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Asthma and rhinitis in cleaning workers: a systematic review of epidemiological studies

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ABSTRACT

Objective: This article presents a systematic review of epidemiological studies linking cleaning work and risk of asthma and rhinitis. **Methods:** Published reports were identified from PubMed covering the years from 1976 through June 30, 2012. In total, we identified 24 papers for inclusion in the review. The quality of studies was evaluated using the Strengthening of the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist of 22 items for cross-sectional, cohort and case-control studies. **Results:** Increased risk of asthma or rhinitis has been shown in 79% of included epidemiological studies. In four studies the increased risk of asthma in cleaning workers was confirmed by objective tests, such as bronchial hyper-reactivity or airflow obstruction. Level of exposure to cleaning products, cleaning sprays, bleach, ammonia, mixing products and specific job tasks has been identified as specific causes of asthma and rhinitis. **Conclusions:** Possible preventive measures encompass the substitution of cleaning sprays, bleach and ammonia, avoidance of mixing products, the use of respiratory protective devices, worker education and medical surveillance.

INTRODUCTION

Cleaning anything involves making something else dirty, but anything can get dirty without something else getting clean (Laurence J Peter, US educator and writer, 1919–1988).

Cleaners constitute a large professional group in developed countries. According to EUROSTAT, in 2006 in 20 European countries there were 3.6 million people employed in industrial cleaning [1]. Industrial cleaning accounts for 3% of total employment in the private sector; most of the employees are females and work part-time while about 30% of cleaning workers are migrant workers [1,2]. In a survey of 4500 Spanish women, 39% were current and former domestic cleaners [3]. In surveillance studies carried out in Spain, United States and Brazil cleaning products were among the most reported causes of occupational asthma or work-related asthma (WRA) [4–6] while in United Kingdom and France cases of occupational asthma/WRA due to cleaning products were not frequently reported [7,8]. In recent years cleaning has been associated with WRA and work-related rhinitis [9,10].

The epidemiological literature on respiratory health outcomes and risks of cleaners has been reviewed. Two reviews were update on the risk of asthma in cleaners in epidemiological and surveillance studies and case reports for the period 2003–2005 and 2006–2009, respectively [11,12]; 6 and 7 epidemiological studies reporting the assessment of the risk of asthma in cleaners for the period 2003–2005 and 2006–2009, respectively, were reviewed. Charles et al. reviewed the epidemiological studies reporting all occupational hazards, 1981–2005, 11 of which have assessed the risk of asthma in cleaners [13]. Quirce and Barranco recently reviewed the association between asthma and cleaning but the search strategy was not reported [14]; 7 epidemiological studies have reported the risk of asthma in cleaners. The four reviews have reported neither the evaluation of quality of epidemiological studies nor the risk of rhinitis.

This article presents a systematic review of epidemiological studies linking exposure to cleaning products and the risk of asthma and rhinitis and discusses suggestions for prevention.

METHODS

Data sources, search strategy and study selection

Published reports were identified from PubMed covering the years from 1976 through June 30, 2012. We used the following key words search strategy: (cleaning worker* OR cleaning product* OR cleaner* OR bleach OR hypochlorite OR ammonia OR cleaning spray* OR disinfectant*) AND (asthma OR rhinitis OR respiratory). Using this schema we identified 678 potentially eligible citations. In a first selection we discarded 525 papers because they were not in the field of asthma and rhinitis in cleaners and 113 because they were not in English. In a second selection we discarded 20 studies on cleaning workers because they were not epidemiological studies on asthma and rhinitis: eight case reports, five surveillance studies, two exposure studies, five reviews. One study was discarded because it was on skin disease. Nineteen epidemiological studies published in English that reported the odds of asthma/rhinitis associated with exposure to cleaning products were included. We also reviewed all papers for reference citations within 1976–2012 time frame that had not been otherwise identified in the initial search and we identified an additional 5 studies for inclusion. In total we identified 24 papers for inclusion in the systematic review.

Quality assessment

The quality of observational studies was evaluated using the Strengthening of the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist of 22 items for cross-sectional, cohort and case-control studies [15]. Data for quality assessment were extracted using a standard record sheet which included the checklist of 22 items independently by two reviewers (IF and AS). Discrepancies were resolved by consensus. The studies were classified into the following three categories: A, more than 80% of STROBE criteria fulfilled; B, 50–80% of STROBE criteria fulfilled; and C, less than 50% of STROBE criteria fulfilled [16]. 20 studies were classified into category A, 4 in category B, and none in category C (Tables 1 and 2).

[TABLE 1][TABLE 2]

Definitions

We defined cleaning workers (cleaners) as people whose paid or unpaid work involves cleaning of public or private buildings. In this definition, we include employed non-domestic and domestic indoor cleaners as well as non-professional home cleaners (homemakers). We do not include other jobs involving the use of cleaning products at work such as health care professionals and food industry workers.

The definition of asthma was based on symptoms gathered from the following questionnaires (Tables 1 and 2):

- European Community Respiratory Health Survey (ECRHS) questionnaire in 16 studies;
- Third National Health and Nutrition Examination Survey (NHANES III) questionnaire [17];
- French Pollution Atmosphérique et Affections Respiratoires Chroniques (PAARC) Survey questionnaire [18];
- previously validated questionnaires [1];
- Helsinki Office Environmental Study modified questionnaire [20];
- non-validated questionnaires [21,22].

Reported asthma was confirmed by a physician (physician-diagnosed asthma) in 2 studies [19,23]. The definition of asthma was based on symptoms and objective tests, such as assessment of bronchial reactivity through a methacholine challenge test [24–26], airflow limitation through a forced spirometric test [18] or reversibility of airways obstruction in five studies [20].

The diagnosis of rhinitis was always based on symptoms [10,27–29].

RESULTS

We selected 24 epidemiological studies on asthma or rhinitis in subjects exposed to cleaning products evaluated for methodological quality [15]: 7 cross-sectional and 3 longitudinal population-based studies, 7 case-control studies, 5 cross-sectional and 2 longitudinal studies in working groups. Potential source of information and/or selection biases were discussed in all studies. Direction and magnitude of bias was examined in three studies [24,30,31]. Study size was not explained in one cross-sectional study [29]. It was unclear if 3 studies were free of commercial funding [18,21,29]. In 7 studies, the participation rate was not specified (Tables 1–3).

