

# Use of Disinfectants and Cleaning Products Associated with Respiratory Disease: A Scoping Review

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## SUMMARY

**Introduction:** there is extensive evidence on the harmful respiratory effects of exposure to disinfectants and cleaning products. **Methodology:** an exploratory systematic review was carried out in five databases: LILACS, PubMed, MEDLINE and BIREME. Twenty articles from 2013 to 2024 were selected for the present review. **Results:** chemical compounds present in some disinfectants and cleaning products such as Polyhexamethylene guanidine (PHMG) and Chloromethylisothiazolinone/Methylisothiazolinone (CMIT/MIT) influence the development of Humidifier Respiratory Distress Syndrome (HDRS) and increased incidence of asthma and Chronic Obstructive Pulmonary Disease (COPD) in adults. **Conclusions:** There is a relationship between exposure to chemical compounds in certain disinfectants and lung health impairment. It is imperative to increase the general population's awareness of the effects of these substances will lead to improved self-care in those who are in daily contact with these elements.

**Keywords:** Respiratory Tract Diseases; Disinfectants; Asthma; Chronic Obstructive Pulmonary Disease.

## INTRODUCTION

Asepsis measures have transformed the history of mankind forever. Over the years, the way in which human habitations and food are disinfected has evolved in parallel with the development of industrial chemistry and its technification. There is ample evidence on the consequences of the use of antiseptics and disinfectants on human health, as well as the impact of their decomposition products in the water we use for our daily needs and in the cleaning of hospital institutions [1]. On the other hand, interference in the efficacy and functioning of medications has been observed in patients with chronic diseases, and cases of metabolic alterations have even been documented [2–5].

The arrival of the COVID-19 pandemic represented a change in asepsis measures not only in healthcare settings, but even more so in domestic environments, which leads to questioning the impact on health of

exposure to new products in addition to considering the harmful effects that the disposal of these can produce on other living beings [4].

It has been documented that the effects of frequent use of cleaning products are largely conditioned by the type of exposure, its frequency and cumulative exposure to them [6, 7]. Therefore, it is important to distinguish between frequent and persistent contact in people depending on their work environment, compared to those exposed to these compounds in domestic environments [7]. In fact, significant harmful effects have been evidenced after relatively short exposures, even with minimal cumulative exposure, especially in children under 5 years, even after years of cessation of the use of these cleaning products [8].

Likewise, the effects produced by contaminants on human beings have called the attention of the scientific community to explore the consequences of their contact with other species that may be exposed, demonstrating the affection produced by the derivatives of the

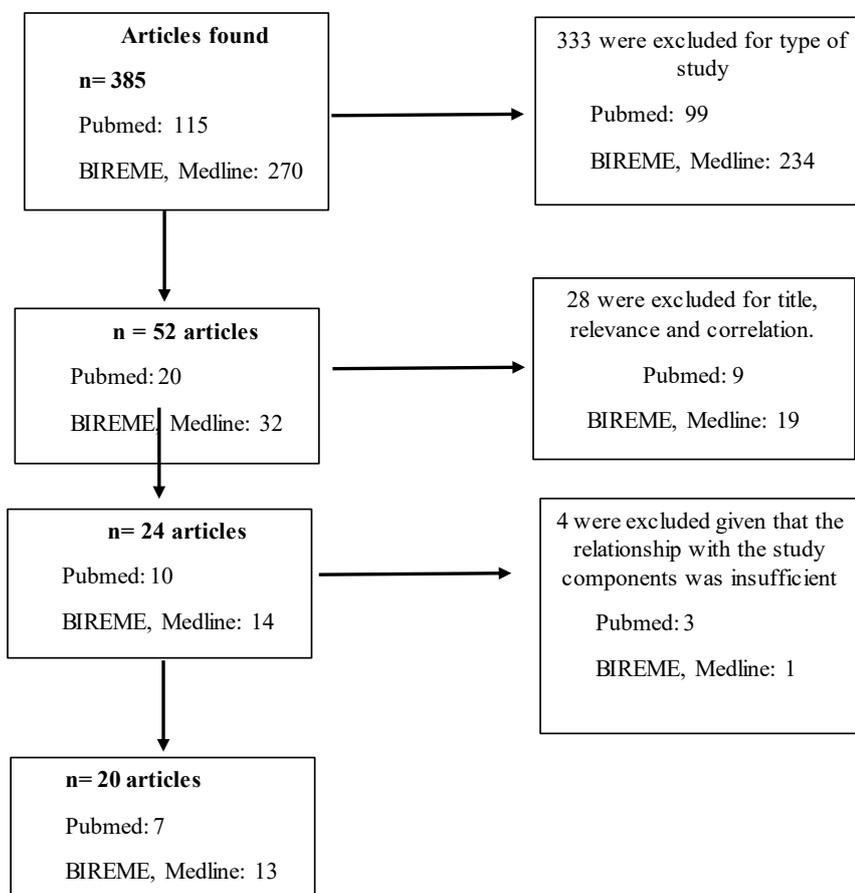
components used in the cleaning products that remain suspended in the air or are expelled in different water sources and that despite the treatment of these persist as residues and can cause harmful effects of which their scope is unknown [9, 10]. In this sense, harmful effects have also been documented that can affect animal species that are in contact with these water sources and that present pathologies that diminish their quality of life and the prolongation of their existence [11].

