



Cleaning sprays, household help and asthma among elderly women



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Summary

Objective: There is increasing evidence on the deleterious role in asthma of the use of household cleaning products in spray forms in adults. Household help might induce misclassification errors. The aim of the present analysis was to study associations between household exposure to cleaning sprays and current asthma in elderly women, taking into account household help. **Methods:** A nested case–control survey on respiratory health was undertaken among a random sample of French women from the E3N study. Data were available for 570 women (235 with current asthma and 335 without asthma history; 68 years old on average, 59% never smokers). Three estimates of domestic exposure were used: 1) self-reported, 2) using principal component analysis, 3) a composite score for sprays. Associations between domestic exposures and asthma were assessed by logistic regression, adjusted for age, educational level, BMI and smoking status. Analyses were further stratified on household help in order to evaluate a potential misclassification bias.

Results: Among women without household help ($n = 325$), a significant association was observed between weekly use of at least one spray and current asthma (OR [95% CI]: 1.86

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[1.04–3.33]). No association was observed among women with household help.
Conclusions: Weekly household use of cleaning sprays may have a deleterious effect on asthma. It is important to take into account household help to limit misclassification bias.
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Introduction

The use of cleaning products in spray form has increased in past decades [1]. The harmful effect of products in spray form at home [2], or used by spray painters [3], machine workers [4], or in agriculture [5] at work, have been observed in several diseases. Bello et al. [6,7], studying detailed tasks among cleaners, classified the use of cleaning sprays as high risk for inhalation exposure. Beyond exposures at work, tools to assess exposure to cleaning agents in the domestic setting are being developed [8–11]. Beside self-reported exposure, recent studies suggested to use principal component analysis to synthesize information from numerous variables [8] or a composite score for cleaning sprays or scented products [11]. Related socio-economic conditions, such as household help, have not yet been taken into account. Household help is strongly related to social status but also depends on age-related health problems, especially in the elderly [12]. Furthermore, household help might induce misclassification errors in the evaluation of exposure.

Evidence is increasing regarding the role of exposure to cleaning products to explain part of the increase in asthma prevalence observed in most developed countries [13–15]. Deleterious effects of occupational exposure to cleaning products have been reported for asthma [15,16] and asthma severity [17] in particular in cleaners [15,18] and healthcare professionals [19]. Although it has sparsely been studied, there is increasing evidence on the deleterious role in asthma activity and incidence, of the use of cleaning products in spray form both at work [15,18–20] and at home [8,9]. The underlying mechanisms (allergic, non-allergic) that may lead to a deleterious role of spray use on asthma are unknown [8]. The possibility of a stronger association with severity in the absence of inhaled steroid treatment has been raised [17]. Women are at higher risk than men of a deleterious role of cleaning products either at work or at home [8,18,21]. Obesity is a risk factor for asthma, especially in women [22] and a recent study demonstrated that overweight increased the effect of indoor pollutants on asthma in children [23]. Asthma in the elderly, still understudied, is a growing public health issue [24], and home cleaning of particular relevance in this context, as it concerns women beyond the age of retirement.

Taking advantages of detailed information regarding domestic tasks and respiratory phenotypes available in aging women from the French E3N study (Etude Epidémiologique auprès des femmes de la Mutuelle Générale de l'Education Nationale), the aim of the present analysis was to study the relationship between domestic exposure estimates, especially the use of cleaning sprays, and current asthma in elderly women, taking into account potential help for domestic cleaning activities.

Materials and methods

The analysis is based on a subsample of women from the large E3N cohort for whom detailed respiratory and environmental data have been collected.

Study population

The E3N study is a prospective cohort study undertaken in 1990, among 98,995 women aged 40–65 years at baseline. These women are members of the MGEN (Mutuelle Générale de l'Education Nationale), a French national health insurance plan covering mostly teachers. The E3N study is the French component of the European Prospective Investigation into Cancer and Nutrition (EPIC) [25]. Information on lifestyle and medical history were collected every two years by self-administered questionnaires. Up to now, nine questionnaires were sent since 1990. Information on asthma in E3N ("Have you ever had an asthma attack?"), was recorded from the second questionnaire (Q2, 1992) till 2005 (Q8). No pulmonary function test was performed.