[TABLE 3]

Cross-sectional population-based studies (Table 1)

Seven cross-sectional population-based studies, ranging from 1975 to 2006, showed an association between exposure to cleaning products and:

- asthma symptoms, with a risk estimate between 1.5 and 2.5 [3,24,25,32,33];
- asthma symptoms and bronchial hyper-reactivity, odds ratio (OR) 2.5 (95% confidence interval (CI) 1.03–6.2) and OR 2.0 (95% CI 1.3–2.9), respectively [24,25];
- asthma symptoms with airflow limitation, OR 2.5 (95% CI 1.3–4.7) [18].

In one study, there was a non-statistically significant association between exposure to cleaning products and WRA (OR 2.4, 95% CI 0.5–10.6) [17].

Longitudinal population-based studies (Table 1)

Longitudinal population-based studies showed an association between exposure to cleaning products and incidence of:

- adult new-onset asthma (OR 1.8, 95% CI 1.01–3.2) [34];
- adult new-onset non-infectious rhinitis (OR 2.1, 95% CI 1.1–4.0) [27];
- adult new-onset perennial rhinitis (OR 1.4, 95% CI 1.0–2.1) [28].
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Case-control studies (Table 1)

In three studies there was an association between cleaning work and asthma symptoms or severe asthma symptoms, with a risk estimate between 1.9 and 7.4 [21,35,36]. Medina-Ramón et al. showed an association between intermediate (OR 23, 95% CI 1.9–274) or high exposure to bleach (OR 14, 95% CI 1.3–153) and asthma symptoms [37]. Weekly use of more than two types of sprays was associated with asthma symptoms (OR 2.5, 95% CI 1.5–4.0), current asthma (OR 1.7, 95% CI 1.1–2.6) and poorly-controlled asthma (OR 2.0, 95% CI 1.2–3.3) [31]. In two studies, there was no association between cleaning work and asthma with reversible airway obstruction or severe exacerbation of asthma [20,38].

Cross-sectional studies in working groups (Table 2)

Between 1998 and 2011, five studies were published in Europe, North America and Brazil, four of which showed an association between exposure to cleaning products and:

- asthma symptoms, with a risk estimate between 1.7 and 3.3 [26,30];
- asthma symptoms and bronchial hyper-reactivity, with a risk estimate between 2.8 (95% CI 1.3–6.2) and 5.0 (95% CI 1.9–13.2) [26];
- rhinitis symptoms (OR 2.1, 95% CI 1.2–3.7) [10].

In one study, there was no difference in the prevalence of asthma/rhinitis between 40 cleaners and 40 controls [29].

The exposure to cleaning products was evaluated in various occupations, such as professional [10,19,26,29,30] or domestic cleaners [26]. In Brazilian non-domestic cleaners rhinitis symptoms were 3 times more frequent than asthma symptoms [10].

Longitudinal studies in working groups (Table 2)

One longitudinal study in working groups demonstrated in Spanish home cleaners an association between exposure to cleaning sprays and the incidence of asthma symptoms, with a risk estimate of 1.5 (95% CI 1.1–2.0) [23]. In one report asthma was higher in former cleaners than in current cleaners [22].

Confounding variables and risk factors (Table 3)

In the majority of studies the risk of asthma or rhinitis was simultaneously adjusted for the potential confounding variables sex, age and smoking. In three studies female gender was a risk factor for WRA, rhinitis or perennial rhinitis [10,19,28]. On the contrary, Hellgren et al. showed an association between male gender and rhinitis [27].

In current domestic cleaners, the risk of asthma decreased with increasing age while in a cohort of female cleaners age was not a risk factor for asthma [3,22].

The potential relationship between smoking and asthma in subjects exposed to cleaning agents was investigated in five studies. In one cross-sectional study in working groups current smoking was a risk factor (OR 3.2, 95% CI 1.4–7.2) [10] while in one cross-sectional population-based, 2 longitudinal studies in working groups and one case–control study smoking was not a risk factor [22,23,31,32].

Two studies compared the risk of asthma in domestic and non-domestic cleaners: the risk of current asthma was higher in domestic cleaners (OR 1.5, 95% CI 1.1–1.9) than in non-domestic cleaners (OR 1.1, 95% CI 0.7–1.6) [3]. The risk of asthma symptoms and asthma symptoms and BHR were higher in private home cleaners (prevalence ratio (PR) 3.3, 95% CI 1.9–5.8, and PR 5.0, 95% CI 1.9–13.2, respectively) than in other cleaners (PR 1.0, 95% CI 0.5–2.0, and PR 1.7, 95% CI 0.5–5.5, respectively) [26].

The duration of occupational exposure was associated with the risk of WRA or work-related rhinitis in non-domestic cleaners while in another study was not associated with asthma [10,19].

Six studies examined the level of exposure as a risk factor. Obadia et al. (2009) showed no association with asthma while Vizcaya et al. showed an association between the exposure to the number of different workplace or products used and asthma [19,30]. In three reports, the level of exposure to cleaning sprays or bleach was associated with asthma [23,31,37]. On the contrary, Nielsen and Back showed no significant association with the level of exposure to cleaning sprays [22].

The risk of asthma or rhinitis was associated with exposure to various cleaning products [26,34,36], tasks [19], exposure to cleaning sprays, ammonia, bleach or hydrochloridric acid [10,23,26,30] or mixing products [26,37]. However, in a study on female cleaners cleaning sprays were not a significant risk factor for asthma [22]. Interestingly enough, using liquid cleaning products was negatively associated with asthma [37].

In two studies, atopy was a risk factor for asthma and rhinitis [10,24] while in several other studies atopy was not a risk factor [23,26,32,37]. In other papers, the risk of asthma or rhinitis was adjusted for atopy [21,24,27].

Socio-economic status has seldom been examined as a risk factor for asthma in subjects exposed to cleaning products. In a few studies the risk of asthma or rhinitis was adjusted for socio-economic status [23,28,33] while Zock et al. demonstrated that socio-economic status was not a confounding factor for the risk of asthma [32].

