

Risks to Asthma Posed by Indoor Health Care Environments



A Guide to Identifying
and Reducing
Problematic Exposures



Without Harm



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EXECUTIVE SUMMARY

Information garnered from contemporary literature plainly indicates that patients, staff and visitors to hospitals and clinics are all at some risk of experiencing an asthma attack. In light of the fact that people tend to think of hospitals and clinics as places of sanctuary from suffering and illness, it is astonishing to consider that spending time in a health care facility exposes individuals to health risks. An accumulation of evidence supports the concern that some substances typically utilized or found in health care facilities can be asthmagens (agents that cause asthma *de novo*) or triggers of asthma. The good news is that steps can readily be taken to mitigate risk due to these harmful exposures. This guide focuses on eleven key agents of concern with respect to their properties as potential risk factors for asthma; we then take an extensive look at alternative practices and products that can decrease potential harm.

This guide has been written for a widespread audience interested in the indoor air quality of health care facilities, specifically as related to asthma. It contains both rigorously researched information about hazard, and practical tools and resources that will promote effective implementation of safer alternatives. Information within this manual will be useful to health care providers, facility administrators, industrial hygienists and others responsible for environmental controls, in addition to the public health community. Outside of the immediate health care sector, individuals, advocates, or coalitions following concerns within health care environments will also find relevant details about commonly encountered agents within facilities and what can be done to reduce or eliminate these exposures.

The prevalence of asthma in children and adolescents has risen by a staggering 25-75% per decade since 1960. While the prevalence of asthma in adults is unclear,



“Health care facilities should set examples for others by demonstrating practices that are safe for those who spend time for them and sustainable for the environment-at-large.”

asthma induced or significantly exacerbated by work exposures has emerged as the most commonly reported occupational lung condition, and it is estimated that 10-23% of new adult onset asthma in this country is due to occupational exposures. Awareness of these statistics should propel us into action; it is time to ask ourselves how the indoor environment created by individual facilities is contributing to adverse health outcomes.

Ironically, many products that are used in hospitals to keep patients, visitors, and personnel safe from pathogens represent some of the very same products that have some potential to cause or exacerbate asthma in susceptible individuals. We must reconsider the safety of certain practices that have long been believed to generate an established standard of care. Our creativity and commitment are both necessary for the maintenance of high standards as we investigate an array of safer options.

Fortunately, an abundance of information is now available to decision-makers in health care that can facilitate change for an improved indoor environment, and hence, less risk relative to asthma. Although the substances we refer to in this paper are specific to asthma, we should bear in mind that these same materials may pose other germane health concerns. Discussion of these additional risks is beyond the scope of this guide, but such information is widely available.

This document investigates the state of the evidence of chemical and biologic agents commonly encountered in health care facilities that pose a risk of asthma to people who spend time in them, including patients, staff, and visitors. We systematically review databases from three leading resources:

- The Association of Occupational and Environmental Clinics (AOEC)
- The Collaborative on Health and the Environment (CHE)
- The Institute of Medicine (IOM)

Together, these three sources—supplemented with information from individual journal articles and other reviews of the literature—provide a comprehensive description of the current understanding of the state of the evidence linking asthma to

substances found in health care facilities. Each database is unique in its investigations and conclusions. The **AOEC** lists occupational agents that have been shown to cause asthma *de novo*, in people previously free of the disease. The AOEC list does not include information about substances' tendency to cause asthma attacks in people already diagnosed with the disease. It includes chemicals, biologic agents, and physical hazards found in workplace environments, including hospitals. The **CHE** draws from three major textbooks of environmental medicine and toxicology, in addition to literature reviews, to determine strength of the evidence associating asthma with chemical and biologic agents (though no distinction is made between propensity to cause versus trigger asthma). Their research cuts across workplaces, indoor air, homes, and intrauterine environments, and is not entirely specific to asthma. Finally, the **IOM** report is an analysis of associations between indoor air quality and health problems in non-occupational settings. Also based on extensive reviews of the literature, they review the strength of the evidence associating 26 biological and chemical agents in indoor air with the onset and/or exacerbation of asthma. Where evidence is conflicting or outdated, we have at-

tempted to fill in the gaps with our own review of relevant literature.

The aim of this guide is threefold: 1) to point out that for certain substances common in health care facilities, potential risk of asthma risk is significant; 2) to demonstrate how prompt action to reduce exposures can be carried out; and 3) to facilitate decision-making within health care institutions. We present a detailed overview of eleven categories of agents:

- Cleaners, disinfectants, sterilants
- Natural rubber latex
- Pesticides
- Volatile organic compounds/
Formaldehyde
- Baking flour
- Acrylics
- Fragrances
- Phthalates
- Environmental tobacco smoke
- Biologic allergens
- Drugs (medicines)

In our discussion of each substance, the following three elements serve as the foundation for our analysis:

1) Scientific evidence of potential to produce harm: The potential to induce or exacerbate asthma is determined from our three chief resources: the AOEC, the CHE, and the IOM, plus additional

literature reviews where applicable. Quality of evidence is presented using the language specific to each resource. Table 1 offers a summary of asthma associations with substances of concern as related to strength of the evidence. We have integrated each database's system of reporting within the table so that readers can compare strength of the evidence among resources.

2) Exposure considerations for people in health care facilities: Individual risks are predicated upon personal susceptibility factors, in addition to the types and degrees of exposure experienced within various areas of specific facilities. Those in closest proximity to the substances, and those who spend more time in certain problematic areas are likely to experience higher risk. Some exposures, such as fragrances and cleaners, are nearly universal, and therefore could affect anyone within a facility. Other exposures are more specific to occupational duties, and may affect those using the substance more exclusively, such as acrylics in orthopedic departments, or baking flour in facility kitchens. Still other materials, such as pesticides, may involve high exposures for those who use them directly, but may still produce some undefined

risk to many others at lower levels. Table 2 reveals specific areas within hospitals that can involve exposures for personnel, patients, and visitors. Readers will note that some degree of universal exposure is possible in eight of the eleven categories.

