

Professional cleaning and asthma

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Purpose of review

The purpose of this review is to summarize the recent evidence on the effect of cleaning jobs on asthma, based on case reports and series of occupational asthma among cleaners, and epidemiological studies on the relationship between different characteristics of cleaning and asthma risk, as well as to elaborate the evidence on potential occupational exposures responsible for the increased asthma risk observed in cleaners.

Recent findings

Six recent epidemiologic studies strengthen the evidence that domestic and industrial cleaners are at higher risk of asthma compared with professional employees in Europe and the United States. These studies take into account individual confounders, such as age and cigarette smoking. This finding is supported by case reports and registry-based studies of occupational asthma. The studies and reports have identified some chemicals, such as bleach, as specific causes of asthma. Increased risk of asthma has also been related to some specific job tasks, such as cleaning windows and washing dishes.

Summary

Recent studies strengthen the evidence of an increased asthma risk among cleaners or individuals in other jobs in which they are involved in cleaning. Further research should be directed to elaborate how much of asthma is related to specific sensitization to certain chemicals and how much to airway inflammation induced by exposure to a mixture of irritants.

Keywords

asthma, cleaners, epidemiologic studies, occupational exposures

Introduction

Cleaners constitute a large professional group; for example, 4% of the working population in the United States and 3% in Finland have a job in this category [1], and an even larger proportion of the population is involved in various domestic cleaning activities. Some earlier population-based epidemiological studies [2–4] and analyses of occupational disease registry-based data [1,5] have suggested that cleaners have an increased risk of asthma. More than 250 known specific occupational agents have been associated with asthma [6], including isocyanates and other reactive chemicals, flour dust, animal-derived proteins, wood dust, metals and natural rubber latex. Professional cleaners work in diverse job tasks, ranging from domestic cleaning to cleaning offices, industrial plants, kitchens and hospitals. They are exposed to a large number of gaseous and particulate compounds. Cleaning agents themselves are obviously important exposures, but cleaners are also exposed to other compounds, such as house dust containing animal dander, mites, cockroaches, microbes from damp materials, and chemicals and particles from various sources of indoor air pollution, and all of these may contribute to the increased risk of asthma observed among cleaners. The purpose of this systematic review is to elaborate the most recent evidence on the effect of cleaning job on asthma, based on case reports and series of occupational asthma among cleaners, occupational disease registry-based reports and registry-linkage studies, and epidemiologic studies on the relation between different characteristics of cleaning and the risk of asthma, as well as to elaborate the most recent evidence on potential occupational exposures responsible for the increased risk of asthma observed in cleaners.

Search strategy

We conducted a systematic Medline literature search from 2003 to November 2005 using the following keywords: cleaners OR cleaning agents. This produced a total of 128 citations. We reviewed the 128 abstracts and identified 12 relevant publications [7–13,14•–16•,17••, 18•].

Review of cleaning and asthma

Occupational exposures among cleaners

Our systematic search revealed no population-based studies focusing on assessment of occupational exposures among cleaners. The Danish National Institute of Occupational Health reported, based on three representative cross-sectional studies of workforce in 1990, 1995 and

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Table 1 Main chemical components of cleaning products

Type of agent	Purpose	Examples	Potential health effects
Detergents	Lower surface tension of water	Fatty acid salts (soap), organic sulphonates	Skin, eye and mucous membrane irritation
Complexing agents (water softeners)	Dissolve and bind calcium and other cations; regulate the pH	EDTA, tripolyphosphates	Skin, eye and mucous membrane irritation
Alkaline agents	Dissolve fatty substances, disinfection, inhibit corrosion of metal surfaces	Silicates, carbonates, sodium hydroxide, ammonia	Skin, eye and mucous membrane irritation
Acids	Dissolve calcium	Phosphoric, acetic, citric, sulphamic, hydrochloric acid	Skin, eye and mucous membrane irritation
Solvents	Dissolve fatty substances	Alcohols, glycol ethers	Neurotoxic
Corrosion inhibitor	Protection of metal surfaces	Ethanol amines	Sensitization
Film formers, polishes	Surface care	Wax, acryl polymers, polyethylene	Sensitization
Disinfectants	Destroy bacteria and other micro-organisms	Hypochlorite, aldehydes, quaternary ammonium compounds	Sensitization, mucous membrane irritation
Preservatives	Avoid microbial growth during product storage	Benzalkonium chloride, isothiazolinones, formaldehyde	Sensitization
Perfumes, scents	Introduce pleasant smell	d-limonene, terpenes (pinene)	Sensitization, irritation

EDTA, ethylenediamine tetraacetic acid. Reproduced from [16*].