This investigation was carried out with the objective of analyzing the available evidence on the respiratory consequences derived from the persistent use of disinfectants and antiseptics in the general population.

## METHODOLOGY

A scoping review was conducted. The following databases were used for the search: LILACS, MEDLINE, PubMed and BIREME, using the following MeSH terms: "Disinfectants [MeSH]" AND "Lung diseases (MeSH)" in combination with DeCS terms: "Disinfectants" AND "respiratory diseases". In addition, databases such as Embase and Scopus were consulted, and free-reading documents that can be found in Google Scholar, reports from the Panamerican Health Organization (PAHO) and the World Health Organization (WHO) were reviewed to complement with gray literature through snowball method to expand the results for the research.

Figure 1. PRISMA diagram of the selection of articles included in the review.



Source: own elaboration based on the results of the research.

Literature published from January 2013 to February 2024 was collected, retrieving a total of 385 documents, including cohort studies, cross-sectional analyses, case reports, epidemiological investigations, case-control studies, systematic reviews, scoping reviews and narrative reviews.

A filtering of the literature found was carried out taking as inclusion criteria observational studies, randomized clinical studies, systematic reviews and literature reviews that included participants of all ages,

studies conducted with human subjects, thus systematic reviews that depicted effects described in animals were also taken into account, with focus on the respiratory effects of exposure to disinfectants or cleaning products, in English and Spanish, that evaluated outcomes such as asthma and COPD, especially if related with the exposure to Olyhexamethylene Guanidine (PHMG) and Chloromethylisothiazolinone/Methylisothiazolinone (CMIT/MIT), and an special focus in studies performed in the context of the COVID-19 pandemic. Articles

that did not show a direct relationship between the compounds and the development of respiratory diseases such as asthma, Chronic Obstructive Pulmonary Disease (COPD) and Humidifier Respiratory Distress Syndrome (HDRS), effects on other body systems (cardiovascular, gastrointestinal, skin), not published on English or Spanish, not available from open access or access throughout institution. Subsequently, duplicate, non-relevant articles were eliminated. To ensure the reliability of the data extracted, the articles were evaluated and selected according to the quality criteria of the Joanna Briggs Institute [12] and classified according to their methodological rigor and relevance to the research.

A total of 334 articles were obtained from which 52 articles were extracted. A second filtering process was carried out to classify the evidence in two groups: relationship between disinfectants or cleaning products and development of lung lesions or respiratory diseases. Twenty articles were used for the present review. The first two authors classified and read the articles found and a third author resolved discrepancies in the information retrieved. The article selection process is schematized in Figure 1.

