



Allergens and irritants in household cleaning products Clinical testing for triggers of asthma and allergies

KEYWORDS: Asthma, allergy, testing, cleaning, irritants, allergens.

ABSTRACT

Guidelines for asthma management recommend regular cleaning regimes for pest control and removal of allergens such as dust and pet dander from the indoor environment. However, many cleaning products on the market contain irritants and allergens that may aggravate symptoms in sensitive individuals particularly those with asthma and allergies. Epidemiological studies have identified a link between cleaning products and respiratory symptoms, however there are few clinical studies that assess the effect of specific ingredients in cleaning products. This paper will review the effect of cleaning products on individuals in a domestic environment through specific inhalation challenges. Furthermore, asthma intervention studies that involve cleaning regimes and the choice of cleaning products will be discussed. Innovation in green and eco-friendly formulations may not necessarily equate to a "human-friendly" formulation. More awareness and research is required in order to assess the impact of cleaning product formulations on an inhabitant's indoor air environment, and ultimately their respiratory health.

INTRODUCTION

Volatile Chemical Products (VCP) such as personal care products and cleaning agents, are emerging as the main contributor to urban organic emissions. Strikingly, VCP levels are estimated to be ~7 times higher in indoor environments when compared to outside ambient air (1). These VCPs can generate irritants and allergens in the indoor environment and exacerbate symptoms in sensitive individuals suffering from asthma and allergies. In a 2014 study in five European countries (n=1202), exposure to cleaning products was self-reported as an asthma trigger in 42% of patients at an average frequency occurrence of 8.2 weeks in the year.

The most common self-reported trigger was dust or dusting with 72% of participants reporting a reaction at some stage, and an average occurrence of 18.6 weeks in the year (2). The Guidelines for the Diagnosis and Management of Asthma coordinated by the National Heart, Lung, and Blood Institute (NHLBI) of the National Institutes of Health in the US advise a regular cleaning regime for effective pest control and reduced exposure to allergens (3). Regular cleaning to improve indoor air quality however will also increase the risk of exposure to certain chemicals used in cleaning products that may aggravate asthma and allergies. The avoidance of spray and other cleaners producing high levels of Volatile Organic Compounds (VOC) in particular is recommended in

the management of asthma (2). Occupational asthma as a result of exposure to cleaning products is now a global health concern following the publication of several high-impact epidemiological studies. The first study to identify professional cleaning as a high-risk occupation was the European Community Respiratory Health Survey (ECRHS-I), an international population-based cross-sectional study carried out in 1990-95 (4). The ECRHS-I study outlined a clear increased risk for the development of new onset asthma in cleaning workers. Several studies have since identified specific professional cleaning products associated with new-onset asthma including bleach, amine compounds, and Quaternary Ammonium Compounds (QAC) based products (5). Many of these professional cleaning products are now routinely used in the home. A follow up study to the ECRHS-I published in 2007 (ECRHS-II) went on to describe that using cleaning sprays at least weekly in the non-occupational setting was associated with increased asthma symptoms or medication use (6). These findings are the basis of major concern surrounding the use of cleaning products in the home and the development or aggravation of respiratory disorders. Many of the studies that have investigated the effects of cleaning products on health have done so in an occupational context, or through epidemiological surveys. Very few clinical testing studies have been conducted on the effects of direct exposure to cleaning products. Occupational asthma studies can be used as an informative model in risk assessment for development and aggravation of asthma in the home. This review will discuss the clinical testing that has been conducted to directly assess cleaning product use in a domestic setting and its effects on respiratory function.

CLINICAL CHALLENGE STUDIES OF IRRITANTS AND ALLERGENS IN CLEANING PRODUCTS

Cleaning products and their ingredients are capable of both causing new onset asthma, and exacerbating existing conditions. A longitudinal study from Zock *et al* as part of the ECRHS-II study specifically investigated the effects of exposure to cleaning products on non-professional cleaners in the home. This study demonstrated that non-professional use of household cleaning products in spray form was associated with new-onset asthma in adults (7). This study has some caveats as the asthma symptoms were associated with several types of sprays with different chemical components and did not identify specific causative agents. They speculate that the presence of sensitizers may have

played a role in the onset of asthma, however this was not thoroughly investigated. Asthma can be triggered by both a hypersensitivity to an allergen, or a non-specific bronchial effect due to exposure to irritants. Cleaners contain a wide variety of ingredients which may include respiratory irritants, sensitizers and allergens. While epidemiological surveys are vital in identifying exposure risks and disease, many of these studies do not specifically identify the causative agents. If formulation is to improve in order to reduce risk to consumers, more in-depth testing is required.

