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## Women using bleach for home cleaning are at increased risk of non-allergic asthma



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### ABSTRACT

**Background:** Bleach is widely used for household cleaning. Although it is recognized that occupational use of bleach may have adverse respiratory health effects, it is unknown whether common domestic use of bleach may be a risk factor for asthma.

**Aim:** To assess whether the domestic use of bleach for home cleaning is associated with asthma and other respiratory outcomes.

**Methods:** Questionnaire-based information on respiratory symptoms and cleaning habits and data from skin prick-tests, bronchial responsiveness challenge and white blood cells were analyzed in 607 women participating in the follow-up of the Epidemiological Study on the Genetics and Environment of Asthma (EGEA). Bleach use was evaluated in 3 categories (<1 day/week; 1–3 days/week; 4–7 days/week “frequent”).

**Results:** Overall, 37% of the women reported using bleach weekly. Women using bleach frequently (11%) were more likely to have current asthma as compared to non-users (adjusted Odds-Ratio (aOR) = 1.7; 95% Confidence Interval (95%CI) 1.0–3.0). Among women with asthma, frequent use of bleach was significantly associated with higher blood neutrophil cell counts. Bleach use was significantly associated with non-allergic asthma (aOR 3.3; 95%CI 1.5–7.1), and more particularly with non-allergic adult-onset asthma (aOR 4.9; 95%CI 2.0–11.6). Consistently, among women without allergic sensitization, significant positive associations were found between use of bleach and bronchial hyperresponsiveness, asthma like-symptoms and chronic cough. No association was observed for allergic asthma.

**Conclusions:** Frequent use of bleach for home-cleaning is associated with non-allergic adult-onset asthma, elevated neutrophil counts and lower-airway symptoms in women.

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### 1. Introduction

The need for more research on asthma risk factors that operate through non-allergic mechanisms has been highlighted, as it

appears that a significant proportion of adult asthma cases is not attributable to atopic sensitization [1,2]. In particular, there is a growing interest for the role of low to moderate exposure to irritants in the development of non-allergic asthma [3–6]. Recent occupational studies demonstrate an increased risk of asthma in cleaners and health-care workers exposed to cleaning products, especially in women [4,7–13]. It has been found that professional cleaners in private homes (vs. industrial cleaners) reported more frequent asthma and adverse respiratory symptoms [14,15]. Specific exposures incriminated in these studies include the use of bleach, ammonia, quaternary ammonium compounds and sprays [8,9,12].

Although cleaning products are widely used at home, few studies have investigated the effects of their nonprofessional use in the general population. Recent studies have shown that domestic use of cleaning sprays is associated with an increased risk of asthma and wheeze among adults [16–18] and children [19]. Household cleaning products include sensitizers but also airway irritants such as bleach. Bleach is one of the most common products used all around the world for home cleaning [9,20]. Bleach is a sodium hypochlorite solution that has been used for more than 200 years. It was initially used for bleaching clothes, then found to have disinfectant properties [21]. Bleach might have protective effects against allergic diseases through inactivation of indoor allergens and pathogens [20,22]. Conversely, bleach may have adverse respiratory effects, either through acute high-level inhalation of chlorine or chloramine gas due to inappropriate mixture of bleach with other agents, or possibly through exposures to low-level of chlorine-derived irritants [20,23]. To the best of our knowledge, no study has investigated whether common domestic use of bleach is associated with allergic and non-allergic asthma. One population-based study has shown that adults using bleach for home-cleaning were less likely to be sensitized to indoor and outdoor allergens, but more likely to have respiratory symptoms [20].

The purpose of the present study was to investigate the relationship between domestic use of bleach for cleaning and asthma and respiratory outcomes in women from the epidemiological study of genetics and environment of asthma (EGEA). Because bleach may have a protective effect on allergic sensitization, and bleach use has been found to be associated with irritant-induced (non-allergic) asthma in occupational setting, we considered separately allergic and non-allergic asthma. Then, to investigate the relationships between bleach use and respiratory symptoms and bronchial-hyperresponsiveness, we stratified the analysis on allergic status.

