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Domestic exposure to irritant cleaning agents and asthma in women

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Abstract

An adverse role of frequent domestic use of cleaning agents, especially in spray form, on asthma has been reported. However, sparse studies have investigated respiratory health effects of chronic domestic exposure to irritant cleaning agents. This study aims to investigate associations between weekly use of irritant domestic cleaning products and current allergic and non-allergic asthma in a large cohort of elderly women.

We used data from the Asthma-E3N nested case-control study on asthma (n=19,404 women, response rate: 91%, 2011), in which participants completed standardized questionnaires on asthma and on the use of domestic cleaning products including irritants (bleach, ammonia, solvents and acids). Allergic multimorbidity in asthma was assessed from allergic-related medications recorded in drug refunds database. The association between use of irritants and current asthma was estimated by logistic regression (current vs. never asthma) and multinomial logistic regression (never asthma, non-allergic asthma, allergic asthma) adjusted on age, smoking status and body mass index (BMI).

In the 12,758 women included in the analysis (mean age: 70 years, current smokers: 4%, BMI≥ 25 kg/m²: 32%, low education: 11%, current asthma: 23%), 47 % reported weekly use of at least one irritant cleaning product at home. Weekly use of irritant products was associated with a higher risk of current asthma (adjusted Odds-Ratio: 1.17, 1.07-1.27). A statistically significant dose-response association was reported (p trend <0.0001), with both the number of irritant products used weekly (1 irritant: 1.12, 1.02-1.23; 2 irritants: 1.21, 1.05-1.39; 3 irritants or more: 2.08, 1.57-2.75) and the frequency of use (1-3 days/week:1.12, 1.02-1.23; 4-7 days/week = 1.41,1.22-1.64). A dose-response association was observed with the frequency of products used (p trend <0.05), for both non-allergic (4-7 days/week, 1.27, 1.02-1.57) and allergic asthma (1.52; 1.27-1.82).

In conclusion, weekly use of common cleanings irritants was associated with an increased risk of current asthma, whatever the allergic status.

Key words (max 6): Asthma; asthma treatment; domestic cleaning; allergy; irritants

1. Introduction

Adults spend most of their times inside buildings, at work or at home, and may be exposed to many chemicals(1), including cleaning agents(2). For infection control and hygiene purpose, the use of cleaning products and disinfectants has grown in the past decades, and especially in hospitals and at home. In two French studies, more than 70% of French women reported to clean their houses at least weekly whatever their age, and were more exposed than men to cleaning products(3,4). Moreover, cleaning products have specific purposes (detergent, disinfectant), leading to a potential sequential use of several products to do all the cleaning tasks, and potentially to a mixture effect on health(5). Cleaning products are composed of many ingredients which may be airway irritants (bleach, ammonia, solvents, acids)(6) or allergens (perfumes such as limonene)(7,8), which induce or exacerbate asthma(2,9,10). Inversely, bleach may inactivate common indoor allergens, and the use of bleach has therefore been suggested to reduce the risk of sensitization to indoor allergens (11).

Asthma, a complex multifactorial disease for which environmental factors may play a key role in its development or exacerbation (12), is characterized by a strong phenotypic heterogeneity, and the allergic status is one of the main characteristic of disease heterogeneity. Non-allergic asthma is more frequent among patients with adult-onset asthma, which may be more severe and more frequent among women(13,14). The underlying mechanisms in non-allergic asthma are still poorly characterized, and the potential role of the irritant cleaning products remain unknown. In epidemiological studies, the gold standard to evaluate the allergic status is based on biological tests (skin prick tests or specific IgEs), which are not usually available in large population-based surveys. Drug reimbursement databases may be an alternative to improve the asthma phenotypic characterization (15). However, to our knowledge such a database has never been used to evaluate the allergic status as an asthma multimorbidity in an epidemiological cohort.