DISCUSSION

The results of our review indicate that exposure to cleaning products in various jobs/tasks and settings increase the risk for asthma and rhinitis. This is also supported by the results of several surveillance studies from various countries [4–6] although in other studies from other countries cases of occupational asthma/WRA due to cleaning products were not frequently reported [7,8]. In four studies the risk of asthma was confirmed by objective tests, such as bronchial hyper-reactivity or airflow obstruction supporting the results of studies in which the definition of asthma was based on symptoms only (Tables 1 and 2) [18,24–26]. Domestic cleaners tended to have a higher risk of asthma than non-domestic cleaners as it was also confirmed in a focus group study [3,26,39].

In Brazilian cleaners, rhinitis symptoms were 3 times more prevalent than asthma symptoms [10]. Similarly, in workers exposed to sensitizing agents occupational rhinitis tended to be 3 times more frequent than occupational asthma [40].

In subjects exposed to cleaning products, level of exposure may be the main risk factor (Table 3), in agreement with observations on occupational asthma and rhinitis [40,41]. In a few cases specific products, such as ammonia, bleach and cleaning sprays were associated with asthma or new-onset asthma [23,26,37,42] and a dose–

response relationship between the use of bleach or cleaning sprays and asthma or new-onset asthma was also demonstrated [23,37]. Massin et al. measured concentration levels of chloramines, often derived from mixing bleach with dishwashing liquid, and aldehydes and assessed respiratory symptoms among 175 cleaning and disinfecting workers in the food industry [43]; a dose–response relationship between eye, nasal and throat symptoms and exposure levels was found. Exposure studies showed that airborne exposure levels of chlorine and ammonia were detectable at concentrations ≥ 0.1 ppm during domestic cleaning work and the use of concentrated ammonia solutions (e.g. 3%) in poorly ventilated areas may produce significant ammonia exposure [37,44]. Moreover, the large use of common sprays at home may have significant implications for public health; e.g. Zock et al. estimated that one in seven adult asthma cases may be related to the use of household cleaning sprays [23].

In a few studies gender was analysed as risk factor with contradictory results (Table 3). In a cross-sectional study in working groups non-domestic female cleaners were at increased risk of WRA (OR 3.9, 95% CI 2.1–7.4) [19], while gender was not a risk factor for asthma in a cross-sectional population based study [32]. The risk of rhinitis was associated with male cleaners or female cleaners [27,28]. Contradictory results were also reported in population-based epidemiological studies, although females tended to have a higher risk factor for asthma and rhinitis more often than males [45–48].

In one cross-sectional population based study, the risk of asthma decreased with increasing age [3], in agreement with cohort studies in apprentices bakers/pastry makers or exposed to laboratory animals or latex, in which WRA and work-related rhinitis tended to occur within the first 2–3 years of exposure [49].

In one study, only atopy was a risk factor for asthma and rhinitis and smoking was a risk factors for asthma (109) while in several others atopy and smoking were not risk factors [23,26,32,37]. The risk in subjects exposed to cleaning products seems not dependent on atopic status, supporting the view that asthma and rhinitis are mainly due to irritants and low-molecular weight agents [23,26,30,42]. Moreover, there is little to support that the risk of asthma and rhinitis is increased in smokers exposed to cleaning products, in agreement with a review on smoking and occupational asthma [50].

One limitation of studies in exposed to cleaning products is that occupational asthma and work-exacerbated asthma has seldom been differentiated. However, in health care professional exposed to cleaning products the prevalence of occupational asthma and work-exacerbated asthma was 0.8% and 1.1%, respectively [51].

Suggestion for prevention

Occupational asthma and rhinitis are considered potentially preventable diseases [52,53]. It is surprising that prevention of work-related respiratory diseases in cleaners has been neglected by the biomedical research in spite of a large body of knowledge on the dimension of the problem (Tables 1 and 2) and identification of

specific products and job tasks responsible for asthma and rhinitis symptoms (Table 3).

In fact, the review of 24 epidemiological studies suggests possible preventive intervention with the aim of improving respiratory health in cleaners, such as:

- substitution of cleaning sprays with liquid multi-use cleaning products [23,26,37];
- substitution of bleach and ammonia with less irritating product [10,26,37,42,51]. Particularly, the substitution of hypochlorite bleach is highly recommended and feasible, as was recently shown in six hospitals of Eastern Massachusetts where bleach was not used [54];
- avoidance of mixing cleaning products, especially bleach with other products [26,37];
- ingredients of cleaning agents could be pretested for their ability to cause sensitization.

Most cases of WRA in cleaners are due to exposure to one or more irritants and unidentified ingredients which need further evaluation while a minority are associated with sensitizers [10,30,34,37,42,55–60]. Moreover, preventive interventions are more difficult in domestic cleaners and occupational domestic cleaners, in spite of the fact that they are at higher risk of asthma and respiratory symptoms than professional cleaners, perhaps because of lower or no worker education, lack of awareness regarding risks, protective clothing and respiratory devices and no surveillance [23,26,36,37,39].

There is evidence that in the last 2–3 decades, the prevalence and incidence of occupational asthma and rhinitis due to laboratory animals, isocyanates, and latex decreased over time, suggesting benefit from preventive measures [61–63]. Unfortunately, time trends for asthma and rhinitis or controlled intervention studies in cleaners are not available.

A public health approach contributing to reduce hazardous cleaning product use was described in the study of Pechter et al. performed on immigrant cleaning workers [64]. Improved conditions were obtained by eliminating the most hazardous chemicals, reducing the number of products used, banning mixing products and improving safety training. Unfortunately, in the paper there was no control of the alleged improved conditions on work-related respiratory symptoms of immigrant cleaning workers.

An interesting example of prevention is included in a New York State law, effective September 1, 2006, which requires that in all elementary and secondary schools environmentally sensitive cleaning products must be used in order to minimize adverse impact on children's health but also, as a "by-product", on cleaners health, as reported by Mazurek et al. [4].

CONCLUSIONS

A number of epidemiological studies have identified that domestic and professional cleaning work, especially when associated with the use of household cleaning sprays, bleach and ammonia or exposure to mixing products, may have relevant implications for public health [65]. It has been estimated that a number of adult asthma cases, e.g. up to one in seven cases, could be attributed to the use of sprays. Several risk factors were also identified, allowing the development of effective prevention strategies. Unfortunately, the conclusion of research on cleaners and consequent policy implications have not been heeded by commercial cleaning stakeholder organizations, such as manufacturers, vendors and commercial cleaning companies. However, collaboration between scientific communities and European safety and health agencies may improve the respiratory health of workers and citizens exposed to cleaning products.