2000, that the prevalence of professional cleaning was decreasing, resulting in a reduced prevalence of skin contacts to cleaning agents [8]. In his review of occupational hazards among cleaners, Zock [16*] summarized the main chemical components of cleaning products, their purposes and potential health effects (Table 1). The 10 groups are detergents, complexing agents used as water softeners, alkaline agents, acids, solvents, corrosion inhibitors, film formers and polishes, disinfectants, preservatives, and perfumes and scents. All these groups of cleaning products contain specific chemicals that could contribute to development of asthma or to exacerbation of symptoms among asthmatics through sensitization or irritative mechanisms. Rosenman and colleagues [7] published a review of all work-related asthma cases identified through the SENSOR-reporting system in California, Massachusetts, Michigan and New Jersey, during 1993–1997. This study, described in more detail below (in occupational disease registry-based reports), provides information on the types of cleaning agents and on specific cleaning chemicals, which were reported as causes of work-related asthma. The specific agents identified are shown in Table 2. Exposure to these agents took place in a number of occupational settings under various job titles.

The population-based epidemiological studies discussed later in more detail provided some information on the occurrence of different occupational exposures in cleaning jobs [17**]. The diversity of their approaches makes it difficult to give an overall picture and the specific findings are presented below.

Case reports and series

Case reports and series are an important source of information on the role of specific agents in causation of occupational asthma, especially when diseases are identified in new occupational settings. Our systematic

literature search revealed one recent article with cases of occupational asthma among cleaners or in relation to exposure to cleaning agents [7]. As part of the above-mentioned review of work-related asthma cases in California, Massachusetts, Michigan and New Jersey, Rosenman and colleagues [7] described four cases in detail. The diagnosis of these cases was based on the temporal relation between the suspect occupational cause and occurrence of asthma symptoms and signs, but no specific challenge tests were performed. For

Table 2 Number of cases of work-related asthma associated with different types of cleaning products: California, Massachusetts, Michigan and New Jersey, 1993–1997

Agent	Number of cases
Cleaning materials, household cleaners (not specified)	107
Bleach	43
Acids, bases, oxidizers	23
Disinfectants (not specified)	20
Carpet cleaner	17
Floor stripper/waxes	16
Ammonia	14
Mixing bleach and acid or ammonia	11
Glutaraldehyde	8
Graffiti remover	8
Soaps	5
Ethanol	4
Quaternary ammonia	3
Formaldehyde	3
Ethylene glycol monobutylether	3
Ethanolamines	3
Oven cleaner	2
Sulfonates	2
Caustic	2
Phenols	2
Limonene	2
Glass cleaner	2
Copier cleaner	1
Iodophors	1
Total	300*

*182 individuals had exposure to one, 44 to two and 10 to three cleaning products. Reproduced from [7].

example, a Californian 55-year-old male school custodian developed symptoms of wheezing, cough and chest tightness after using large amounts of two graffiti-removal products. One product contained dimethyl glutarate, dimethyl adipate, gamma-butyrolactone, ethylene glycol, *n*-butyl ether, dimethyl succinate and propylene glycol butyl ether, and the other contained D-limonene, alkyl polyglycoside and propylene carbonate. In another example, a 59-year-old female hospital housekeeper developed dyspnea on exertion, occasional chest pain, chest tightness and shortness of breath over a period of 5 years. The symptoms were experienced mainly during the workdays and got worse throughout the workweek. In spirometry, her FEV₁ was 81% of predicted and there was a 17% improvement in response to bronchodilator medication. The case associated her symptoms to three cleaning products. One suspect product contained amine, another two quaternary ammonium compounds, namely ammonium chloride and didecyl dimethyl ammonium chloride. The third product contained 2-phenyl phenol and *o*-benzyl-*p*-chlorophenol.