In 2009, a specific respiratory health survey was conducted to improve asthma characterization among participants from the E3N study. Among the 70,428 women who returned the 8th questionnaire in 2005 and still alive in 2009 (see Fig. E1 for more details, [Supplementary material](#)), we randomly selected 800 women on asthma (1 control per case, no matching of cases and controls). These women received a detailed questionnaire regarding respiratory health, symptoms, allergy, and domestic exposures. Questionnaires were self-completed and returned by mail. A 93% response rate was obtained ($n = 745$). Women with missing data for domestic exposure ($n = 24$) or asthma ($n = 52$), and women with non current asthma ($n = 32$) were excluded from the analysis. Women with "ever asthma" (according to the main E3N questionnaires) who did not report asthma in the specific respiratory health questionnaire were also excluded ($n = 67$). The study population consisted of 570 women: 235 with current asthma and 335 without asthma history (women who never had asthma).

Assessment of asthma phenotypes in the specific respiratory health survey

Ever asthma was defined according to the British Medical Research Council (BMRC) definition, by a positive answer to at least one of these two questions "Have you ever had asthma attacks?" and "Have you ever had attacks of breathlessness at rest with wheeze?". Current asthma was further defined among women with ever asthma, by the presence in the last twelve months of asthma attack or asthma treatment or one of five asthma-like symptoms (wheezing, woken up with a feeling of chest tightness, attack of shortness of breath at rest, attack of shortness of

breath after exercise, woken by attack of shortness of breath). This definition has been used previously in another French study [8,26,27] and is very close to the one used in the European Community Respiratory Health Survey (ECRHS), in which asthma had to be confirmed by a doctor [28]. A 5-level asthma symptom score was built by summing the five asthma-like symptoms in the last twelve months, and then categorized into 3 classes (0, 1, ≥ 2 symptoms), as previously described [8,29,30]. Allergic rhinitis, proposed as a good marker of atopy [31], was defined as in the ECRHS survey, by a positive answer to the question: "Do you have any nasal allergies, including hay fever?" [31]. All asthma medications dispensed by the French health insurance MGEN (Mutuelle Générale de l'Éducation Nationale) have been collected every year since 2004. The MGEN database contains comprehensive information on asthma medications dispensed to all of the E3N women. Women with current asthma were then classified as having or not inhaled corticosteroids (ICS) canisters dispensed in the 12 months before the exact return date of the specific respiratory health questionnaire (2008–2009).

Assessment of domestic exposure in the specific respiratory health survey

Domestic exposures were evaluated in three different ways. The first was self-report by questionnaire; the second was an indicator generated by principal component analysis [8] and the third was a recently described composite score [11].

Questionnaires

Domestic exposure in the past twelve months was estimated by the same questionnaire as the one previously used [8,9]. The frequency of various cleaning tasks and products use was provided and classified in four categories: never, less than 1 day/week, 1–3 days/week, 4–7 days/week. Women who reported home cleaning at least one day per week were considered as exposed for home cleaning. Frequency of nine types of sprays (furniture, glass cleaning, carpets/rugs/curtains, mopping the floor, oven, ironing, air refreshing, degreasing, insecticide/pesticide/anti-dust mite product) was collected (see [Appendix 1, Supplementary material](#)). Women who reported the use of at least one type of sprays at least one day per week were considered as exposed for spray use. Women exposed to sprays were classified as either weekly exposed to one spray or weekly exposed to at least two sprays. Information on household help (yes, no) was also recorded.

Principal component analysis (PCA)

PCA (see [Table E1, Supplementary material](#)) enables synthesized information from numerous variables to be obtained and is classically used to estimate dietary patterns in nutrition studies [32,33]. We applied this method to summarize 26 questions on cleaning tasks, cleaning products and sprays used (see [Appendix 1](#)), as previously described in the Epidemiological study on the genetics and environment of asthma (EGEA) [8]. For each product and cleaning task, the frequency, recorded as never, <1, 1–3, or 4–7 days/week, was assigned a quantitative value of 0, 0.5, 2 and 5.5, respectively. The factors were rotated using an orthogonal transformation of axis to obtain a more interpretable structure. The number of factors to retain was determined

using the eigenvalues graph. Variables that loaded at >0.30 were considered to be making a contribution to the factor. PCA identified four domestic exposure patterns ([Table E1](#)). The first factor labeled 'Essential tasks' was defined by domestic tasks and the use of products related to common home cleaning (cleaning the house, dusting, mopping...). The second factor, labeled 'Chemical products' was defined by the use of different chemical products (solvents, decalcifiers, ammoniac...). The third factor, labeled 'Multiple sprays' was defined by the use of different sprays (degreasing, oven sprays...). The fourth factor, labeled 'Glass cleaning' was defined by domestic tasks and the use of cleaning products related to the cleaning of windows and mirrors (glass cleaning sprays, cleaning windows or mirrors...). The score obtained for each domestic exposure pattern was divided into tertiles in order to study the associations between exposure and asthma phenotypes.