The PRISMA statement [13] was implemented to synthesize the results found in exploratory systematic

reviews (PRISMA-ScR), PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) and subsequently the steps proposed by Arksey and O'Malley [14] and revised by Levac were followed [15], which are based on a) identification of the research question; b) identification of relevant studies; c) selection of studies; d) data extraction; e) synthesis and reporting of results. The research question was answered: What are the respiratory health consequences of prolonged exposure to disinfectants, antiseptics or cleaning products in the general population?

## RESULTS

A total of 20 articles were included in this review. Of which 5 were narrative reviews, 5 systematic reviews, 2 cohort studies, 2 randomized clinical trials, 2 cross-sectional studies, 1 epidemiological investigation, 1 clinical description and 2 case reports. Of the included studies, 60% were conducted in South Korea, 30% in China, and the remaining 10% in the United States. The main characteristics of the studies included are described in Table 1.

Table 1. Characteristics of the studies included in the exploratory review

Title	Year	Authors	Summary	Ref
Exposures to humidifier disinfectant and various health conditions in Korean based on personal exposure assessment data from compensation claimants.	2023	Hong, M, et al	The use of disinfectants is associated with bronchitis, allergic rhinitis and asthma in children. Toxic hepatitis and preterm delivery in pregnant women.	[16]
Health effects associated with the use of humidifying disinfectants: a systematic review for exploration.	2022	Song, J, et al	The pulmonary effects of disinfectants to humidifiers are dose responsive. Compounds such as CMIT/MIT can cause of illness.	[17]
Characteristics of a new respiratory syndrome associated with the use of a disinfectant humidifier: disinfectant humidifier-related respiratory syndrome (HDRS).	2020	Leem, J, et al	Description of humidifier-associated respiratory syndrome as responsible for lung disease associated with the use of fragrances and humidification systems.	[18]
Association of occupational exposure to disinfectants with incidence of chronic obstructive pulmonary disease among U.S. nurses.	2019	Dumas, O, et al	Healthcare workers in contact with cleaning products have a higher risk factor for developing COPD.	[19]
Association between occupational exposure to disinfectants and asthma in young adults working in cleaning or health care services: results of a cross-sectional analysis in Germany.	2019	Weinmann, T, et al	Major risk factor in cleaning-related professions or occupations for contracting occupational asthma.	[20]

Occupation and task as risk factors for asthma related outcomes among healthcare workers in New York City..	2019	Caridi, M, et al	Higher incidence of occupational asthma in surgical-related professions due to significant exposure to cleaning products.	[21]
Two cases of toxic lung injury associated with chloromethylisothiazolinone and methylisothiazolinone.	2018	Lee, E, et al	Description of a case of twin girls with respiratory syndrome associated with humidifier disinfectants, radiological follow-up until the age of 5.	[22]
Humidifier disinfectants are a cause of lung injury among adults in South Korea: a community-based case-control study.	2016	Park, J-H, et al	Description of the main findings in radiography that can confirm HDRS in suspected patients.	[23]
Work-related respiratory symptoms among healthcare facility cleaners: a cross-sectional study.	2014	Lipinska-Ojrzanowska, A, et al	There is a documented correlation between respiratory distress symptoms and bronchial irritation among cleaning staff.	[24]
A cluster of lung injury cases associated with the use of household humidifiers: an epidemiological investigation.	2014	Kim, H, et al	Radiographic timeline of respiratory illness related to humidifier disinfectants.	[25]
A cluster of lung injuries associated with the use of household humidifiers: clinical, radiological, and pathological description of a new syndrome.	2014	Hong, S, et al	Clinical and radiological description of HDRS.	[8]
Humidifier Disinfectant-associated Children's Interstitial Lung Disease	2014	Kim, K, et al	Clinical description of respiratory syndrome associated with humidifier disinfectants.	[26]
Inhalation toxicity from humidifier disinfectants as a risk factor for infant interstitial lung disease in Korea: a case-control study.	2013	Yang, H, et al	Pulmonary repercussions of infant exposure to humidifier disinfectant components.	[27]
Frequency, intensity, and duration of exposure: what we know about work-related asthma risks for healthcare workers due to cleaning and disinfection.	2023	Wilson, A, et al	Relationship between the frequency, intensity, and concentration of exposure to cleaning products and the incidence of chronic respiratory diseases.	[28]
Review of health risks from inhalation of chloromethylisothiazolinone (CMIT) and methylisothiazolinone (MIT) used as disinfectants in household humidifiers.	2022	Kim, J, et al	New pathological link found between the use of CMIT/MIT as components in humidifier disinfectants.	[11]
A general overview of health risks and occupational injuries and diseases attributed to cleaning agents in Sweden.	2022	Kathare, M, et al	Relationship between the incidence of chronic respiratory diseases and occupational cleaning tasks.	[7]
Are healthcare workers at a higher risk of developing obstructive respiratory diseases due to cleaning and disinfection agents? A systematic review and meta-analysis.	2021	Starke, K, et al	There is an increased risk of contracting obstructive lung disease among healthcare workers exposed to disinfectants and cleaning products.	[6]

