEF charts were analysed individually. These results are consistent with the case–control study, in which 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 presented here support the present authors' previous reasoning that occupational asthma in domestic cleaning jobs

TABLE 3 Independent associations between specific cleaning exposures and daily reported symptoms

	Exposed days	URTSs#	LRTSs¶
Cleaning tasks			
Vacuuming	227 (39)	2.0 (1.0–4.2)	NI
Cleaning products			
Diluted bleach	345 (59)	NI	2.5 (1.1–5.8)
Degreasing sprays+	206 (35)	NI	2.6 (1.1–6.6)
Air refreshing sprays+	79 (14)	NI	6.5 (2.1–20)

Data are presented as n (%) or odds ratio (95% confidence interval). URTSs: upper respiratory tract symptoms; LRTSs: lower respiratory tract symptoms; NI: not included in the model. #: blocked nose, watery eyes and throat irritation; ¶: tightness of chest, wheezing, shortness of breath and cough; +: including atomisers. Logistic mixed models were fitted that included all exposures presented in the table and a random intercept (n=582). 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 LRTSs were additionally adjusted for daily number of cigarettes smoked.

is probably irritant-induced or irritant-aggravated. This is supported by the fact that atopy was neither associated with LRTSs nor modified the associations between cleaning products and LRTSs, as well as by the observation that only two of the 11 females with possible occupational asthma were atopic. However, sensitisation to substances such as pinene [19] or limonene [20], which are present in air refreshing sprays/atomisers, 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 sensitised 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 the present population, mean levels of airborne chlorine during cleaning activities (including use of bleach) ranged up to 0.4 ppm, with peaks of up to 1.3 ppm [11]. In agreement with the present results, an experimental study reported that two out of seven individuals with BHR experienced respiratory symptoms following a 60-min 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 LRTSs and exposure to air refreshing sprays/atomisers is consistent with the known susceptibility of asthmatic subjects to odours, which have been related to respiratory complaints, including tightness of the 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 PEF 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 $L \cdot min^{-1}$ (2.6% of population median PEF) in PEF at night

TABLE 4 Expert and Oasys (occupational asthma system) scores for individual peak flow record outcomes in cases scoring positively for occupational asthma# by at least one measure

Case No.	Age yrs	Smoking status	Domestic cleaning work yrs	Recent respiratory symptom history¶	Symptoms reported in diary+		Holiday improvement§	Atopyƒ	BHR##	Home/work analysis		Bleach/degreaser analysis	
					URTSs	LRTSs				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

URTSs: upper respiratory tract symptoms; LRTSs: lower respiratory tract symptoms; BHR: bronchial hyperresponsiveness; A: asthma; CB: chronic bronchitis; ID: inadequate data. #: 11 of 37 analysed; ¶: reported at time of either population-based cross-sectional study or case–control study; +: with severity score of ⩾2 on ⩾1 day; §: self-reported improvement in asthma attacks, wheezing, shortness of breath, cough, phlegm, runny/blocked nose and watery eyes (information from case–control study); ƒ: specific serum immunoglobulin E level of >0.35 $kU \cdot L^{-1}$ to at least one of nine common allergens; ##: fall of ⩾20% in forced expiratory volume in one second associated with a methacholine dose of ⩽1 mg; ¶¶: information only available for nose and eye symptoms.