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DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

REFERENCES

- Brun E, editor. The occupational safety and health of cleaning workers. Luxemburg: EU-OSHA -- European Agency for Safety and Health at Work; 2009
- Björnsson K. Industrial cleaning: outsourcing versus in-house production. EUROSTAT – statistics in focus – Industry, trade and services, Theme 4, 2/1999
- Medina-Ramon M, Zock JP, Kogevinas M, Sunyer J, Antó JM. Asthma symptoms in women employed in domestic cleaning: a community based study. *Thorax* 2003;58:950–954
- Mazurek JM, Filios M, Willis R, Rosenman KD, Reilly MJ, McGrevy, Schill DP, et al. Work-related asthma in the educational services industry: California, Massachusetts, Michigan, and New Jersey, 1993–2000. *Am J Ind Med* 2008;51:47–59
- Mendonça EM, Algranti E, Freitas JBP, Rosa EA, Freire JAS, Santos UP, Pinto J, Bussacos MA. Occupational asthma in the city of São Paulo, 1995–2000, with special reference to gender analysis. *Am J Ind Med* 2003;43:611–617
- Orriols R, Costa R, Albanell C, Alberti C, Castejon J, Monso E, Panades R, et al; Members of the Malaltia Ocupacional Respiratòria (MOR) Group. Reported occupational respiratory diseases in Catalonia. *Occup Environ Med* 2006;63:255–260
- Kopferschmitt-Kubler MC, Ameille J, Popin E, Calastreng-Crinquand A, Vervloet D, Bayeux-Dunglas MC, Pauli G. Occupational asthma in France: a 1-yr report of the Observatoire National de Asthmes Professionnels project. *Eur Respir J* 2002;19:84–89
- McDonald JC, Keynes HL, Meredith SK. Reported incidence of occupational asthma in the United Kingdom, 1989–97. *Occup Environ Med* 2000;57:823–829
- Arif AA, Delclos GL, Serra C. Occupational exposures and asthma among nursing professionals. *Occup Environ Med* 2009;66:274–278
- Maçãira de Fátima E, Algranti E, Coeli Mendonça EM, Bussacos MA. Rhinitis and asthma symptoms in non-domestic cleaners from São Paulo metropolitan area, Brazil. *Occup Environ Med* 2007;64:446–453

- Jaakkola JJK, Jaakkola MS. Professional cleaning and asthma. *Curr Opin Allergy Clin Immunol*. 2006;6:85–90
- Zock J-P, Vizcaya D, Le Moual N. Update on asthma and cleaners. *Curr Opin Allergy Clin Immunol* 2010;10:114–120
- Charles LE, Loomis D, Demissie Z. Occupational hazards experienced by cleaning workers and janitors: a review of the epidemiologic literature. *Work*. 2009;34:105–116
- Quirce S, Barranco P. Cleaning agents and asthma. *J Investig Allergol Clin Immunol* 2010;20:542–550
- Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, for the STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol* 2008;61:344–349
- Mendy A, Gasana J, Vieira ER, Forno E, Patel J, Kadam P, Ramirez G. Endotoxin exposure and childhood wheeze and asthma: a meta-analysis of observational studies. *J Asthma* 2011;48:685–693
- Arif AA, Delclos GL, Whitehead LW, Tortolero SR, Lee ES. Occupational exposures associated with work-related asthma and work-related wheezing among U.S. workers. *Am J Ind Med* 2003;44:368–376
- Le Moual N, Kennedy SM, Kauffmann F. Occupational exposures and asthma in 14,000 adults from the general population. *Am J Epidemiol* 2004;160:1108–1116
- Obadia M, Liss GM, Lou W, Purdham J, Tarlo SM. Relationship between asthma and work exposure among non-domestic cleaners in Ontario. *Am J Ind Med* 2009;52:716–723
- Jaakkola JJK, Piipari R, Jaakkola MS. Occupation and asthma: a population-based incident case-control study. *Am J Epidemiol* 2003;158:981–987
- Ng TP, Hong CY, Goh LG, Wong ML, Koh KTC, Ling SL. Risk of asthma associated with occupations in a community-based case-control study. *Am J Ind Med* 1994;25:709–718
- Nielsen J, Bach E. Work-related eye symptoms and respiratory symptoms in female cleaners. *Occup Med* 1999;49:291–297
- Zock JP, Plana E, Jarvis D, Antó JM, Kromhout H, Kennedy SM, Künzli N, Villani S, et al. The use of household cleaning spray and adult asthma. An international longitudinal study. *Am J Respir Crit Care Med* 2007;176:735–741
- Kogevinas M, Antó JM, Soriano JB, Tobias A, Burney P, and the Spanish Group of the European Asthma Study. The risk of asthma attributable to occupational exposures. A population-based study in Spain. *Am J Respir Crit Care Med* 1996;154:137–143
- Kogevinas M, Antó JM, Sunyer J, Tobias A, Kromhout H, Burney P, and the European Community Respiratory health Survey Study Group. A population based study on occupational asthma in Europe and other industrialised countries. *Lancet* 1999;353:1750–1754
- Zock JP, Kogevinas M, Sunyer J, Almar E, Muniozguren N, Payo F Sánchez JL, Antó JM; on behalf of the Spanish working group of the ECRHS. Asthma risk, cleaning activities and use of specific cleaning products in Spanish indoor cleaners. *Scand J Work Environ Health*. 2001;27:76–81
- Hellgren J, Lillienberg L, Jarlstedt J, Karlsson G, Torén K. Population-based study of non-infectious rhinitis in relation to occupational exposure, age, sex, and smoking. *Am J Ind Med* 2002;42:23–28
- Radon K, Gerhardinger U, Schulze A, Zock J-P, Norback D, Toren K, Jarvis D, et al; Occupational Group of the ECRHS study. Occupation and adult onset of rhinitis in the general population. *Occup Environ Med* 2008;65:38–43
- Corradi M, Gergelova P, Di Pilato E, Folesani G, Goldoni M, Andreoli R, Selis L, Mutti A. Effect of exposure to detergents and other chemicals on biomarkers of pulmonary response in exhaled breath from hospital cleaners: a pilot study. *Int Arch Occup Environ Health* 2011;165:741–748
- Vizcaya D, Mirabelli MC, Antó JM, Orriols R, Burgos F, Arjona L, Zock JP. A workforce-based study of occupational exposures and asthma symptoms cleaning workers. *Occup Environ Med* 2011;68:914–919
- Le Moual N, Varraso R, Siroux V, Dumas O, Nadif R, Pin I, Zock JP, Kauffmann F; on behalf of the Epidemiological Study on the Genetics and Environment of Asthma. Domestic use of cleaning sprays and asthma activity in women. *Eur Respir J* 2012;40:1381–1389