Source: own elaboration based on the results of the review

The studies reviewed in this investigation focused mainly on the adverse effects of the components of humidifier disinfectants used both in homes and health institutions, which were associated with pulmonary

diseases in pregnant women, children and young adults [11, 25, 27]. HDRS was observed to represent the leading cause of lung disease, with an incidence of 47.3 (95% CI 6.1 - 369.7 in 2014) and 116.1 (95%

CI 6.5 - 206.3 in 2016) [23]. Despite the existence of policies prohibiting the use of harmful components [17, 18, 22] and occupational measures aimed at mitigating the toxic effects of cleaning product components [17, 19–23].

In addition, a relationship was found between cleaning products used both in homes and in occupational work of health personnel and the development of respiratory symptoms, de novo asthma and asthma exacerbation in countries such as China, Switzerland and the United States [7, 19, 24]. The characteristics of the articles used in this review are summarized in Table 1.

### Humidifier disinfectants and its relationship with HDRS

Humidifier disinfectants are widely used in South Korea to prevent bacterial growth in the water tanks, the occurrence of respiratory symptoms of unknown etiology has been suggested, with a challenging therapeutic response to corticosteroids and bronchodilators, starting in 2011 [8, 25–27].

At a hospital in South Korea, an outbreak of respiratory symptoms was reported in 30 patients, including pregnant women, that were neither associated with an infectious agent nor attributed to autoimmune pathology [23, 25]. During their hospitalization, radiological and tomographic imaging was performed, revealing ground-glass opacities in all patients. In these patients a common factor was revealed: the use of humidifier disinfectants containing PHMG as the main ingredient [24].

It has been evidenced in the literature that humidifier disinfectant components contain not only PHMG, but (CMIT/MIT) [11, 17], compounds that are related to HDRS.

In addition, the incidence of HDRS has been shown to have a positive correlation with the estimated exposure concentration to the compound and the distance at which the person has contact with these compounds [17]. This generates a wide diversity of pathologies ranging from otorhinolaryngological disease to neoplasms of pulmonary origin [16]. Case reports have even been described of exposure to these compounds for only months and the presence of pulmonary pathology in twin girls of 6 months of age, with pathological radiological findings that persisted after 5 years of presenting symptoms and the subsequent suspension of exposure to the compounds [22].

Other effects that have been described at the pulmonary level, described as non-HDRS diseases, are idiopathic interstitial pneumonia, bronchitis, allergic rhinitis and asthma. Extrapulmonary cases of toxic hepatitis, ocular irritation and increased development of COPD have been reported in patients not exposed to tobacco smoke or any other additional predisposing factor [8, 22, 23].

Currently, the mechanism of action of these components for the development of pulmonary disease is unknown; however, it is presumed that its etiology may be due to reactive oxygen species that cause inflammation, which can lead to cell death and genomic alterations [16].