Occupational disease registry reports and registry-linkage studies

Population-based occupational disease registries provide an important source of information on the occurrence of asthma in different jobs and on specific causes of occupational asthma. The problem related to occupational disease registries is their tendency to include mainly occupational asthma cases caused by already established asthmogens and, therefore, the registry information is often not sensitive to new causes. Another problem is that the validity of the registries is dependant on the quality of the diagnostics applied by those reporting cases to the registry. Registries in the United States [5,7], the United Kingdom and Finland [1] have been used to elaborate the role of professional cleaning in causation of asthma.

In the United States, four states – California, Massachusetts, Michigan and New Jersey – conduct work-related asthma surveillance as part of the Sentinel Event Notification System for Occupational Risks (SENSOR) [19]. All reports in California, 99% in Massachusetts and more than 80% in Michigan and New Jersey are received from physicians. After case identification, a standardized follow-up questionnaire is administered by telephone in all four states, enquiring about workplace exposures associated with asthma, and up to three exposure agents are recorded as the possible cause of asthma.

A series of studies have been reported based on SENSOR. Reinisch and colleagues [5] published already, in 2001, results from the Californian surveillance system showing that janitors and cleaners had the highest incidence rate of work-related asthma out of 31 occupational

groups, their incidence being 625 per 1 000 000 person-years (based on 32 observed cases). Of all new-onset work-related asthma cases, 3.4% were exposed to cleaning materials.

Rosenman and colleagues [7] analysed all 1915 confirmed cases of work-related asthma that were identified by the SENSOR-programme in California, Massachusetts, Michigan and New Jersey in 1993–1997. A cleaning product was defined as any material used for cleaning or disinfecting surfaces in general work environments. Specific situations involving cleaning of medical instruments, specialized industrial settings, disinfecting pool water, cleaning food or cleaning animals were not included, because the focus of the report was on cleaning products that are potentially widely used both at work and by the general public. Some cleaning products were among the three suspected causal agents for 236 (12%) of the cases. Most of these cases (80%) were new-onset and, in most cases, the suggested causal agent was not reported earlier as a cause of occupational asthma. Table 2 displays the number of cases exposed to different types of cleaning products. In most of the cases, the agent was not very specific and was described just as a 'cleaning compound' or 'carpet cleaner'. Of the cleaning products identified, the most common were irritants, such as acids, ammonia or bleach, or disinfectants, such as formaldehyde, glutaraldehyde and quaternary ammonia compounds. The largest proportion of cases (67%) was working in the service industry. Janitors, nurses and nurses' aids were the three most common occupations reported.

Although analyses based on occupational disease registries and linkages of them to other registries [1,5,7] provide information on the role of professional cleaning and exposure to cleaning agents in the causation of asthma, there are some important limitations, including no or limited information on potential confounders, such as smoking. McCurdy and colleagues [9] compared the prevalence of smoking in different occupations in 30 centres from 14 countries using the European Community Respiratory Health Survey. Cleaners had one of the highest prevalences of smoking – 48.1% in men and 50.7% in women. The corresponding prevalences among professional, administrative, clerical and service groups, which have been used as a reference group in many studies [1], were 35.4 and 33.6%. Given accumulating evidence of the effect of personal smoking on asthma [20], failure to control for confounding by smoking may overestimate the effect of cleaning and other occupational exposures.

Epidemiologic studies

Six recent epidemiologic studies [10–12,14[•],17^{••},18[•]], summarized in Table 3, have assessed the risk of asthma