Composite score

As previously described by Mehta et al. [11] in the Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults (SAPALDIA), a composite score variable was built for cleaning sprays or scented products. A factor analysis confirmed that most of the variation in reported use of spray products or scented products derived from the use of five types of sprays: cleaning sprays for furniture, glass and rug/carpet/curtain, oven and degreasing sprays. Therefore, a frequency score was built as in Mehta et al., by assigning for each of these 5 sprays a 4-class score based on the frequency of use (recorded as never, <1, 1–3, or 4–7 days/week). The final composite score (range 0–15) was calculated by taking the sum of the 5 individual frequency scores and then divided into five categories (0, 1, 2, 3, ≥ 4).

Assessment of other variables

Relevant information for educational level (classified as <high school diploma, high school to 2-level university diploma, 3-/4-level university diploma, ≥ 5 -level university diploma) was obtained from the E3N first questionnaire in 1990. The most recent information was used for tobacco consumption (classified as never smoker, past smoker or current smoker) and body mass index (BMI classified as <20, 20–24.9, ≥ 25 kg/m²) derived from the 2005 questionnaire.

Statistical analyses

The description of the population according to the asthma status was evaluated using Chi-squared tests for categorical variables and *t*-tests for continuous variables. Associations between current asthma and domestic exposures (self-reported, patterns and composite score) were evaluated by univariate and multivariate logistic regression analyses, using women without asthma as reference. All multivariate analyses were adjusted for age (as continuous variable), education level, BMI and smoking status (as categorical variables). Trend analyses were performed using multivariate logistic regression models, considering weekly use of sprays as a continuous variable. Less misclassification errors are expected among women without household help, therefore models were stratified on household help. Analyses were further conducted by taking into account ICS

canisters dispensed among women with current asthma. Analyses were further stratified on allergic rhinitis, in order to evaluate the underlying mechanism (allergic, non-allergic). Analyses were also stratified on BMI, in order to evaluate a potential interaction with domestic exposure to cleaning products on asthma. All analyses were conducted using SAS statistical software, version 9.1.

Results

In 2009, the 570 women were aged 59–84 years old (median age: 67, mean age: 68), most of them were never smokers and only 7% current smokers (Table 1). They had a relatively

high educational level (36% ≥ 3 years of university level), and nearly 40% benefited of household help. Household help increased with educational level and age (Fig. 1). The association of household help with educational level was only observed in the group of women aged 59–67 years old (p interaction = 0.11).

More than 50% of women with current asthma had ICS canisters dispensed in the last year. Household help was unrelated to asthma.

Cleaning exposure

On average, weekly home cleaning was reported by 67% of the participants. Home cleaning was twice as frequent among women without household help (see Table E2,

Table 1 Description of the population.

	All <i>n</i> = 570	Never asthma <i>n</i> = 335	Current asthma <i>n</i> = 235	<i>p</i>
Age (years), mean \pm SD	68.2 \pm 6.2	68.1 \pm 6.4	68.4 \pm 6.0	0.52
Body mass index (BMI) (kg/m ²), mean \pm SD	23.9 \pm 3.8	23.6 \pm 3.8	24.2 \pm 3.8	0.12
BMI (kg/m ²), %				
<20	11.4	11.8	10.9	0.19
20–24.9	58.6	61.2	54.7	
≥ 25	30.0	27.1	34.4	
Smoking status (%)				
Never smoker	58.7	60.3	56.4	0.42
Past smoker	34.6	32.4	37.6	
Current smoker	6.7	7.3	6.0	
Educational level (%)				
<High school diploma	10.0	12.2	7.0	0.13
High school to 2-level university diploma	54.2	55.0	53.1	
3-Level or 4-level university diploma	17.2	15.3	19.7	
≥ 5 -Level university diploma	18.6	17.5	20.2	
Household help (%)	39.7	40.8	38.1	0.53
Weekly home cleaning (%)	67.2	67.8	66.2	0.70
Weekly use of sprays (%)				
0 Spray	75.0	76.8	72.4	0.39
1 Spray	15.4	14.9	16.1	
≥ 2 Sprays	9.6	8.3	11.5	
Weekly use of air-refreshing sprays(%)	11.4	10.5	12.7	0.41
Weekly use of degreasing sprays (%)	8.5	6.5	11.3	0.05
Weekly use of window/mirror sprays (%)	7.4	7.8	6.9	0.69
Asthma symptom score (%)				
0 Symptom	46.4	69.5	13.5	<0.0001
1 Symptom	28.3	23.5	35.1	
≥ 2 Symptoms	25.3	7.1	51.4	
Allergic rhinitis (%)	47.6	30.0	72.7	<0.0001
Dispensed inhaled corticosteroids (%)	24.6	6.3	50.6	<0.0001