### Cleaning products and development of asthma and COPD

Currently, disinfectants used in the health care field contain multiple chemical compounds to ensure the cleaning and disinfecting action of fixed areas and different medical devices [19]. There is sufficient evidence that suggests the relationship between exposure to household and occupational cleaning products and the development of chronic lung diseases such as asthma and COPD [6, 16, 17, 19–21, 24, 26, 28].

The cleaning products most found in studies include formaldehyde, glutaraldehyde, sodium hypochlorite, hydrogen peroxide, alcohol, quaternary ammonium compounds and enzymatic cleaners [20]. A significant dose-dependent association has been observed between the use of any disinfectant and the frequency with which these products are used, with the development of the pathologies [19, 21, 28].

In addition, several variables that could be related to the development of pulmonary diseases were evaluated, such as active use or history of tobacco use, occupational exposure within health care institutions, and whether the participants had a previous diagnosis of asthma. No statistically significant association was found between tobacco exposure and the development of asthma or COPD compared with exposure to other products for the same outcome. However, a positive association was found between work tasks performed within health care institutions and the development or exacerbation of the pulmonary pathologies [19].

Analysis of the literature revealed that cleaning personnel in health care institutions face a significantly higher risk of developing COPD and asthma due to their greater exposure and frequency of contact with chemical components. Similarly, health personnel who work in surgical rooms and perform cleaning or disinfection tasks, both in fixed areas and on medical equipment, such as operating room nurses and surgical instrument technicians, show a higher incidence of pathologies such as asthma, COPD and its exacerbations. On the contrary, administrative activities, hospital care and outpatients, despite involving contact with chemical components of cleaning products, show a lower association with the development or exacerbation of these diseases [19–21, 28, 29]. A summary of the most relevant components of disinfectants and cleaning products related to lung diseases is presented in Table 2.

Table 2. Most relevant components of disinfectants and cleaning products related to lung disease

Compound	Respiratory disease associated	Non respiratory effects
PHMG CMIT/MIT	Lung disease associated with disinfectants Pulmonary fibrosis COPD Asthma Upper and lower respiratory tract diseases Allergic asthma and rhinitis	Psychiatric effects Toxic hepatitis Eye irritation Premature birth
Glutaraldehyde Peracetic Acid Chloramines Quaternary Ammonium	Occupational asthma COPD	Eye irritation Contact dermatitis
Sodium Hypochlorite Hydrogen Peroxide	COPD	Eye irritation Contact dermatitis

Source: Own elaboration based on references [6–8, 11].

## DISCUSSION

Furthermore, most of the studies reviewed have focused on the clinical and radiological manifestations observed in patients during their consultation in emergency departments, which suggests the relationship these products may have as one of the main causes of pulmonary disease. However, so far, no conclusive evidence has been found to establish a direct relationship between the distance at which contact with these substances occurs, nor the duration or cumulative concentration of exposure, and the development of respiratory diseases. These findings underscore the need for future research that delves deeper into the underlying mechanisms and risk factors associated with the use of disinfectants in humidifiers, with the goal of developing more effective prevention strategies [4, 10].

One of the studies mentions a direct relationship between the exposure to Humidifier Disinfectants and the development of lung injury [23], nonetheless, the conclusion drawn by this study must be taken with caution, though it has high ICs and ORs that may be distorted by the small sample size. Yet, the inclusion of this study is considered important as it can provide a theoretical and empirical foundation for a much larger experimental design to mitigate the limitations of this one.

In conducting this scoping review a wide array of study types was included, ranging from observational studies and systematic reviews to case reports. This inherent heterogeneity can pose challenges to the validity and quality of the results. To mitigate this effect, a comprehensive strategy for categorizing the included studies based on their design, quality, and relevance was performed. A subgroup analysis to separately evaluate the outcomes of different study types allowed for a more nuanced interpretation of the

data. Additionally, using robust criteria for assessing the quality of each study type helped to ensure that only high-quality evidence was given significant weight in the analysis.

Despite these measures, several limitations may arise from this approach. Firstly, the variability in study design and quality can lead to inconsistent findings that complicate the synthesis of results. Secondly, case reports and narrative reviews, though informative, often lack the rigorous methodology of experimental studies, potentially introducing biases. Finally, the inclusion of diverse study types may limit the ability to draw definitive conclusions, necessitating cautious interpretation of the findings. By acknowledging and addressing these limitations, we can enhance the robustness and reliability of our scoping review.