Table 3 Recent epidemiologic studies on cleaners and asthma

First author, year	Study design	Study population	Assessment of asthma	Assessment of exposure	Results	Comments
Arif, 2003	Population-based cross-sectional study	6551 adults from US NHANES III survey	Questionnaire: work-related asthma	40 occupational groups; reference: management, secretarial and clerical occupations	Cleaners vs reference: OR 2.37 (95% CI 0.53–10.58) Equipment cleaners vs reference: OR 10.57 (95% CI 1.54–72.45)	Adjustment for age, sex, atopy and smoking status
Jaakkola, 2003	Population-based incident case-control study (Finnish Environment and Asthma Study) and Asthma Study (PAARC)	521 new asthma cases, 932 controls both aged 21–63 years	Standard clinical examination including spirometry and PEF-surveillance	29 occupational groups; reference: professional and administrative occupations	Cleaners vs reference in women: OR 1.42 (95% CI 0.81–2.48)	Adjustment for age and smoking
Le Moual, 2004	Cross-sectional study (PAARC)	14 151 adults aged 25–59 years	Questionnaire: asthma attacks ever; adult-onset asthma	29 occupational groups; reference: professional and administrative occupations Asthma-specific job-exposure matrix for asthmogens [17**]	Cleaners vs reference: OR 1.04 (95% CI 0.70–1.54) Institution-based care workers vs reference: OR 1.57 (95% CI 0.96–2.5) Industrial cleaning agents, asthma ever: OR 1.51 (95% CI 1.51–2.16)	Adjustment for age, sex and smoking
Medina-Ramon, 2003	Population-based cross-sectional study	4521 women aged 30–65 years	Questionnaire: asthma attack or awakening by shortness of breath in past 12 months	Questionnaire: detailed history of current and former cleaning work	Current domestic cleaners vs never: OR 1.46 (95% CI 1.10–1.92) Former domestic cleaners vs never: OR 2.09 (95% CI 1.70–2.57)	Age and smoking
Medina-Ramon, 2005	Population-based prevalent case-control study	Among domestic cleaners: 40 asthma or chronic bronchitis cases, 155 controls	Questionnaire: asthma attack or awakening by shortness of breath in past 12 months	Interview: frequency of 23 cleaning tasks and 22 cleaning products; accidents with inhalation exposure	Risk of being a case increased related to mopping the floor, cleaning windows or mirrors, washing dishes, cleaning the oven, use of bleach, and non-domestic cleaning	Age and smoking
Le Moual, 2005	Case-control study	148 cases of asthma from chest clinics, 228 population-based controls	Clinical diagnosis, severity according to eight-grade score	Asthma-specific job-exposure matrix [17**]	Exposure to industrial cleaning agents on severe asthma: OR 8.1 (95% CI 1.5–44.4)	Age, sex and smoking

in relation to job categories, including cleaners, or to occupational exposures, including cleaning agents, and the risk of asthma. Asthma and chronic bronchitis have similar symptoms and signs and can both be related to cleaning activities. In some of the studies, the health outcome was not clinically diagnosed and therefore the overlap between asthma and chronic bronchitis cannot easily be elaborated.

Arif and colleagues [10] compared the prevalence of work-related asthma and wheezing in 40 occupational groups using a study population of 6551 adults from the US NHANES III nationally representative survey. The prevalence of work-related asthma among cleaners was 3.7%, whereas the corresponding prevalence in the reference group of management, secretarial and clerical occupations was 2.9%, resulting in an odds ratio of 2.37 (95% CI 0.53–10.58) adjusted for age, sex, atopy and smoking status. The prevalence of asthma among equipment cleaners was 14.1%, with an adjusted odds ratio of 10.57 (95% CI 1.54–72.45).

The authors of this review [12] conducted a population-based incident case–control study of 521 new adult-onset asthma cases and 932 controls selected randomly from the source population, which produced the cases. The odds ratios adjusted for age and smoking were estimated for 28 occupational groups using professional and administrative persons as the reference group. The occupations were coded according to the 1988 International Standard Classification of Occupations (ISCO-88). The adjusted odds ratio of asthma for female cleaners was elevated, at 1.42 (95% CI 0.81–2.48). The precision of the effect estimate was compromised by a relatively small number of cleaners in the study population. Strengths of this study were standardized clinical diagnosis of asthma, assessment of work history before the onset of asthma and individual-level adjustment for smoking.

Le Moual and colleagues [14^{*}] studied the relation between occupational exposures and asthma in the 1975 French PAARC survey – a cross-sectional study of 14 151 adults aged 25–59 years living in seven major cities. They compared the risk of asthma in 29 occupational groups classified according to ISCO-88 to the risk in administrative and service jobs, which formed the reference category. Cleaners were not found to have any increase in the asthma risk (adjusted odds ratio 1.04, 95% CI 0.70–1.54), defined as having ever had asthma attacks. Institution-based personal care workers, who are commonly exposed to cleaning agents, had an elevated risk of asthma with an adjusted odds ratio of 1.57 (95% CI 0.96–2.58). Applying a job exposure matrix for asthmagens, as described by Kennedy and colleagues [21], significant associations were found between asthma and industrial cleaning agents, with adjusted odds ratio

1.51 (95% CI 1.05–2.16) for ever asthma and 2.51 (95% CI 1.33–4.75) for adult-onset asthma.