Irritant-induced asthma has historically been described at work after an accidental massive exposure to irritants(6), and can sometimes be induced by the concomitant use of products that should not be mixed(16). Recent epidemiological findings suggested an association between chronic use of low to moderate chronic exposure to irritants and asthma(6,17) though mechanisms remain unclear. Data on

domestic use of cleaning products suggested an association with respiratory diseases, especially for sprayed products(4,3,7). In a recent survey, daily use of disinfectants at home was associated with incident asthma(18). In addition, daily use of bleach at home was associated with non-allergic asthma(19), suggesting a role of chronic use of cleaning products in irritant-induced asthma outside professional context. The role of the number of irritant cleaning products used at home on asthma has not been evaluated. Although it has been suggested that chronic use of irritant cleaning products may induce asthma through a non-allergic mechanism rather than an allergic one(6), allergic status has rarely been examined in epidemiological studies on the association between irritant cleaning agents and asthma (2,19).

The purpose of the present study was to investigate the association between chronic use of irritant cleaning products at home and current asthma in elderly women. The Asthma-E3N study represents a unique opportunity to evaluate allergy through drug refund data, and to test the hypotheses that chronic exposure to domestic irritant products increases the risk of asthma, and more specifically of non-allergic asthma, with a dose response relationship both for the frequency of use and the number of irritant products used.

2. Material and methods

2.1 Study design and population

The French **E3N cohort** (http://www.e3n.fr/) is an epidemiologic study, set up to study the role of nutrition and hormones on cancers and other chronic conditions, among 98,995 women, mainly teachers from the MGEN (*Mutuelle Générale de l'Education Nationale*) health Insurance plan(20). Various health data were recorded by biennial questionnaires. The E3N cohort also benefits from the access to drug refund data from the MGEN health insurance database since 2004.

Asthma-E3N is a case-control study on asthma nested in the E3N cohort and set up in 2011, among 21,300 women selected from the cohort. This study included all women who had ever had asthma (i.e., women who reported "asthma" at least once in the main E3N questionnaires between 1992 and 2005, n=7,100) and 14,200 aged-matched "women without asthma" (i.e., women who never reported "

asthma" in the main E3N questionnaires). Standardized questionnaires were sent by mail to collect data on asthma, respiratory symptoms and treatments, and on frequency of use of domestic cleaning products, including four largely used types of irritants (bleach, ammonia, solvents and other acids). A total of 19,404 women responded to the questionnaire (participation rate: 91%).

2.2 Current asthma and allergic comorbidities

Women who were defined as 'ever asthma' according to the E3N questionnaires or who answered positively in the Asthma-E3N questionnaire to at least one of the following two questions: 'Have you ever had asthma attacks?' and 'Have you ever had attacks of breathlessness at rest with wheeze?', were classified as **'ever asthma',** as suggested by the British Medical Research Council (BMRC). Women who never reported 'ever asthma' in E3N questionnaires and who answered negatively to the asthma questions in Asthma-E3N were classified as '**never asthma**'. Among women with 'ever asthma', those who reported asthma attacks, use of asthma treatment or at least one out of five asthma 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 up by an attack of shortness of breath) in the last twelve months were defined as '**current asthma'.** Current asthma definition is very close to the one used in the European Community Respiratory health Survey (ECRHS)(21) and the French EGEA survey(3,4).

The MGEN drug administrative database allows to extract refunds for anti-allergic (allergic rhinitis (AR), atopic dermatitis and allergic conjunctivitis) treatments in the 12 months before the Asthma-E3N questionnaire. For each participant, assessment of anti-allergic treatments was based on the refund database records, of specific therapeutic indications for one or several of these three allergic comorbidities, according to the 5-level ATC codes (22) listed in the '*Thériaque'* database (http://www.theriaque.org). The list of used ATC codes is available in supplementary materials (table S1). Subsequently, a 3-level asthma phenotype was defined: never asthma (reference group), and allergic (at least one anti-allergic treatment recorded in the last 12 months) current asthma, and non-allergic (no anti-allergic treatment recorded) current asthma.