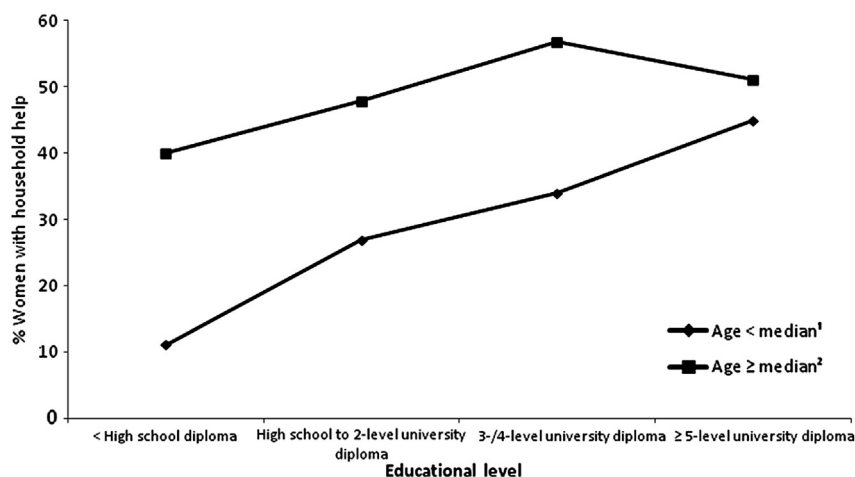


Figure 1 Household help and educational level according to median age. The median age was 67.3 years old. ¹ $p = 0.003$ for Chi-test for household help according to educational level among women aged <67.3 years old. ² $p = 0.27$ for Chi-test for household help according to educational level among women aged ≥67.3 years old.

[Supplementary material](#)). A weekly use of at least one spray was reported by 25% of the participants (15% used 1 spray and 10% used at least 2 sprays). The three sprays mostly used were air-refreshing, degreasing and window/mirror sprays. Among women using at least two sprays, 60% used degreasing sprays.

According to PCA, among women with the highest use of sprays (3rd tertile of the 'Multiple sprays' pattern), 47% did not report a weekly use of sprays, which means almost half of them used one or more sprays less than weekly. Likewise, among women in the 3rd tertile of the 'Glass cleaning' pattern, 72% did not report cleaning windows or mirrors, or using glass cleaning sprays weekly. Among the three types of sprays mostly used, only degreasing sprays loaded for the 'Multiple sprays' pattern (at > 0.30), window/mirror sprays loaded for the 'Glass cleaning' pattern and air-refreshing sprays did not load for any of the four patterns.

The composite score for sprays or scented products use ranged from 0 to 9: 19% of the studied population had a score of 0, 24% had a score of 1, 23% had a score of 2, 15% had a score of 3 and 19% had a score ≥4. Among women with a composite score of 2 or 3, 88% of them did not use any of the five sprays weekly. Among women with a composite score ≥4, 40% did not use weekly any of the five sprays (they use at least four of the five sprays less than weekly).

Domestic exposure and current asthma

Results of analyses between current asthma and domestic exposure estimates are presented in Tables 1 (univariate only) and 2 (univariate and multivariate). A positive non-significant association was found between current asthma and weekly use of at least one spray (odds ratio (OR) [95% confidence interval (CI)]: 1.34 [0.91–1.97]). After adjustment for age, education level, BMI and smoking status, the OR slightly increased (OR: 1.45 [0.94–2.24], $p = 0.09$). The multivariate association slightly increased with the number of sprays weekly used (1.23 [0.73–2.08] and 1.53 [0.77–3.05] for only one spray and at least two sprays, respectively; p for trend = 0.18). Results remained similar after exclusion of 21 subjects occupationally exposed to cleaning agents (OR for weekly use of at least

one spray: 1.38 [0.89–2.16]) or when restricting the analysis to the 331 never smokers (OR for weekly use of at least one spray: 1.63 [0.90–2.96]).