Medina-Ramon and colleagues [11] conducted a population-based cross-sectional study of 4521 women aged 30–65. This study showed that 593 (13%) women employed in domestic cleaning had an increased risk of asthma symptoms, with an adjusted odds ratio of 1.46 (95% CI 1.10–1.92), compared with women who had never worked in cleaning. The adjusted odds ratio for former domestic cleaning work was 2.09 (95% CI 1.70–2.57). Current and former non-domestic cleaning work was not significantly associated with asthma. In the second phase [17^{**}], they focused on domestic cleaners in the study population. They recruited from those domestic cleaners who were still in the same or similar work a year later 117 cases of asthma or chronic bronchitis and 281 controls without any respiratory symptoms. The final study population comprised 40 cases and 155 controls. These participants underwent a face-to-face interview, which enquired detailed information about history of employment and characteristics of current domestic cleaning work. The frequency of 23 specified cleaning tasks and use of 22 different cleaning products at the time of the study were recorded as times per week, per month or per year. Questions were asked also about accidents that had occurred when using a single or a mixture of several cleaning products that had led to the inhalation of a significant quantity of vapour, gas or fumes. Of 23 cleaning tasks, mopping the floor (unadjusted OR 2.8, 95% CI 1.2–6.8 for intermediate exposure, and unadjusted OR 1.1, 95% CI 0.4–3.1 for high exposure), cleaning windows or mirrors (unadjusted OR 1.6, 95% CI 0.7–4.0 and unadjusted OR 1.9, 95% CI 0.8–4.7), washing dishes (unadjusted OR 2.0, 95% CI 0.8–5.1 and 2.3, 95% CI 1.0–5.3), and cleaning the oven (unadjusted OR 2.0, 95% CI 0.8–5.0 and unadjusted OR 1.9, 95% CI 0.8–4.7) showed elevated effect estimates. The risk of being an asthma/chronic bronchitis case was related to use of several of the 22 cleaning products studied, including use of bleach (344–640 times per year: adjusted OR 3.3, 95% CI 0.9–11; more than 640 times per year: 4.9, 95% CI 1.5–15), washing dishes (376–520 times per year: OR 3.2, 95% CI 1.0–10 and more than 520 times per year: OR 3.2, 95% CI 1.1–8.9), and being employed in non-domestic cleaning (ever compared with never: OR 8.5, 95% CI 3.2–23). Use of liquid multi-use products was negatively associated with the risk.

As part of the Epidemiological Study on the Genetics and Environment of Asthma, Le Moual and colleagues [18^{*}] studied the associations between occupational exposures and asthma severity in a case–control study of 148 adult cases from French chest clinics and 228 population-based controls. Asthma severity was defined according to an eight-grade clinical score. Cases with severe and mild

severity scores were compared with controls. Exposure to industrial cleaning agents was related to severe asthma, with an adjusted odds ratio of 8.1 (95% CI 1.5–44.4).

Conclusions

Accumulating, consistent evidence exists from population-based epidemiological studies conducted mainly in European countries and the United States that professional cleaners have a higher incidence of asthma compared with administrative and professional employees used as the 'unexposed' reference category. This finding is supported by case reports and registry-based studies of occupational asthma among cleaners or individuals in other types of jobs in which they are involved in cleaning activities. The studies and reports have identified some chemicals, such as bleach, ammonia-containing compounds and disinfectants including glutaraldehyde or formaldehyde, as specific causes of asthma/chronic bronchitis. Increased risk of asthma has also been related to some specific job tasks, such as mopping the floor, cleaning windows, mirrors and ovens, and washing dishes. Despite this increasing evidence of an association, it remains unclear how much of asthma is related to specific sensitization to certain chemicals or other agents and how much is related to inflammation in the airways induced by exposure to a mixture of irritant chemicals and other compounds. Perhaps both types of reactions play a role in the asthma of cleaners. Moreover, the importance of other types of exposures than the cleaning agents for asthma has not been studied in cleaner populations.

Acknowledgements

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References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 128).

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