- Zock JP, Kogevinas M, Sunyer J, Jarvis D, Torén K, Antó JM, for the European Community Respiratory Health Survey. Asthma characteristics in cleaning workers, workers in other risk jobs and office workers. *Eur Respir J* 2002;20:679–685
- Eng A, 'T Mannelte A, Douwes J, Cheng S, McLean D, Ellison-Loschmann L, Pearce N. The New Zealand workforce survey II: occupational risk factors for asthma. *Ann Occup Hyg* 2010;54:154–164
- Kogevinas M, Zock JP, Jarvis D, Kromhout H, Lillienberg L, Plana E, Radon K, et al. Exposure to substances in the workplace and new-onset asthma: an international prospective population based study (ECRHS-II). *Lancet* 2007;370:336–341
- Kennedy SM, Le Moual N, Choudat D, Kauffmann F. Development of an asthma specific job exposure matrix and its application in the epidemiological study of genetics and environment in asthma (EGEA). *Occup Environ Med* 2000;57:635–641
- Le Moual N, Siroux V, Pin I, Kauffmann F, Kennedy SM, on behalf of the Epidemiological Study on the Genetics and Environment of Asthma (EGEA). Asthma severity and exposures to occupational asthrogens. *Am J Respir Crit Care Med*. 2005;172:440–445
- Medina-Ramon M, Zock JP, Kogevinas M, Sunyer J, Torralba Y, Borrell A, Burgos F, Antó JM. Asthma, chronic bronchitis, and exposure to irritant agents in occupational domestic cleaning: a nested case-control study. *Occup Environ Med* 2005;62:598–606
- Henneberger PK, Mirabelli MC, Kogevinas M, Antó JM, Plana E, Dahlman-Höglund A, Jarvis DL, et al. The occupational contribution to severe exacerbation of asthma. *Eur Respir J* 2010;36:743–750
- Arif AA, Hughes PC, Delclos GL. Occupational exposures among domestic and industrial professional cleaners. *Occup Med* 2008;58:458–463
- Siracusa A, Desrosiers M, Marabini A. Epidemiology of occupational rhinitis: prevalence, aetiology and determinants. *Clin Exp Allergy* 2000;30:1519–1534
- Maestrelli P, Boschetto P, Fabbri LM, Mapp CE. Mechanisms of occupational asthma. *J Allergy Clin Immunol* 2009;123:531–542
- Mirabelli MC, Zock JP, Plana E, Antó JM, Benke G, Blanc PD, Dahlman-Höglund A, et al. Occupational risk factors for asthma among nurses and related healthcare professional in an international study. *Occup Environ Med* 2007;64:474–479
- Massin N, Hecht G, Ambroise D, Héry M, Toamain JP, Hubert G, Dorotte M, Bianchi B. Respiratory symptoms and bronchial responsiveness among cleaning and disinfecting workers in the food industry. *Occup Environ Med* 2007;64:75–81
- Fedoruk MJ, Bronstein R, Kerger BD. Ammonia exposure and hazard assessment for selected household cleaning product uses. *J Expo Anal Environ Epidemiol* 2005;15:534–544
- Chen Y, Mai XM. Smoking and asthma in men and women with normal weight, overweight, and obesity. *J Asthma* 2011;48:490–494
- Torén K, Ekerljung L, Kim JL, Hillström J, Wennergren G, Rönmark E, Lötval J, Lundbäck B. Adult-onset asthma in west Sweden – incidence, sex differences and impact of occupational exposures. *Respir Med*. 2011;105:1622–1628
- Matheson MC, Dharmage SC, Abramson MJ, Walters EH, Sunyer J, de Marco R, Leynaert B, et al. Early-life risk factors and incidence of rhinitis: results from the European Community Respiratory Health Study – an international population-based cohort study. *J Allergy Clin Immunol* 2011;128:816–823
- Jacquemin B, Kauffmann F, Pin I, Le Moual N, Bousquet J, Gormand F, Just J, et al., on behalf of the Epidemiological study on the Genetics and Environment of Asthma (EGEA). Air pollution and asthma control in the Epidemiological study on the Genetics and Environment of Asthma. *J Epidemiol Community Health* 2011;66:796–802
- Moscato G, Pala G, Boillat MA, Folletti I, Gerth van Wijk R, Olgiati-Des Gouttes D, Perfetti L, et al. EAACI position paper: prevention of work-related respiratory allergies among pre-apprentices or apprentices and young workers. *Allergy* 2011;66:1164–1173
- Siracusa A, Marabini A, Folletti I, Moscato G. Smoking and occupational asthma. *Clin Exp Allergy* 2006;36:577–584
- Arif AA, Delclos GL. Association between cleaning-related chemicals and work-related asthma and asthma symptoms among healthcare professionals. *Occup Environ Med* 2012;69:35–40