Regarding the most frequently used types of sprays, current asthma was significantly related to a weekly use of degreasing sprays (Table 1), an association of borderline significance after adjustment for age, smoking habits, BMI and educational level (OR: 1.90 [0.96–3.77], $p = 0.06$). No association was observed between current asthma and other domestic exposure estimates: neither for home cleaning, nor for the four domestic exposure patterns estimated using PCA (Table 2), nor for the composite score (results not shown).

Household help

In women without household help, all associations were stronger. Results stratified on household help for the associations between domestic exposure and current asthma are presented in Fig. 2. In the 325 women without household help, the association between weekly use of at least one spray and current asthma was statistically significant (OR: 1.86 [1.04–3.33]). The ORs were 1.29 [0.63–2.66] for weekly use of one spray and 2.63 [1.03–6.67] for weekly use of at least two sprays (trend, $p = 0.04$). No association was found in the 214 women with household help (OR: 0.98 [0.47–2.03] for weekly use of at least one spray). However, the formal test for interaction between spray use and household help was not statistically significant ($p = 0.15$). Similarly, for the weekly use of degreasing sprays and current asthma, a significant association was observed in women without household help (3.32 [1.34–8.22]) but not in those with household help (0.76 [0.23–2.49]). The analyses regarding other markers of exposure were unchanged by considering household help. Further analyses were restricted to the 325 women without household help.

Allergic rhinitis, inhaled corticosteroids and overweight among women without household help

After stratification on allergic rhinitis, the association between weekly use of at least one spray and current asthma largely increased among the 165 women without

Table 2 Domestic exposure to cleaning products and current asthma.

	Self-reported exposure OR [95% CI]		Principal component analysis OR [95% CI]							
	Home cleaning	Spray use	Factor 1		Factor 2		Factor 3		Factor 4	
	≥1 day/wk	≥1 day/wk	'Essential tasks'		'Chemical products'		'Multiple sprays'		'Glass cleaning'	
			2nd Tertile	3rd Tertile	2nd Tertile	3rd Tertile	2nd Tertile	3rd Tertile	2nd Tertile	3rd Tertile
Crude association										
Never asthma (n = 335)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Current asthma (n = 235)	0.93	1.34	0.92	0.84	1.18	1.20	0.89	0.93	0.99	0.90
	[0.65–1.34]	[0.91–1.97]	[0.59–1.42]	[0.54–1.30]	[0.76–1.84]	[0.77–1.86]	[0.58–1.39]	[0.60–1.44]	[0.64–1.54]	[0.58–1.41]
Adjusted association ^a										
Never asthma (n = 335)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Current asthma (n = 235)	0.97	1.45	1.05	1.10	1.16	1.28	0.89	0.91	0.95	0.79
	[0.65–1.46]	[0.94–2.24] [#]	[0.64–1.70]	[0.67–1.83]	[0.71–1.88]	[0.77–2.10]	[0.55–1.45]	[0.56–1.49]	[0.59–1.53]	[0.48–1.28]

[#]p = 0.09 for weekly use of at least one spray and current asthma.

^a Odds ratios [95% confidence interval] (OR [95% CI]) were adjusted for age, education level, body mass index and smoking status.