2.3 Domestic use of cleaning products

Frequency of use of cleaning products was reported in a specific questionnaire in 4 classes (never, less than once a week, 1-3 days a week, and 4-7 days a week (daily use)), as previously described(4), for the four following irritants: bleach, ammonia, solvents and acids. A participant was considered weekly exposed to an irritant if she reported its use at least once a week. Frequency and the number of irritant products used weekly were classified as follows: a) frequency of use, defined in 3 classes (0: never or less than once a week for the 4 irritants; 1: 1-3 days per week; 2: 4-7 days per week (daily) for at least one irritant), b) number of products used, defined in 4 classes (0: never or less than once a week for the 3 irritants, 1: 1 irritant used weekly; 2: two irritants used weekly; 3: at least three irritants used weekly) or in 3 classes, after combining the 2 last classes (at least 2 irritants used weekly) to avoid small sample. In addition, a participant was considered as a 'spray user' (weekly use; yes/no) if she reported weekly use of at least one of the following products in spray form: furniture, glass, floor, oven, air freshener, insecticide or others.

2.4 Covariates

Age was considered as a continuous variable and smoking status as a 3-classes categorical variable: "never smoker", "past smoker" and "current smoker". Body Mass Index (BMI ; <20, [20-25[, [25-30[, ≥30 kg/m^2) and educational level (< high school diploma, high school to 2-level university diploma, 3-level or 4-level university diploma, >5-level university diploma) were defined by 4-classes categorical variables. Use of inhaled corticosteroids (ICS), an anti-inflammatory treatment, in the past 12 months was assessed from the MGEN drug administrative database (see online supplement), as previously defined(23). Household help was defined as a binary variable, following the answer to "Do you get help to clean at home?".

2.5 Statistical Analysis

Associations between the use of domestic irritant cleaning products and current asthma and the 3-level asthma outcome accounting for anti-allergic treatment were evaluated by logistic and multinomial regression models, respectively. In addition, as allergic and non-allergic asthma may not

be well separated disease entities, a stratified analysis on allergy was conducted as previously suggested(24). All analyses were adjusted for age, smoking status and BMI (3,4,19).

Further analyses were conducted to address the potential role of effect-modifiers in the irritant use and current asthma association, including household help, spray use and ICS use. We hypothesized a stronger association among participants without household help (less misclassification errors) (4) and among those using sprays (known to be associated with an increased risk of asthma (25)), and a lower association among those using ICS (an anti-inflammatory treatment) (4).

In addition, several sensitivity analyses were performed to test the robustness of our results according to the definition of the allergic status, by using first a more specific definition based on at least 2 refunds in the last year (instead of 1), and secondly a more sensitive definition by adding ATC codes with less specific therapeutic indications than those selected in the main analysis (see supplementary file, Table S2) and thirdly, using a definition based on allergic diseases as reported by questionnaire instead of assessed through drug refund data (see supplementary file).

All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

3. Results

Figure 1

A total of 12,758 women, 2,869 with current asthma and 9,889 without asthma, were included in the analysis (Figure 1), after exclusion of women with missing or incoherent data for ever asthma (n=2,054), household help (n=1,213) or domestic exposure (n=547). In addition, 2,832 women without current asthma or with missing values for current symptoms were excluded from the analysis. Excluded women because of missing data were older, more often overweighted and current smokers, had a lower educational level and used more cleaning sprays and irritants, as compared to included women (Table S3). Excluded women because of incoherent asthma data were more often ever smokers, had a higher educational level, more allergic comorbidities and more often refunds of ICS in the last 12 months, as compared to included women.

Women were aged on average 70, a third of them were overweight (BMI $\geq$ 25 kg/m^2), half of them never smoked and half of them reported the use of at least one irritant cleaning product weekly (Table 1). Women with current asthma had a higher BMI, were more often smokers, had more often help for their cleaning tasks, used more cleaning irritants and sprays, had more often allergic rhinitis or allergic comorbidities and ICS refunds than women who never had asthma ($p<0.0001$).

Table 1

3.1 Use of irritant cleaning products and risk of current asthma

Weekly use of at least one irritant cleaning product at home was associated with a higher risk of current asthma (adjusted Odds-Ratio (ORa) [95%CI]: 1.17 [1.07-1.27], Table 2). A dose-response relationship was observed (p trend <0.0001): the risk of current asthma increased with increased number of irritant products used, and increased frequency of use. Analyses stratified on household help (supplementary material, Table S4) or spray use (Table S5) or considering ICS refunds (Table S6) led to statistically significant associations within each group and no statistically significant interactions were reported. Nevertheless, associations were slightly stronger among women without household help (Table S4), women regularly using sprays (Table S5) and asthmatics without ICS refund (Table S6) in the last 12 months.