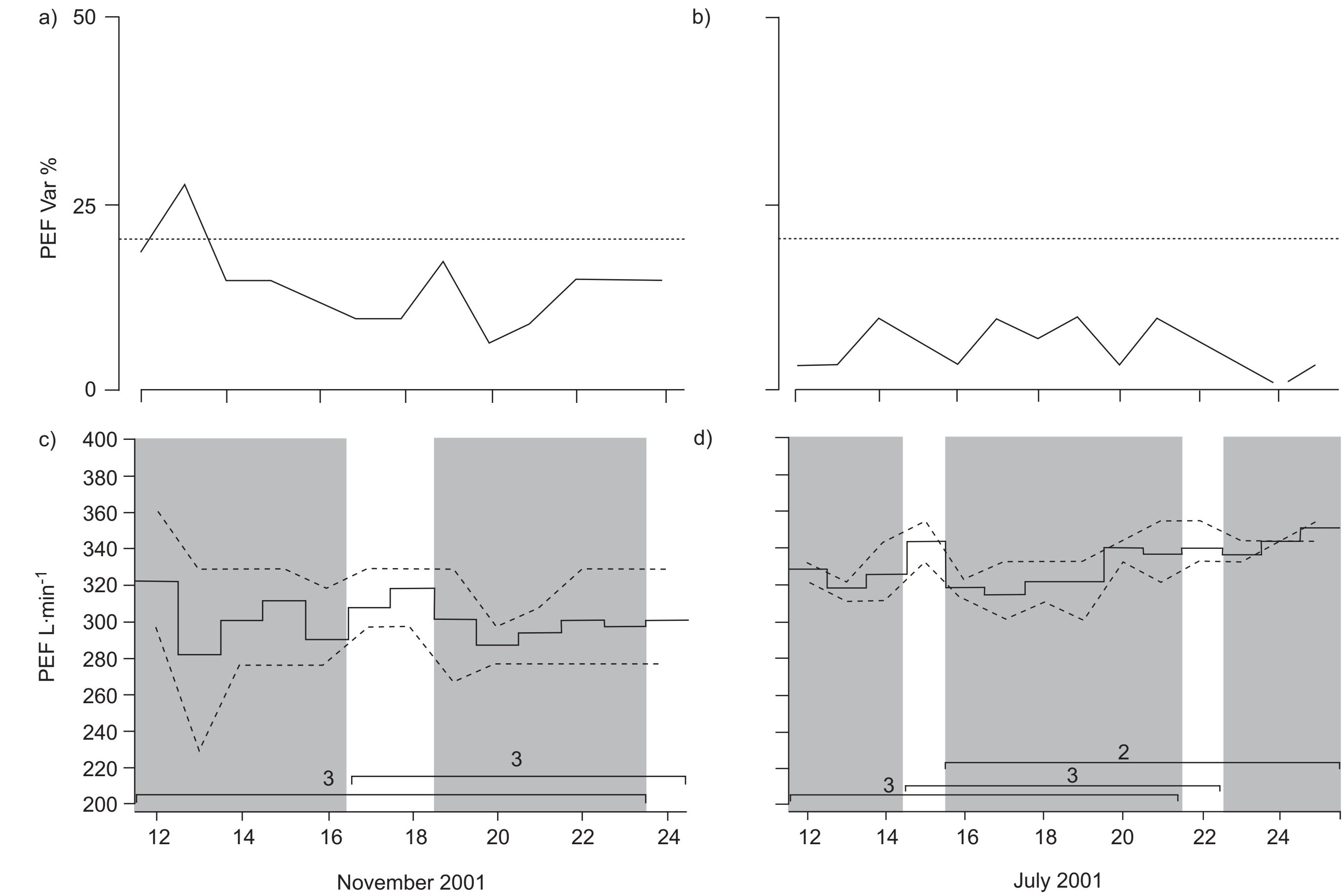

FIGURE 1. Positive Oasys (occupational asthma system) graphs for the analysis of: a, c) work (■) and leisure (□) days (case No. 2 (table 4); Oasys overall score 3); and b, d) days with (■) and without (□) exposure to bleach/degreasers (case No. 1 (table 4); Oasys overall score 2.67). a, b) Diurnal variation (Var) from predicted peak expiratory flow (PEF) and c, d) corresponding PEF record. ——: mean daily PEF; - - - -: maximum/minimum daily PEF; · · ·: 20% diurnal variation (proportion of time spent above this value is helpful in the diagnosis of asthma). Horizontal bars show Oasys scores for complexes.

associated with use of diluted ammonia. Although this mean change was within the normal range of PEF reproducibility [25, 26], it is noteworthy that two females experienced a decrease of >5% and one of >10% following 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 be due, in part, to the substantial proportion of subjects in the study population with a history of chronic bronchitis symptoms and/or 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 performed three times a day, resulting in a somewhat low sensitivity and invoking 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 females. It is important to bear in mind, however, that Oasys is less sensitive when there are <4 measurements·day^{-1}, <3 days consecutively at work and/or the study has a duration of <3 weeks [28]. For this reason, with the type of records obtained in the present 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 the short periods of consecutive days with exposure, and had to be restricted to bleach/degreasers exposure.

The present study has several limitations that should be taken into account. First, the lack of intra-individual variability for infrequent cleaning exposures forced several cleaning agents, such as waxes, oven sprays and hydrochloric acid, to be excluded from analyses, precluding the recognition of potential 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 the present study was based on presence/absence of exposure, which minimised 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, the present study placed the priority on examining a wide range of exposures rather than on characterising 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 diagnoses 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 tract symptoms on working days and on days on which they use irritant cleaning products, including sprays. A clear effect of these exposures on peak expiratory flow, however, was only evident in a few individuals. These 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 cleaners and to investigate the short- and long-term effects of irritant cleaning products in other cleaning workers and 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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