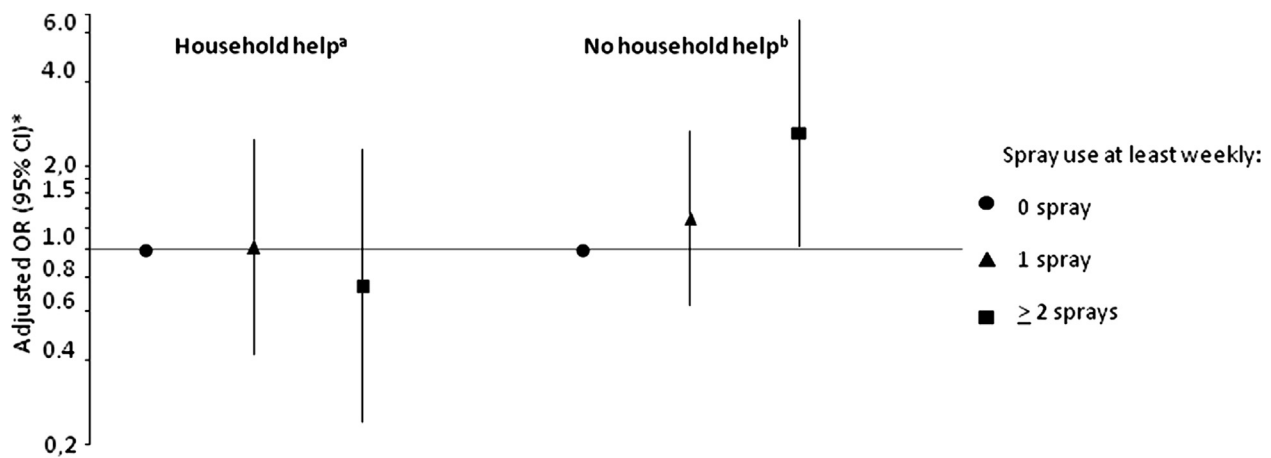


Figure 2 Spray use and current asthma stratified on household help. *Odds ratios [95% confidence interval] (OR [95% CI]) were for adjusted for age, educational level, body mass index and smoking status. ^aCurrent asthma ($n = 85$) vs. Never asthma ($n = 129$). ^bCurrent asthma ($n = 138$) vs. Never asthma ($n = 187$).

allergic rhinitis (OR: 7.69 [2.60–22.7]). No association was found among the 150 women with allergic rhinitis (OR: 1.00 [0.39–2.56]). The test for interaction between spray use and allergic rhinitis was statistically borderline significant (p interaction = 0.06). No association was found between the weekly use of at least one spray and allergic rhinitis (OR: 1.06 [0.58–1.93]).

The association of current asthma with weekly use of at least one spray increased when restricting the group of women with current asthma to the 70 women without dispensed ICS (OR: 3.11 [1.56–6.17]; Fig. 3). No association was found when comparing the 68 women with current asthma and dispensed ICS to the 187 women without asthma history (OR: 0.92 [0.41–2.10]). The formal test for interaction between spray use and ICS canisters dispensed was not statistically significant (p interaction = 0.62).

After stratification on BMI, the ORs for the weekly use of at least one spray and current asthma were 1.85 [0.92–3.72] in the 217 women with a BMI < 25 kg/m² and 2.07 [0.67–6.40] in the 87 women with a BMI ≥ 25 kg/m² (see Fig. 3). After restricting that analysis for the group of women with current asthma to those without ICS canisters dispensed, the OR in the 67 women with a BMI ≥ 25 kg/m² was almost twice the OR in the 173 women with a BMI < 25 kg/m² (ORs: 4.77 [1.26–18.04] and 2.64 [1.14–6.13] respectively; p interaction = 0.54).

Discussion

Positive associations were found between weekly use of at least one spray and current asthma among French elderly