Vendepas *et al* carried out a retrospective study of Specific Inhalation Challenges (SIC) in workers with cleaning related asthma symptoms to identify specific mechanisms and causative agents. A SIC study assesses subjects breathing function following exposure to a specific chemical challenge. In this study, cleaning workers suspected of occupational asthma underwent an SIC with cleaning products used in the work place. Participants were exposed to products through a "realistic" approach that mimics conditions of exposure in the work place. Cleaning agents diluted in warm or cold water were brushed on cardboard or sprayed according to information collected through interviews and consultation. Workers were exposed for 1, 4, 10, 15, 30 and 60min time periods on the same day until FEV₁ fell 20% in a spirometry test, or 2 hrs accumulative time had passed. The spirometry test is an indicator of obstructive and restrictive lung disease. The FEV₁ is calculated as a ratio of the Forced Expiratory Volume in one second (FEV₁) and Forced Vital Capacity (FVC). A 20% or greater fall in FEV₁ when the participant was exposed to specific cleaning products was considered a positive SIC. This study reported that 39% of the participants exposed to the cleaning agents and/or disinfectants used at their workplace exhibited asthmatic symptoms (8). Importantly, this study provides evidence that there is a specific hyper-sensitivity mechanism as opposed to a non-specific mechanism due to exposure to irritants. This study also identified a possible sensitiser as QACs. Cleaning products containing QACs induced a positive FEV₁ in 59%(10) of the participants of the study.

A study carried out in Spain by Medina-Ramón *et al* assessed the short term effects of cleaning exposures on respiratory symptoms and FEV₁ measurements in female domestic cleaners with existing respiratory disorders (9). Spirometry tests were carried out daily over a two week period in 43 female domestic cleaners aged 31-66 years with a history of obstructive lung disease. Over the two-week period, associations were assessed between daily cleaning exposure, respiratory symptoms and FEV₁ measurements. A drop of 20% in FEV₁ was indicative of Bronchial Hyperresponsiveness (BHR), a non-specific restriction of the lung. Participants experienced worsening of respiratory symptoms on days on which they spent more time cleaning. More than 30% of the participants showed indications of occupational asthma according to the spirometry test. The study further suggests a connection between work related respiratory symptoms following exposure to certain cleaning products. Respiratory symptoms were predominantly associated with the use of diluted bleach, degreasing sprays and air refreshing sprays (9). Interestingly, in contrast to the study by Vendepas *et al*, this study concluded that occupational asthma in domestic cleaning jobs is probably irritant-induced or irritant-aggravated as participants were measured for skin reactions to a number of allergens (atopic reactions) and there was no association between atopic reactions and BHR symptoms, furthermore only 2 of the 11 participants with indications of occupational asthma were atopic.

In a more domestic cleaning focussed study, Bernstein *et al* assessed the health effects of cleaning activities prospectively in women with and without asthma who regularly clean their home (10). In this study Bernstein *et al* carried out a parallel-group longitudinal pilot study in 25 asthmatic and 19 non-asthmatic women. This study unsurprisingly showed an increase in lower respiratory tract symptoms in asthmatic women during cleaning compared to non-asthmatic women. However, the authors came to this conclusion based on reporting of symptoms. Spirometry testing of lung function did not indicate any significant differences between participating groups. The authors suggest that there is a known discrepancy between symptoms and objective changes in lung function that has been observed in other studies.