- Moscato G, Vandenplas O, Van Wijk RG, Malo JL, Quirce S, Walusiak J, Castano R, et al., EAACI Task Force on Occupational Rhinitis. Occupational rhinitis. *Allergy*. 2008;63:969–980
- Tarlo SM, Liss GM. Prevention of occupational asthma. *Curr Allergy Asthma Rep* 2010;10:278–286
- Bello A, Quinn MM, Perry MJ, Milton DK. Characterization of occupational exposure to cleaning products used for common cleaning tasks—a pilot study of hospital cleaners. *Environ Health* 2009;8:11
- Dijkman JH, Vooren PH, Kramps JA. Occupational asthma due to inhalation of chloramines-T. I. Clinical observation and inhalation provocation studies. *Int Arch Allergy Appl Immunol* 1981;64:422–427
- Kujala VM, Reijula KE, Ruotsalainen E-M, Heikkinen K. Occupational asthma to chloramine-T solution. *Respir Med* 1995;89:693–695
- Hole AM, Draper A, Jolliffe G, Cullinan P, Jones M, Newman Taylor AJ. Occupational asthma caused by bacillary amylase used in the detergent industry. *Occup Environ Med* 2000;57:840–842
- Rosenman KD, Reilly MJ, Schill DP, Valiante D, Flattery J, Harrison R, Reinisch F, et al. Cleaning products and work-related asthma. *J Occup Environ Med* 2003;45:556–563
- Brant A, Hole A, Cannon J, Helm J, Swales C, Welch J, et al. Occupational asthma caused by cellulase and lipase in the detergent industry. *Occup Environ Med* 2004;61:793–795
- Medina-Ramon M, Zock JP, Kogevinas M, Sunyer J, Basagaña X, Schwartz J, Burge PS, et al. Short-term respiratory effects of cleaning exposures in female domestic cleaners. *Eur Respir J* 2006;27:1196–1203
- Folletti I, Forcina A, Marabini A, Bussetti A, Siracusa A. Have the prevalence and incidence of occupational asthma and rhinitis because of laboratory animals declined in the last 25 years? *Allergy* 2008;63:834–841
- Tarlo SM, Liss GM. Diisocyanate-induced asthma: diagnosis, prognosis, and effects of medical surveillance measures. *Appl Occup Environ Hyg* 2002;17:902–908
- Vandenplas O, Larbanois A, Vanassche F, François S, Jamart J, Vandeweerdt M, Thimpont J. Latex-induced occupational asthma: time trend in incidence and relationship with hospital glove policies. *Allergy* 2009;64:415–420
- Pechter E, Azaroff LS, López I, Goldstein-Gelbs M. Reducing hazardous cleaning product use: a collaborative effort. *Public Health Rep* 2009;124(Suppl 1):45–52
- Bernstein JA, Brandt D, Rezvani M, Abbott C, Levin L. Evaluation of cleaning activities on respiratory symptoms in asthmatic female homemakers. *Ann Allergy Asthma Immunol*. 2009;102:41–46

TABLES

Table 1. Risk of asthma/rhinitis in subjects exposed to cleaning products in epidemiologic studies among various occupations.

References/country	Study year	Subjects (n)	Exposed to cleaning products (n)	Participation rate (%)	Age (yr, mean or range)	Methods for defining asthma (unless otherwise stated)	OR in exposed to cleaning products (95% CI)	Reporting quality ^a
<i>Cross-sectional population-based studies</i>								
Kogevinas et al. 1996/Spain [24]	1992	2646	91 cleaners	61	20-44	ECRHS Q ± methacholine challenge	Asthma sx or medication 2.1 (1.3-3.3)	A
Kogevinas et al. 1999/9 western European and 3 other industrialized countries [25]	1992	15637	443 cleaners	58	20-44	ECRHS Q ± methacholine challenge	Asthma sx or medication and BHR 2.5 (1.03-6.2) Asthma sx or medication 1.8 (1.4-2.3)	A
Zock et al. 2002/11 western European and 3 other industrialized countries [32]	1990-1994	6301	304 indoor cleaners	NR	20-44	ECRHS Q	Asthma sx or medication and BHR 2.0 (1.3-2.9) Asthma sx 2.5 (1.7-3.6)	A
Medina-Ramón et al. 2003/Spain [3]	2000-2001	4521	593 domestic cleaning women	90	51	ECRHS Q	Asthma sx 1.5 (1.1-1.9)	A
Medina-Ramón et al. 2003/Spain [3]	2000-2001	4521	34 hospital cleaners	90	51	ECRHS Q	Asthma sx 2.5 (1.1-5.8)	A
Arif et al. 2003/USA [17]	1988-1994	5022	108 cleaners	98	40	Definition of WRA: NHANES III Q	WRA sx 2.4 (0.5-10.6)	A
Le Moual et al. 2004/France [18]	1975	14151	404 cleaners	70	25-59	PAARC Survey Q and airflow limitation	Asthma sx with airflow limitation 2.5 (1.3-4.7)	B
Eng et al. 2010/New Zealand [33]	2004-2006	2903	152 cleaners	37	44	ECRHS Q	Asthma sx 1.6 (1.1-2.3)	A
<i>Longitudinal population-based studies</i>								
Hellgren et al. 2002/Sweden [27]	1995	1668	246 cleaners	85	37	Definition of non-infectious rhinitis: non validated mailed self-administered Q, age > 15 yr	In male cleaners compared with the rest of study population: adult new-onset non-infectious rhinitis sx 2.1 (1.1-4.0)	B
Kogevinas et al. 2007/11 European countries, Australia and USA [34]	1998-2003	6837	410 exposed to cleaning products	58	43	ECRHS and ECRHS-II Q	Adult new-onset asthma sx 1.8 (1.01-3.2)	A
Radon et al. 2008/13 European and other industrialized countries [28]	1998-2003	4994	291 cleaners	NR	43	Definition of rhinitis: ECRHS and ECRHS-II Q	Adult new-onset perennial rhinitis sx 1.4 (1.0-2.1)	A
<i>Case-control studies</i>								
Ng et al. 1994/Singapore [21]	NS	787 cases with asthma, 1591 non-asthmatic controls	Cleaners	59	20-54	Non-validated Q	In cleaners: asthma sx 1.9 (1.2-3.0)	A
Kennedy et al. 2000/France [35]	NS	173 cases with asthma and 285 non-asthmatic controls	Cleaners	NR	43	ECRHS Q	In exposed to industrial cleaning agents: asthma sx 7.4 (1.4-71.7)	A
Jaakkola et al. 2003/Finland [20]	1997-2000	521 cases with asthma and 932 non-asthmatic controls	Cleaners	cases: 86 controls: 80	21-63	Self-administered Q + reversibility of airways obstruction	In cleaners: adult new-onset asthma sx and reversibility of airways obstruction at lung function 1.4 (0.8-2.5)	A
Le Moual et al. 2005/France [36]	1991-1995	148 cases with asthma and 228 non-asthmatic controls	Cleaners	NR	43	ECRHS Q	In exposed to industrial cleaning agents: severe adult-onset asthma sx 7.2 (1.3-39.9)	A
Medina-Ramón et al. 2005/Spain [37]	2001-2002	14 cases with asthma 155 non-asthmatic controls	Domestic cleaning women	74	50	ECRHS Q	Asthma sx associated with: intermediate exposure to bleach 23.0 (1.9-274) high exposure to bleach 14.0 (1.3-153)	A
Henneberger et al. 2010/11 European countries and USA [38]	1998-2003	74 cases with and 892 controls without severe exacerbation of asthma	Cleaners	59	42	Severe exacerbation of asthma: ECRHS and ECRHS-II Q	Severe exacerbation of asthma sx 0.8 (0.3-1.8)	A
Le Moual et al. 2012/France [31]	2003-2007	244 women with current asthma and 439 non-asthmatic women	Domestic cleaning women	NR	44	ECRHS Q	Weekly use of ≥ 2 types of sprays associated with: asthma symptom score 2.5 (1.5-4.0), current asthma 1.7 (1.1-2.6), and poorly-controlled asthma 2.0 (1.2-3.3)	A