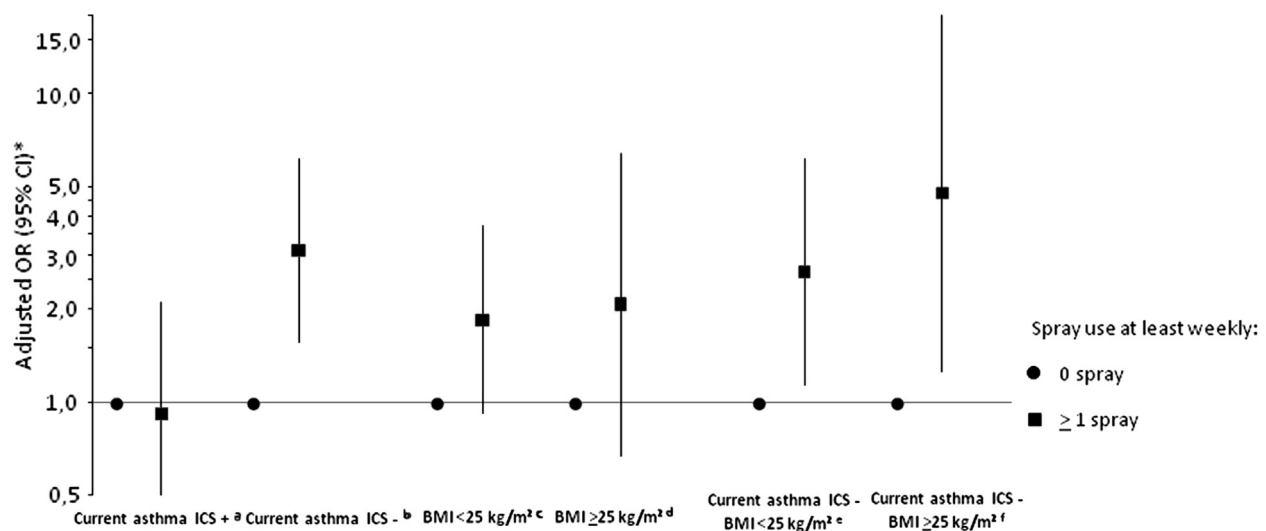


Figure 3 Weekly spray use and current asthma among women without household help according to ICS and BMI. *Odds ratios were for adjusted for age, educational level, body mass index (BMI) and smoking status. ^aCurrent asthma with dispensed inhaled corticosteroids (ICS) ($n = 68$) versus never asthma ($n = 187$). ^bCurrent asthma without dispensed ICS ($n = 70$) versus never asthma ($n = 187$). ^cAmong women with BMI < 25 kg/m², current asthma ($n = 85$) versus never asthma ($n = 132$). ^dAmong women with BMI ≥ 25 kg/m², current asthma ($n = 40$) versus never asthma ($n = 47$). ^eAmong women with BMI < 25 kg/m², current asthma without dispensed ICS ($n = 41$) versus never asthma ($n = 132$). ^fAmong women with BMI ≥ 25 kg/m², current asthma without dispensed ICS ($n = 20$) versus never asthma ($n = 47$).

women without household help. Understanding the types of sprays concerned need further studies, but the associations observed in the present study were mainly explained by the use of degreasing sprays, calling for more studies of such sprays. Mechanisms are not yet known, but the fact that associations were only observed among women without ICS canisters dispensed, suggests an inflammatory role of cleaning sprays. Overall, results support the hypothesis that cleaning sprays have a deleterious effect in the population at any age and represent a public health problem.

Assessment of exposure – strengths and limitations

Strengths of the present study include attempts to improve the characterization of exposure by considering social aspects (household help) and analyses of patterns of cleaning activities. Our results show that not taking household help into account may mask association with exposure, possibly due to over-estimation of self-reported exposure in women with household help. Less misclassification errors are expected among women without household help. Indeed, one could hypothesize that women with cleaning help answered on behalf of their professional cleaner or felt uneasy to answer that they did not clean their home. Consistent with previous results [12], higher educational level, marker of higher social status, was strongly related to more frequent household help. In the E3N study, this association was particularly observed in the group of women aged 59–67 years old, who did not need help in relation to age-related health problems. The modifying effect of household help, a factor dependent of social characteristics has never been studied in epidemiological studies. Discrepancies between studies, conducted in various societies, may depend on the frequency of household help, which vary across countries and time. Our results underline the importance, in further studies, to add questions regarding household help, for a better evaluation of the associations between cleaning products and asthma.

For the present analysis, domestic exposure was assessed by self-report, which is a limitation to our study [8,34]. Women with asthma may feel uncomfortable using sprays and may provide more precise reports of products used or exaggerate their use [8]. Other estimates of exposure were assessed in order to limit misclassification bias. However, neither PCA patterns nor the composite score showed associations with current asthma, which suggests that those methods are not as good estimates as self-report, but cautious interpretation is needed in relation to sample size. Further studies are needed to objectively assess the exposure to cleaning sprays. Ongoing research aims at defining objective methods, like home visits using bar codes of various products, which may provide tools to include in epidemiological surveys with home visits or to validate or improve questionnaires used in very large surveys [35,36]. Indeed, besides a proper estimate of the actual use of various products, more information is needed regarding the specific products used, and possibly the way they are used, as for ventilation in the house which can influence exposure [7].

Deleterious role of exposure to cleaning agents in spray form

Our results extend in elderly women without household help results regarding the potential deleterious effect of

domestic cleaning sprays on asthma observed in younger adults [8,9]. In the ECRHS and EGEA surveys, associations of cleaning sprays have been evidenced in young adults, on incidence and asthma activity, respectively. In the present study the same standardized definition as in the EGEA survey was used for current asthma, based on international standardized recommendations [27,28].