Table 2

3.2 Use of irritant cleaning products and risk of allergic and non-allergic asthma

Associations between weekly use of irritants and current asthma were statistically significant and of similar magnitude for allergic (1.19 [1.07-1.32]) and non-allergic (1.15 [1.02-1.30]) asthma. For non-allergic asthma (Figure 2), no trend was observed according to the number of products used weekly (1 irritant: 1.15 [1.01-1.32]); $\geq$ 2 irritants: 1.13 [0.93-1.37]), whereas the strength of the association increased with the frequency of use (1-3 days/week: 1.12 [0.99-1.28]; 4-7 days/week: 1.27 [1.02-1.57]; p for trend<0.02). By contrast, associations with allergic asthma significantly increased with both

product uses, as numbers (1 irritants: 1.09 [0.97-1.23]; at least 2 irritants: 1.46 [1.25-1.71]) or frequency (1-3 days/week: 1.12 [1.00-1.25]; 4-7 days/week: 1.52[1.27-1.82]); p trend <0.001 for both. Sensitivity analyses varying the sensitivity or specificity of the allergic definition (supplementary material, table S7) showed similar results. When using questionnaire-based allergic definition, no associations was observed between weekly use of irritants and asthma without allergic rhinitis, either considering the number of products or the frequency of use (supplementary material, figure S1). By contrast, an increased risk of asthma with allergic rhinitis was observed with the weekly use of irritants, either in number (1 irritant =1.27 [1.11-1.44]; at least 2 products=1.62 [1.37-1.93]) or frequency (1-3 days /week=1.30 [1.15-1.47]; 4-7 days/week=1.64 [1.35-2.01]), with significant trends (p<0.0001).

Figure 2

In addition, analyses stratified on allergic status was performed on 7829 non-allergic (including 1171 current asthma) and 4445 allergic (including 1587 current asthma) participants. Associations between weekly use of irritants and current asthma were of similar magnitude for non-allergic and allergic participants but non-significant for allergic participants (p=0.15; Table 3). Among both non-allergic and allergic participants, the strength of the association increased with the number and the frequency of use (p trend <0.02 for both).

Table 3

4. Discussion

Our study reported an increased risk of current asthma among weekly users of irritant cleaning products at home, and a dose-response relationship according to both frequency and number of products used. Similar associations were observed whatever the allergic status. Consistent associations were observed in several sensitivity analyses, underlying the robustness of our findings.

Our results are consistent with previous studies on both occupational and domestic use of bleach. Literature has shown an increased risk of asthma for occupational exposure to bleach(10), but research on domestic use of cleaning products is much more limited, especially for irritants. Noteworthy, our

study showed an increased risk of current asthma among irritant users even for a low number of products weekly used, whereas previous studies reported association only for daily (4-7 days/week) use of irritants at home (7,18,26). In the European respiratory ECRHSII cohort, a significant association between daily use of bleach and incidence of asthma symptoms was observed (26) whereas no significant association with incident asthma was observed for weekly use of bleach (7). Among young adults in Germany, an association was observed between daily use of disinfectants, which are possibly mainly irritants (18), and incident asthma among a young population (19-24 years old; 55,6% women). Overall, our results are consistent with previous reports in the professional setting, suggesting an association between low chronic exposure to irritants and asthma (17).

Our results do not support the hypothesis that irritant cleaning products are specifically associated to non-allergic asthma by contrast to some previous studies conducted in younger populations (11,19,26). In ECRHS, participants who use bleach to clean their homes were less likely to be atopic (26). In addition, in the EGEA cohort, daily use of bleach by women at home was associated with non-allergic current asthma(19). Although it has been hypothesized that the use of bleach could inactivate allergens (thus leading to a lower sensitization risk, among subjects with asthma), those with allergic asthma may follow allergens prevention measures and may be more prone using bleach to inactivate allergens. In addition, cleaning products available at retails have a very complex and diverse composition (27), including perfumes(28), considered as sensitizers (10) that could partly explain the association with allergic asthma. Finally, the underlying mechanism in irritant-induced asthma is unknown(6). Different pro-inflammatory mechanisms may be involved in asthma due to low-dose chronic exposure (2,10), including a role of oxidative stress, neutrophilic inflammation, repeated stimulation of local neural endings or the TRP receptor family. Chronic exposure to irritants could also cause damage to the lung epithelial barrier, which could lead to higher systemic exposure to airway allergens, as it was suggested in a study on formaldehyde exposure and mite allergen sensitization(29).