^aThe quality of studies was classified into the following three categories: A, more than 80% of STROBE criteria fulfilled; B, 50-80% of STROBE criteria fulfilled; and C, less than 50% of STROBE criteria fulfilled [15,16]; OR, odds ratio; CI, confidence interval; ECRHS, European Community Respiratory Health Survey; Q, questionnaire; sx, symptoms; NR, not reported; BHR, bronchial hyper-reactivity; WRA, work-related asthma; NHANES, National Health and Nutrition Examination Survey; PAARC, Pollution Atmosphérique et Affections Respiratoires Chroniques; NS, not stated.

Table 2. Risk of asthma/rhinitis in epidemiologic studies in cleaning workers.

References/country	Study year	Subjects (n)	Agents	Participation rate (%)	Age (yr, mean or range)	Methods for defining asthma (unless otherwise stated)	OR, unless otherwise stated (95% CI)	Reporting quality ^e
<i>Cross-sectional studies in working groups</i>								
Zock et al. 2001/Spain [26]	1998	67 indoor cleaners 1272 office workers	Cleaning products	74	NR	ECRHS Q ± methacholine challenge	Asthma sx 1.7 ^b (1.1–2.7)	A
Zock et al. 2001/Spain [26]	1998	21 private home cleaners 1272 office workers	Cleaning products	74	NR	ECRHS Q ± methacholine challenge	Asthma sx and BHR 2.8 ^b (1.3–6.2) Asthma sx 3.3 ^b (1.9–5.8)	A
Maçãira et al. 2007/Brazil [10]	2002–2003	341 non-domestic cleaners	Cleaning products	NR	36	Definition of rhinitis: ISAAC Q	Asthma sx and BHR 5.0 ^b (1.9–13.2) Females (vs. males): rhinitis sx 2.1 (1.2–3.7)	A
Ohadja et al. 2009/Canada [19]	NS	566 non-domestic cleaners 587 other building workers 761 current professional cleaners	Cleaning products	38	49	Validated Q	In female cleaners: WRA sx 3.9 (2.1–7.4)	A
Vizcaya et al. 2011/Spain [30]	2007–2008	86 former cleaners 70 never cleaners	Hydrochloridric acid	19	45	ECRHS self-administered Q	In 204 cleaners working in hospital: current asthma 2.1 (1.1–4.2)	A
Corradi et al. 2011/Italy [29]	NS	40 cleaners 40 controls	Cleaning products	NR	43	Definition of asthma/rhinitis: ECRHS-II Q	In 333 cleaners using hydrochloridric acid: asthma score 1.7 ^c (1.1–2.6)	B
<i>Longitudinal studies in working groups</i>								
Nielsen et al. 1999/Denmark [22]	1991	775 female cleaners 210 former female cleaners	Cleaning sprays	45	NR	Non-validated Q	^e	B
Zock et al. 2007/10 European countries [23]	1998–2003	3503 non-professional home cleaners	Cleaning sprays	59	43	ECRHS-II Q	In those using cleaning sprays at least weekly: adult new-onset asthma sx 1.5 ^d (1.1–2.0)	A

^aThe quality of studies was classified into the following three categories: A, more than 80% of STROBE criteria fulfilled; B, 50–80% of STROBE criteria fulfilled; and C, less than 50% of STROBE criteria fulfilled [15,16].

^bPrevalence ratio.

^cMean ratio.

^dPrevalence of asthma/rhinitis 2.5%/20.0% (no significant difference from controls).

^eAsthma sx 7% in cleaners, 12% in former cleaners, $p = 0.019$.

^fRelative risk.

OR, odds ratio; CI, confidence interval; NR, not reported; ECRHS, European Community Respiratory Health Survey; Q, questionnaire; sx, symptoms; BHR, bronchial hyper-reactivity; ISAAC, International study on Asthma and Allergies in Childhood; WRA, work-related asthma; NS, not stated.

Table 3. Potentially confounding variables and risk factors for the risk of asthma or rhinitis in epidemiological studies in cleaning workers.