Significant associations were observed when considering exposure of any spray at least once a week. The lack of association regarding home cleaning and cleaning patterns are consistent with previous results from the EGEA study, in which only an association with spray use was observed [8]. Other estimates of exposure (“home cleaning”, patterns of cleaning activities or the composite score of spray exposure) did not show associations with current asthma. Both the patterns and the composite score depended more on the diversity of products used than on the frequency. The ‘Multiple sprays’ pattern did not reflect weekly use of sprays but rather a sporadic use of multiple sprays. Understanding the types of sprays concerned need further studies, but the associations observed in the present study were mainly explained by the use of degreasing sprays, calling for more studies of such sprays.

The deleterious role of products in spray form has been observed in various diseases in the occupational and environmental settings [3–5,10,11,37,38]. The use of products in spray form facilitates respiratory exposure (better than those in non-spray form) [7]. Allergens and irritants are deposited in large airways by turbulent flow, causing chronic inflammatory changes [39]. The size of particles determines how quickly the particle settles, to what extent it follows the movements of the air and the probability of being deposited in a given part of the human respiratory system [40]. In a recent experimental scenario simulating human exposure to aerosol, a potential harmful exposure to a household bathroom cleaner/sanitizer spray, after evaporation, with nanoparticles, has been suggested [41]. Understanding the role of the size of particles from cleaning sprays, which may differ according to the type of sprays (aerosol, atomizer), need further studies, including information on dose–response relationships.

Previous analyses in the EGEA study have shown associations between the use of sprays and IgE-dependent asthma and non-eosinophilic asthma [8]. In the E3N study, no information regarding skin prick tests, levels of IgE or blood eosinophils were available. Allergic rhinitis, which has been proposed as a good marker of atopy [31], was available. Positive associations were found between weekly use of sprays and current asthma only among women without allergic rhinitis, which suggests a non-allergic mechanism. Even if further studies using objective markers are needed, our results are consistent with the hypothesis of an irritant effect of products in spray form.

The role of anti inflammatory treatment and of obesity/overweight

We tested whether a stronger effect occurred in women without ICS treatment, as hypothesized from results in the EGEA survey [17]. Unlike previous studies, we had access to comprehensive dispensed drug database for the whole population. The association of spray use with current asthma was restricted to women without anti-inflammatory therapy.

Beyond the hypothesis of an irritant effect of cleaning agents, one hypothesis to explain our results may be an inflammatory role of cleaning agents. We further tested the potential modifying effect of overweight/obesity. It is worth noting that in those without anti-inflammatory therapy (ICS), the effect was nearly twice as high in overweight/obese women than in others, even if the test for interaction between spray use and BMI was not statistically significant. Systemic/airway inflammation is one of the mechanisms which can explain the association of asthma and obesity [22,42], an association already clearly evidenced in a larger sample from the E3N survey [43]. There are still limited studies on interaction between overweight and environmental factors with asthma, but it is an active topic of research with recent findings demonstrating that overweight increased the effect of indoor pollutants on asthma in children [23]. Interaction of overweight/obesity in the effect of environment has biological plausibility as an underlying state of inflammation which could increase the effect of pro-inflammatory exposures, such as cleaning exposures. Caution in the interpretation of our findings is necessary in relation to sample size. Further studies should clarify the potential modifying role of overweight/obesity on the effect of spray exposure on asthma, in particular in relation to the increasing prevalence of overweight worldwide.

Cleaning sprays and asthma: a public health issue over the life course

There is increasing evidence that the use of cleaning products in spray form, both at work and at home increases the risk of asthma [8,9,15,20]. The use of cleaning products in spray form has increased in last decades [1] and many people, and especially women, are exposed worldwide without knowledge on their potential toxicity. Cleaning products and especially fragrance, contained in products in spray form, have been shown to contain a lot of toxic compounds [44]. Household cleaning substances are classified as the most frequently involved in all human exposure complaints [45]. Our results extend in elderly women without household help results regarding the potential deleterious effect of domestic cleaning sprays observed in adults from two previous surveys [8,9]. Furthermore, a deleterious effect was observed between the use of cleaning sprays by parents during pregnancy or early childhood and the risk of wheezing in children, in two European studies [37,38]. Together with the literature, results suggest a deleterious effect of cleaning sprays in the population at all stages of life and thus, represent a life course public health problem.

Conflict of interest statement

All the authors declare that they do not have any conflict of interest.

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Appendix A. Supplementary material

Supplementary material related to this article can be found at <http://dx.doi.org/10.1016/j.rmed.2013.10.018>.

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