One of the strengths of our analysis is that our study benefited for the first time in the literature from data of a very large population (n>12 000) enriched in asthmatics, including one fourth women with current asthma, allowing for analyses on specific subpopulations to further investigate the association. Although we *a priori* hypothesized that the association would be stronger among those

without household help, we observed that associations were similar whatever the household help status. One possible explanation is that household helpers used the products mainly in the presence of the participants which is likely in our population of elderly women (mean age around 70, in 2011). Such passive exposure may not be negligible (27) and may vary according to the population and the time people spend at home. It might explain why no association had been reported in a recent study in adolescents (30) whereas we report an association in our elderly population. It is also possible that even with household help, there is still an active use of irritant cleaning products. The association between spray use and asthma has been suggested by several studies (4,3,7), and may explain in part observed associations of current asthma with irritants. However, in our study, the reported association between the weekly use of irritants and current asthma was independent of spray use. In addition, as expected, we reported an association slightly less pronounced between irritants and current asthma among asthmatics with refunded ICS (anti-inflammatory). Finally, associations remained significant in various sensitivity analyses suggesting the robustness of our findings.

Access to the exhaustive drug refund data and epidemiological standardized questionnaires for all E3N participants is another strength of the study. For the first time in the literature, we used such a database to evaluate the allergic status, by identifying reimbursement of treatment specifically delivered for allergic rhinitis, conjunctivitis or dermatitis. Studying allergic asthma as a specific phenotype or not (stratified analysis) led to the same conclusion. To evaluate the potential impact of misclassification errors in the allergic status assessment in our findings, we performed sensitivity analyses by varying the specificity of the allergic definition. The magnitude of associations increased with the number of refunds (higher specificity) and decreased when including nonspecific ATC codes (lower specificity), which is consistent with the previous recommendations on the importance to favor specificity over sensitivity in etiological research (31). When we evaluated the allergic status by questionnaire, based on the report of allergic rhinitis (32), i.e not considering conjunctivitis or dermatitis in the definition, significant associations were only observed for allergic asthma. We acknowledge that a method of reference, such as IgE levels or skin prick tests, both unavailable in E3N, would have been more appropriate to distinguish allergic to non-allergic asthma.

Our study also has limitations. The Asthma-E3N population is constituted of mostly educated older women which limits generalizability of the findings. Women included in the E3N cohort are contributing members of the MGEN health insurance plan, which covered mostly workers or their spouses from the state education field. Around 90% of the participants had at least a high school diploma, whereas only 18% of women aged more than 65 years old had this diploma level in 2010 in France (33). Studies in other age or socio-economic categories may be necessary to further investigate the association between domestic use of irritants and asthma. In addition, drug refunds data do not systematically reflect drug intake, nor the windows of exposure (15,23). Although over-the-counter (OTC) drugs could not be recorded, it is expected to have little impact on our results because such drugs are marketed only since 2008 in France (34), and because a study estimated that only 14% of French people with allergic rhinitis only uses OTC antihistamine drugs (35). In addition, assessing exposure to irritant cleaning product in epidemiological settings is not trivial. In our study, we considered cleaning products by unique components hypothesized to be irritants. But some of the ingredients of cleaning products may react with other chemicals such as chloramines (11,36), and mixing bleach with acids produces chlorine, a potent airway irritant (11,16). More objective methods to assess exposure to cleaning products may be helpful in epidemiologic studies to handle the diversity of the products used and potentially study not only groups of products, but their precise ingredients (37).