Reference	Sex	Age	Duration of occupational exposure	Level of occupational exposure	Cleaning/mixing products	Domestic versus non-domestic cleaning	Atopy	Smoking	Socio-economic status
<i>Cross-sectional population based studies</i>									
Kogevinas et al. 1996 [24]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	ND	ND	ND	In cleaners the risk of asthma was higher in atopies than in non-atopies	Risk of asthma adjusted for	ND
Kogevinas et al. 1999 [25]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	ND	ND	ND	ND	Risk of asthma adjusted for	ND
Zock et al. 2002 [32]	Risk of asthma not different for males and females	Risk of asthma not significantly higher in older cleaners	ND	ND	ND	ND	In cleaners the risk of asthma was higher in non-atopies	Risk of asthma not different for smokers and non-smokers	Not a confounding variable for the risk of asthma in cleaners
Medina-Ramón et al. 2003 [3]	Random sample of females	Risk of asthma decreased with increasing age	ND	ND	ND	Current asthma: in domestic cleaning OR 1.5, 95% CI 1.1-1.9, in non-domestic cleaning OR 1.1, 95% CI 0.7-1.6	ND	Risk of asthma adjusted for	ND
Arif et al. 2003 [17]	Risk of WR asthma adjusted for	Risk of asthma adjusted for	ND	ND	ND	ND	Risk of WR asthma adjusted for	Risk of WR asthma adjusted for	ND
Le Monal et al. 2004 [18]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	ND	ND	ND	ND	Risk of asthma adjusted for	ND
Eng et al. 2010 [33]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	ND	ND	ND	ND	Risk of asthma adjusted for	Risk of asthma adjusted for deprivation index
<i>Cross-sectional studies in working groups</i>									
Zock et al. 2001 [26]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	ND	In domestic cleaners associated with -the use of 8 different cleaning products (PR 3.2-4.3); -mixing products (PR 3.2, 95% CI 1.5-7.0)	In domestic cleaning higher risk of asthma sx and BHR than in non-domestic cleaning	Not a risk factor for asthma	Risk of asthma adjusted for	ND
Maciàra et al. 2007 [10]	Female gender associated with rhinitis (OR 2.1, 95% CI 1.2-3.7)	Risk of asthma/rhinitis adjusted for	In non-domestic cleaning the risk of WR asthma/rhinitis increased with exposure duration	ND	In male cleaners the risk of WR asthma/rhinitis associated with the use of ammonia (OR 6.7, 95% CI 1.6-28.1)	ND	Associated with asthma (OR 2.9, 95% CI 1.4-6.7)	Associated with asthma (OR 2.9, 95% CI 1.4-6.7)	ND
Onadía et al. 2009 [19]	Non-domestic females cleaning associated with WR asthma (OR 3.9, 95% CI 2.1-7.4)	Risk of WR asthma adjusted for	Not associated with asthma	Not associated with asthma	In male cleaners: 6 different cleaning tasks significantly associated with WR asthma (OR 2.1-4.5)	ND	ND	Risk of WR asthma adjusted for	ND
Vizcaya et al. 2011 [30]	Risk of asthma adjusted for	Risk of asthma adjusted for	ND	N. of different workplaces or products associated with asthma score (mean ratio 1.7, 1.8 and 1.6, respectively)	Use of hydrochloridric acid associated with asthma score (mean ratio 1.7, 95% CI 1.1-2.6)	ND	ND	Risk of asthma adjusted for	ND
Cornali et al. 2011 [29]	ND	ND	ND	ND	ND	ND	ND	ND	ND
<i>Longitudinal population-based studies</i>									

Hellgren et al. 2002 [27]	Risk of rhinitis associated with male cleaners (OR 2.1, 95% CI 1.1–4.0)	ND	ND	ND	Risk of rhinitis adjusted for	ND	Risk of rhinitis adjusted for	ND	
Kogevinas et al. 2007 [34]	Risk of asthma adjusted for	ND	ND	Risk of asthma associated with exposure to cleaning products	Risk of asthma adjusted for	ND	Risk of asthma adjusted for	ND	
Radon et al. 2008 [28]	Risk of perennial rhinitis associated with female cleaners (OR 1.7, 95% CI 1.1–2.6)	ND	ND	ND	Risk of perennial rhinitis adjusted for	ND	Risk of perennial rhinitis adjusted for	Risk of perennial rhinitis adjusted for level of education	
Longitudinal studies in working groups									
Nielsen et al. 1999 [22]	Participants were female cleaners	ND	ND	Level of exposure to cleaning sprays not significantly associated with asthma	Not a risk factor for asthma	ND	ND	Not a risk factor for asthma	ND
Zock et al. 2007 [23]	Not a risk factor for adult asthma	ND	ND	Risk of asthma associated with use of cleaning sprays >3 day/week (RR 2.1, 95% CI 1.1–3.9) or >2 sprays used (RR 3.0, 95% CI 1.3–6.6)	Risk of adult asthma adjusted for	ND	Risk of asthma associated with use of cleaning sprays (RR 1.5, 95% CI 1.1–2.0)	Not a risk factor for adult asthma	Risk of adult asthma adjusted for
Case-control studies									
Ng et al. 1994 [21]	Risk of asthma adjusted for	ND	ND	ND	Risk of asthma adjusted for	ND	Risk of asthma adjusted for clinical atopy	ND	ND
Kennedy et al. 2000 [35]	Controls matched to cases for 10 year age group	ND	ND	ND	Controls matched to cases for 10 year age group	ND	ND	ND	ND
Jaukkola et al. 2003 [20]	Risk of asthma adjusted for	ND	ND	ND	Risk of asthma adjusted for	ND	ND	Risk of asthma adjusted for	ND
Le Moual et al. 2005 [36]	Risk of severe adult-onset asthma adjusted for	ND	ND	ND	Risk of severe adult-onset asthma adjusted for	ND	Risk of severe adult-onset asthma associated with exposure to industrial cleaning products	Risk of severe adult-onset asthma adjusted for	ND
Medina-Ramón et al. 2005 [37]	Among cases female domestic cleaners only	ND	ND	Dose-response relationship between exposure to bleach and risk of asthma sx	Risk of asthma adjusted for	ND	Risk of asthma associated with inhalation accidents, 2/3 of which related to mixing products (OR 3.3, 95% CI 1.5–7.4)	Risk of asthma adjusted for	ND
Henneberger et al. 2010 [38]	Risk of severe exacerbation of asthma adjusted for	ND	ND	ND	Risk of severe exacerbation of asthma adjusted for	ND	ND	Risk of severe exacerbation of asthma adjusted for	ND
Le Moual et al. 2012 [31]	Among cases female domestic cleaners only	ND	ND	Level of exposure to cleaning sprays associated with asthma sx (OR 2.5, 95% CI 1.5–4), current asthma	Risk of asthma adjusted for	ND	Furniture (OR 2.1, 95% CI 1.2–3.5) and refreshing cleaning sprays (OR 1.8, 95% CI 1.1–2.7) were a risk factor for	Not a risk factor for asthma sx	Not a risk factor for asthma sx

(continued)

Table 3. Continued

Reference	Sex	Age	Duration of occupational exposure	Level of occupational exposure	Cleaning/mixing products	Domestic versus non-domestic cleaning	Atopy	Smoking	Socio-economic status
				(OR 1.7, 95% CI 1.1-2.6) and poorly-controlled asthma (OR 2 (95% CI 1.2-2.3)	asthma sx; glass cleaning sprays were a risk factor for current asthma (OR 1.5, 95% CI 1.0-2.1)				

ND, not done; OR, odds ratio; CI, confidence interval; WR, work related; PR, prevalence ratio; RR, relative risk; sx, symptoms.