These studies indicate that exposure to cleaning products in a domestic setting, either in a professional or domestic capacity is a health risk through specific hypersensitivity or irritant-aggravation causing respiratory symptoms of restrictive lung function or asthma. Medina-Ramón *et al* proposed an association between atopic reactions to common allergens unrelated to cleaning products, with BHR symptoms following exposure to cleaning products. Cross-sensitivity can be built into studies to identify atopic patients, however it does not rule out the fact that participants may be sensitised to specific cleaning product components and does not exclude hypersensitivity. Vendepas *et al* exposed study participants to cleaning agents that were identified as possible sensitisers demonstrating hypersensitivity in 59% of participants. The study from Vendepas *et al* although not without flaws, is stronger in its design and conclusions that hyper-sensitivity mechanism is associated with occupational asthma due to exposure to cleaning products. Vendepas *et al* were able to identify specific compounds and potentially sensitising agents. The studies discussed are limited and do not follow up with an assessment of individual components of cleaning products to confirm hypersensitivity. It still remains to be seen if new-onset asthma as a result of cleaning product exposure is predominantly irritant or hypersensitivity reaction driven. Current evidence would suggest that both mechanisms are involved. However it is clear that both mechanisms play a role in aggravating pre-existing conditions. More in-depth studies are required to identify potential sensitising compounds and allergens that may be currently used in cleaning formulations in order to reduce the risk to the user.

CLEANING PRODUCTS AND INDOOR AIR QUALITY

A recent high-impact study assessed the contribution of household and industrial products such as pesticides, coatings and cleaning agents to VOC in the environment. The contribution from household and industrial products refined from petroleum was equivalent to exhaust from vehicles measured in roadside air in Los Angeles, USA (1). As people spend increasing amounts of time indoors, consumer use of products in the home is a primary source of human exposure to VOC and toxic chemicals (11). Guidelines for the diagnosis and management of asthma from a working group of the NHBLI in the United States includes advice on the management of the home environment and improvement of indoor air quality (3). The report recommends the use of cleaning products and a regular cleaning regime in multifaceted approaches to household management of asthma and allergies in the home. A recent literature review of intervention studies from 1980 to present assessed the impact of different multi-faceted approaches to allergen exposure control in the home (12).

This study concluded that there is an improvement in quality of life and a reduction in exacerbations in patients when exposure to indoor allergens is controlled. Nine of the studies in this review provided cleaning products or professional cleaning services, as the cost of cleaning products can be prohibitive in studies carried out in under-privileged urban areas. The details of the cleaning products supplied in these studies is only given in three cases. Parker *et al* provided participants with gentle unscented cleaners, while the study carried out by Shani *et al* describe providing non-toxic cleaning products (13,14). Sweet *et al* provided a "green cleaning" kit consisting of vinegar, baking soda and an oil-based soap cleaner. The multi-faceted home-based intervention program, which included a regular cleaning regime, decreased triggers and improved asthma outcomes in children with a resultant improvement in caregivers' quality of life. Interestingly, this study reported that the use of fragrance free cleaning products increased by 157% in a follow up with caregivers (15).

In a recent intervention study that included a cleaning regime with "green" cleaning products, participant families were asked "If your child's asthma has improved, what do you think was the cause?" Of the 28 participants the top answers were asthma trigger control (42.9%), housing (35.7%), healthy and green cleaning products (28.6%) and medication management (28.6%) (16).

A regular cleaning regime is an important component of a multi-faceted approach to allergen control and asthma management in the home. This is confounded by the exposure to potentially toxic products, VOC emissions and allergenic compounds. Green and "eco-friendly" formulations are not necessarily more "human-friendly" and more detail on the cleaning products used in current and future intervention program studies is required to assess the effect of new formulations (17). This will inform innovation in the formulation of safer products for the "allergy aware" consumer. Challenge studies that identify specific allergenic components of cleaning products are lacking. As the cases of asthma and allergic diseases continues to rise (18), it is becoming increasingly important to identify low toxic alternatives to identified irritants and allergens including and beyond QAC and bleach (chlorine). The United States Environmental Protection Agency (EPA) currently runs a "safer choice" scheme for identification and labelling of healthier options in cleaning products. Several similar global certification schemes are in operation that assess the chemical profile of cleaning agents and their possible effects on sensitive individuals. Other approaches currently being developed include tiered risk assessment of exposure using multiple data sources and exposure modelling (19,20). These initiatives encourage innovation in formulation and awareness of consumer needs, leading to healthier choices and improvements in indoor air quality. This will have a positive effect on sensitive individuals, in particular those suffering from asthma and allergies. It may also help to stem the trend in increasing cases of respiratory diseases in all households through improvements in indoor air quality in homes.

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