5. Conclusion

Domestic irritant cleaning product use was associated with an increased risk of current asthma in an elderly population. Associations were statistically significant with exposure as low as weekly exposure to one irritant and the strength of associations increased in a dose-dependent manner with both the frequency and the number of products used. Analyses making a distinction between allergic and non-allergic asthma, based on drug refunds for allergic rhinitis, dermatitis or conjunctivitis, showed associations in both asthma phenotypes. Further studies based on refined asthma phenotypes or endotypes are warranted to further investigate the underlying mechanisms in the association between irritant cleaning agents and asthma.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Figure 1. Flowchart for the selected population.

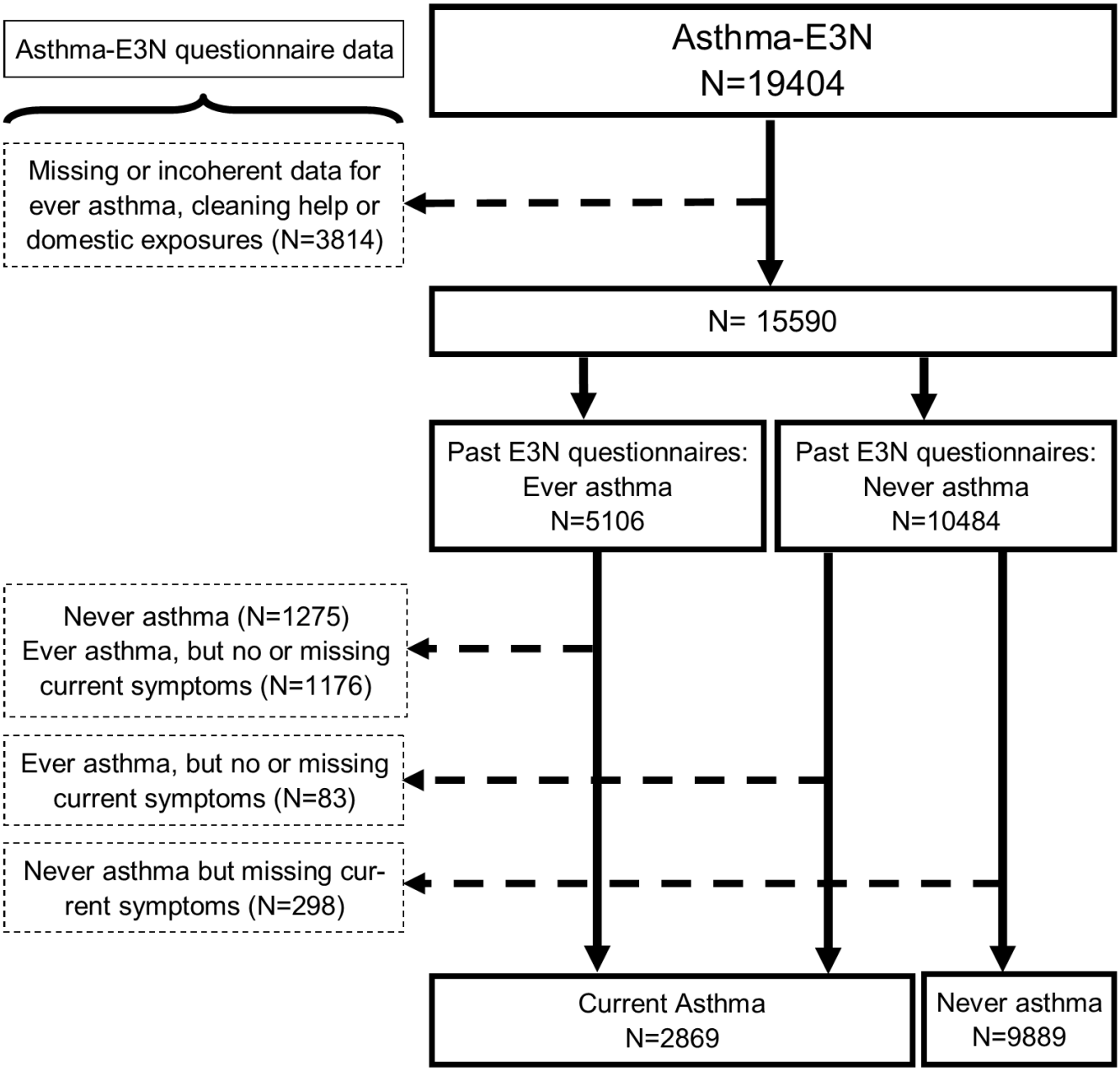


Table 1- Population characteristics according to current asthma status among 12758 women participating in the Asthma-E3N study.