## 2. Material and methods

### 2.1. Study design and subjects

EGEA [24] is a case-control study combined with a family study of relatives of patients with asthma, with 2047 participants (7–70 years) recruited at baseline (asthma cases ( $n = 388$ ), first-degree relatives and spouses ( $n = 1244$ ), controls ( $n = 415$ )) [25]. In 2003–2007, participants were invited to a follow-up study (EGEA2,  $n = 1601$ ), involving a medical examination following a standardized protocol, and standardized questionnaires (derived from the European Community Respiratory Health Survey questionnaire, which was developed using questions of the British Medical Research Council, European Coal and Steel Community, and American Thoracic Society), to diagnose asthma and evaluate respiratory and allergic symptoms, treatments and environmental exposures, including the household use of cleaning products over the last 12 months [16]. A biobank including blood samples has been established (BB-0033-00043). White blood cells counts and

total serum IgE have been measured as described previously [26]. Lung function tests, including methacholine challenge, and skin prick tests (SPT) to 12 aeroallergens were performed. The study protocol was approved by local ethic committees (Necker Enfants-Malades Hospital, Paris) and written informed consent was obtained from all participants.

The present analysis included 607 women aged  $\geq 18$  years at EGEA2, after exclusion of women with asthma in remission ( $n = 45$ ), or with missing values for domestic tasks ( $n = 48$ ), respiratory symptoms ( $n = 5$ ) or SPT ( $n = 76$ ) (Fig. 1).

### 2.2. Methods

Participants were considered to have “ever asthma” if they were recruited as a case at EGEA1, or if they answered positively to one of the two questions: “have you ever had attacks of breathlessness at rest with wheezing?” or “have you ever had asthma attacks?” at EGEA1 or EGEA2 [27]. As proposed for the European Community Respiratory Health Survey (ECRHS) [28], subjects with “ever asthma” who, in addition, reported asthma attacks, asthma treatment and/or asthma-like symptoms (wheezing, nocturnal chest tightness, attack of breathlessness following activity, at rest or at night time) in the past 12 months at EGEA2, were considered to have “current asthma” [16]. Subjects with ever asthma but no current asthma at EGEA2 were excluded from the analysis (Fig. 1). The group of subjects with “never asthma” consisted of subjects who did not report asthma ever at EGEA1 and EGEA2. Adult-onset asthma was defined as an age at first asthma attack  $\geq 16$  years [16,28]. Atopy (SPT+) was defined by the presence of at least 1 positive SPT (mean wheal diameter  $\geq 3$  mm than the negative control) out of 12 aeroallergens [16]. Allergic and non-allergic asthma were defined as current asthma with and without atopy. Furthermore, allergic/inflammatory phenotypes have also been defined as previously described [26], taking into account: i) eosinophil counts, with a cut-off point of  $\geq 250$  eosinophils counts/ $\text{mm}^3$  and ii) neutrophil counts, with a cut-off point of  $>5000$  neutrophils counts/ $\text{mm}^3$ . An asthma symptom score was calculated, independently of asthma status, as the number of positive answers to 5 questions (wheeze with breathlessness, woken up with 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 12 months) [29]. Bronchial hyper-responsiveness (BHR) was defined as a decline in  $\text{FEV}_1$  of  $\geq 20\%$  of its post-dilution value for a methacholine cumulative dose  $\leq 1$  mg. Participants were classified as exposed to bleach ‘weekly’ (1–3 or 4–7 days/week) or non-exposed (never,  $<1$  day/week). Use of bleach 4–7 day/week was defined as ‘frequent’.

### 2.3. Statistical analysis

Associations between the frequency of bleach use and dichotomous outcomes including current asthma, BHR and respiratory symptoms were evaluated by logistic regression. Associations between the frequency of bleach use and 3-level outcomes (asthma status: allergic asthma and non-allergic asthma as compared to never-asthma and symptom score when considered as a categorical variable (0; 1;  $\geq 2$ )), were evaluated by multinomial regression models. When considering the 6-level symptom score, the association with use of bleach was evaluated by negative binomial regression model, to control for over-dispersion.

Sensitivity analyses were performed, considering different definitions for asthma phenotypes. We first used a more specific definition of asthma, where only women with positive responses to asthma questions and BHR were defined as “asthmatics” (women reporting asthma but without BHR were excluded from this

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