Since 2011, the sale of humidifier disinfectants containing PHMGs among their components was banned in South Korea. However, cases of respiratory diseases associated with the use of cleaning products persist in this country despite the measures adopted. It is relevant to mention that the incidence of cases has decreased and that the evidence that has been collected so far comes from retrospective studies. In the literature consulted, no recent cases of HDRS were documented. However, there is also limited availability of the effects of these compounds for the development of mild pulmonary alterations [16–18].

In addition, the factors that may be associated with mortality in patients who develop HDRS are not yet known in depth, since no relationship was found between parenchymal involvement at the radiological level on admission to the emergency department and the incidence of complications and fatal outcomes in patients who presented the syndrome [16, 17].

Regarding the pathogenesis of respiratory disease associated with humidifier disinfectants, there is information about the mechanism of action, such as

inhibition of sulfhydryl group (SH) enzyme activity and other proteins leading to cell death by CMIT/MIT compounds and inhibition of B-lactamase and destruction of cell structure by PHMG [16]. The exposition to these substances has been related to fibroinflammatory processes in bronchioles and pulmonary parenchyma that led to bronchiolitis obliterans [30]. Vaporized particles of the substance used in cleaning products are extremely small and can present radiological findings such as subpleural sparring and diffuse alveolar damage [31]. However, there is still not a complete understanding of the relationship of the chemical compounds and the organic molecular reactions that lead to the development of the disease, so therapeutic strategies in these cases are limited.

On the other hand, regarding the cleaning products currently used, there is growing evidence about the pathogenesis of the compounds and the effects they have at the respiratory level, yet it is still very limited [5, 32]. It has been suggested that lung damage produces a severe inflammatory reaction by irritation leading to tissue destruction, which is not only dependent on concentration but also the sensitivity of the cells to produce this damage is proportional to exposure [33]. Some studies have suggested that exposition to these substances could cause an activation of immune system that would facilitate allergic sensitization by compromising the function of epithelial barriers [34]. Chronical inflammation in low degree could even lead to a destruction in the pulmonary parenchyma that could mimic and obstructive disease like COPD [35].

The chemical compounds found in household cleaning products and the cleaning and disinfection of fixed surfaces in places such as hospitals, orthodontic centers and medical equipment surfaces that are most found are: Formaldehyde, Glutaraldehyde, Sodium Hypochlorite, Hydrogen Peroxide, alcohol, quaternary ammonium compounds and enzymatic cleaners [19]. This opens the door to a discussion of replacement of current cleaning agents with less toxic alternatives, with the same efficacy and effectiveness of the current ones, but without the consequences that have a negative impact on both human and environmental health.

## CONCLUSION

Research reveals an association between exposure to certain disinfectants and lung health. It is crucial that governments prioritize measures to reduce the presence of these compounds in everyday products. In addition, increasing public awareness of their effects can improve self-care, especially among those with ongoing exposure. These actions are essential to mitigate the negative impact on respiratory health and promote safer environments.

The risk of bias and the heterogeneity that emerges from the article challenges the generalization of conclusions observed in this review. However, they

provide theoretical support to continue deepening and increasing the knowledge of the natural history of the disease as well as the harmful effects that products so common in household use can have, compromising people's quality of life.

Although occupational safety policies exist, none of the articles reviewed document the adherence of professionals and workers exposed to chemicals to processes and elements designed to minimize these effects on their health. Likewise, adherence to institutional policies designed to mitigate the harmful effects of cleaning components on workers' health is not reported.

## AUTHORSHIP CONTRIBUTION

The conceptualization and planning of the research was carried out by all the authors. Data collection, processing, and analysis were performed by the first 3 authors. The writing, organization, and approval of the final manuscript were carried out by all authors.

## DECLARATION

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None.

## CONFLICT OF INTEREST

None.

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