	Never asthma	Current asthma	p-value[a]
N	9889	2869	
Age (years), mean ± s.d	69.7 ± 6.1	69.5 ± 5.9	0.69
BMI (Body Mass Index), n (%)	**9889**	**2869**	**<0.0001**
<20	1299 (13.1)	289 (10.1)	
[20-25[	5653 (57.2)	1421 (48.5)	
[25-30[	2348 (23.7)	816 (28.4)	
≥30	589 (6.0)	343 (12.0)	
Smoking status, n (%)	**9853**	**2851**	**<0.0001**
Never smoker	5406 (54.9)	1423 (50.0)	
Ex-smoker	4021 (40.8)	1307 (45.8)	
Current smoker	426 (4.3)	121 (4.2)	
Educational level, n (%)	**9513**	**2754**	0.1224
< high school diploma	1025 (10.8)	286 (10.4)	
High school to 2-level university diploma	4989 (52.4)	1396 (50.7)	
3-level or 4-level university diploma	1826 (19.2)	529 (19.2)	
>5-level university diploma	1673 (17.6)	543 (19.7)	
Household help, n (%)	**9889**	**2869**	
Yes	3794 (38.4)	1328 (46.3)	**<0.0001**
Weekly irritant[b] use, n (%)	**9550**	**2776**	
Yes	4364 (45.7)	1393 (50.2)	**<0.0001**
Weekly spray use, n (%)	**9644**	**2791**	
Yes	2140 (22.2)	726 (26.0)	**<0.0001**
Allergic rhinitis, current (questionnaire), n (%)	**8330**	**2260**	
Yes	1384 (16.6)	1317 (58.3)	**<0.0001**
Treatments for allergic diseases (refund database), 12 months, n (%)	**9889**	**2869**	
Yes	2967 (30.0)	1648 (57.4)	**<0.0001**
ICS[c] use (refund database), 12 months, n (%)	**9889**	**2869**	
Yes	459 (4.6)	1366 (47.6)	**<0.0001**

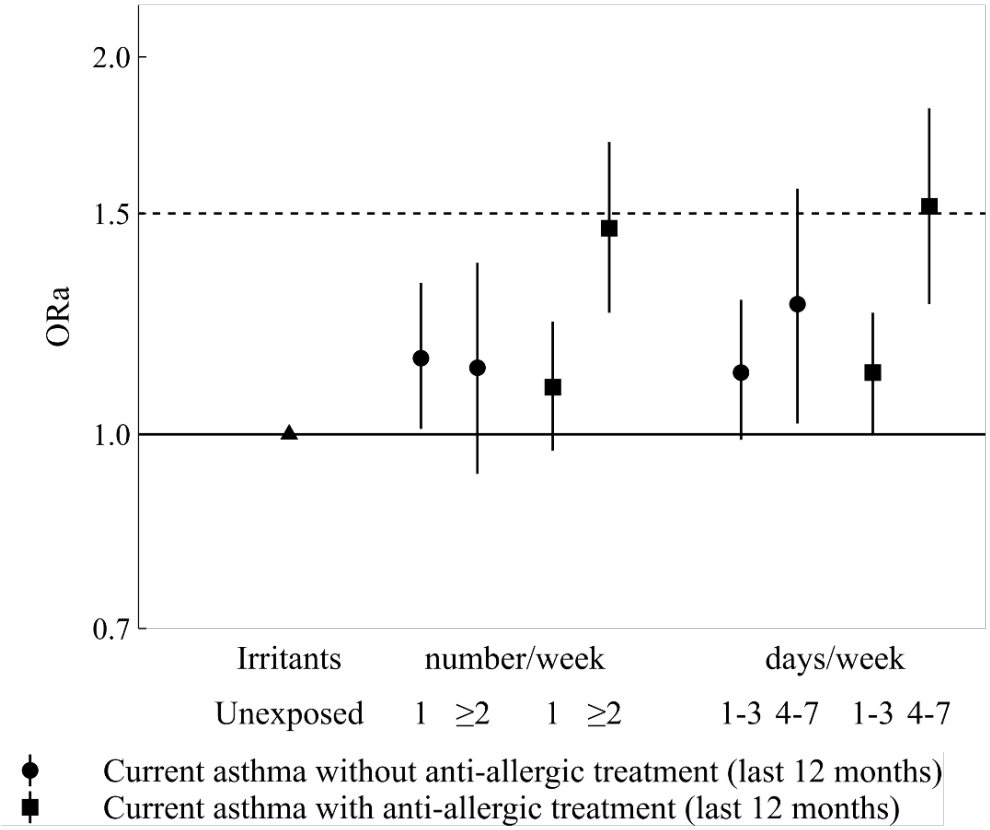
[a] *p-value of the chisq test for difference between never asthma and current asthma group*
[b] *domestic irritant cleaning products used, grouping 4 categories: ammonia, bleach, solvents and acids*
[c] *at least one ICS refunded in the last 12 months (ATC codes: R03BA, R03AK06-13, R03AL08-9)*

Table 2- Associations between domestic irritants use, in frequency or number per week, and current asthma

	n	Never asthma, % n=9550	Current asthma, % n=2776	Crude OR (IC à 95%)	n	Adjusted OR[a,*] (IC à 95%)
At least 1 irritant[b]/week						
No (reference)	6569	54.3	49.8	1	6551	1
Yes	5757	45.7	50.2	**1.20 [1.10-1.30]**	5723	**1.17 [1.07-1.27]**
Number of irritants[b] used / week						
1	4244	34.1	35.6	**1.14 [1.04-1.25]**	4223	**1.12 [1.02-1.23]**
2	1283	10.1	11.5	**1.25 [1.08-1.43]**	1274	**1.21 [1.05-1.39]**
≥3	230	1.5	3.1	**2.20 [1.67-2.89]**	226	**2.08 [1.57-2.75]**
p for trend				**<0.0001**		**<0.0001**
Frequency of irritants[b] used / week						
1-3d/week	4705	37.8	39.6	**1.14 [1.04-1.25]**	4679	**1.12 [1.02-1.23]**
4-7d/week	1052	7.9	10.6	**1.46 [1.26-1.69]**	1044	**1.41 [1.22-1.64]**
p for trend				**<0.0001**		**<0.0001**

[a] *adjusted for age, smoking status and BMI*
[b] *domestic irritant cleaning products used, grouping 4 categories: ammonia, bleach, solvents and acids*
** n=12,274; 52 excluded for missing smoking status data*

Figure 2. - Associations between weekly use of irritants at home, in frequency or number per week, and current asthma with or without allergic comorbidities.



ORa Odds Ratios adjusted for age, smoking status and BMI

Table 3
Adjusted associations between domestic irritants use and current asthma, stratified on allergic status

	In non-allergic individuals [a] (n=7829)		In allergic individuals [a] (n=4445)	
	n	OR[b] [95%CI] for asthma	n	OR[b] [95%CI] for asthma
At least 1 irritant[c]/week				
No (reference)	4272	1	2279	1
Yes	3557	**1.19 [1.05-1.35]**	2166	1.10 [0.97-1.24]
Number of irritants[c] used/week				
1	2655	**1.20 [1.05-1.37]**	1568	1.00 [0.87-1.15]
2	776	1.08 [0.87-1.34]	498	**1.24 [1.01-1.52]**
≥3	126	**1.67 [1.08-2.57]**	100	**2.27 [1.51-3.40]**
p for trend		**0.0127**		**0.0011**
Frequency of irritants[c] used/week				
1-3d/week	2937	**1.16 [1.02-1.32]**	1742	1.04 [0.91-1.18]
4-7d/week	620	**1.32 [1.06-1.65]**	424	**1.37 [1.11-1.70]**
p for trend		**0.0034**		**0.0172**

[a] *at least one treatment for allergic rhinitis, dermatitis or conjunctivitis refunded in the last 12 months*
[b] *adjusted for age, smoking status and BMI*
[c] *domestic irritant cleaning products used, grouping 4 categories: ammonia, bleach, solvents and acids*