3) Availability of safer materials or processes: Although pointing out potential risk patterns is critical, were it not for the availability of alternatives, little could be done in spite of awareness of the problem. Alternative practices or materials are included as vital components within our discussion of each agent. Each facility must determine the advantages and disadvantages of implementing alternatives within their systems. Some alternatives involve significant policy changes, such as tobacco smoke-free or fragrance-free policies. Others involve modifying substances (for example, using products minus problematic constituents) or practices (such as initiating dirt track-off systems, cleaning by a needs assessment rather than an arbitrary schedule, or switching to digital radiology equipment so that film development—and therefore glutaraldehyde exposure—is eliminated). Each of these methods can substantially decrease or eradicate hazardous exposures. Table 3 is an exten-

sive resource guide to alternatives that can be put into practice to reduce risk of asthma within facilities. Information within Table 3 is presented so that readers can use the guide efficiently and comprehensively when attempting to identify specific concerns.

After reviewing this guide, readers should feel sufficiently informed about asthma risks from exposures within health care institutions, in addition to the breadth of alternatives that could substantially diminish these risks. Because putting these principles into practice can be complicated, we offer a final section on tools for decision making within facilities. We discuss how to assemble a working group, and how such a group might consider exposure information and alternative initiatives. We provide the example of a decision tree as a functional tool to effectively integrate the most relevant information into resolution. Finally, we offer a synopsis of recommendations, based on the amalgamation of our findings with a precautionary approach.

In summary, we recommend implementation of alternatives for the following agents because the evidence of potential harm is strong, and though the numbers of exposed people may be high or low, safer alternatives are available:

- Selected cleaners/disinfectants/sterilants

- Natural rubber latex
- Formaldehyde
- Baking flour
- Acrylics
- Environmental tobacco smoke
- Biologic allergens
- Selected drugs

We recommend thoughtfully considering implementation of alternatives for the following chemicals and uses because, although the evidence of potential harm is limited or inconsistent, the number of exposed individuals can be high, and alternatives are available:

- Pesticides
- Volatile organic compounds
- Fragrances
- Phthalates

For those substances which have not been clearly identified as asthmagens or definite triggers of asthma, but ample concern has been generated by the literature regarding other health effects, we suggest a precautionary approach, in which attempts are made to reduce overall use of the substance. Where safer

alternatives are readily available, they can replace substances associated with a range of health effects.

Given the abundance of information included in this guide, it is our intent that readers be inspired to take action. We hope that the information in this guide will empower readers to take steps to reduce exposures to substances that trigger asthma, and to explore safer alternatives. We anticipate that those who do will distinguish themselves as practitioners of health care of a higher order—because, in addition to ministering to individual patients, they are also ministering to indoor environments, thus potentially protecting large numbers of people from asthma onset and exacerbation. By raising the standard of care in this way, they will also inspire other health professionals to pay attention to environmental factors, and to maximize opportunities for disease prevention.

INTRODUCTION AND OVERVIEW

The goal of asthma management programs—sponsored by health plans, clinics, hospitals, public health departments, community-based organizations and coalitions—is to help people with asthma live healthy, active lives, and to reduce the need for emergency room and hospital visits. Yet thousands of people with asthma spend extensive time in hospitals or other health care facilities, not only as patients suffering from asthma attacks, but also as workers, patients with other health problems, and visitors. Paradoxically, while in the hospital, people with asthma can be exposed to dozens of substances that have the potential to trigger an asthma attack. Rapidly evolving science suggests that many of these substances also can cause asthma for the first time in people previously free of the disease. The Hippocratic oath enjoins clinicians to “First, do no harm,” yet the

environments in which many health professionals do their work have the potential to cause harm, both to those who already have asthma, and those who do not.

Progress has already been made in eliminating agents that cause asthma in hospitals. One important asthma trigger no longer found in US health care facilities is tobacco smoke. However, a range of other substances—including chemicals



“Ironically, many products that are used in hospitals to keep patients, visitors, and personnel safe from pathogens represent some of the very same products that have some potential to cause or exacerbate asthma in susceptible individuals.”

used to clean and disinfect floors, surfaces and instruments; chemicals in building materials, furniture and carpets; biological contaminants; powdered latex gloves; and medications—are prevalent in hospitals and clinics, some serving multiple important purposes. In this paper, we ask the following questions as they relate to asthma:

- What are the short- and long-term effects of exposures to these substances for janitorial staff, administrators,

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We argue that for a subset of contaminants found in indoor air, potential risks and availability of alternatives make a compelling case for swift action to eliminate or reduce exposures.

clerical workers, health care personnel, patients, and visitors?

- Are there alternatives to these substances that do not have the potential to cause or exacerbate asthma?
- How might health care facilities make decisions about adopting new techniques or technologies likely to pose less risk?

When building conditions, materials or substances used in health care settings create health risks, administrators, providers, facility managers, and others should consider mitigating those risks. These decisions are difficult, but critical. They take into account characteristics of the hazards and the exposures, as well as the availability and cost of safer, effective alternatives.

The purpose of this guide is to assist health care institutions in understanding exposures that can cause or trigger asthma, and to suggest measures for eliminating or reducing these exposures. We argue that for a subset of contaminants found in indoor air, potential risks and availability of alternatives make a compelling case for swift action to eliminate or reduce exposures. For other substances, the appropriate decision may be less straightforward, but prudent steps include gaining a better understanding of the risk, and more aggressively seeking alternatives.

In Section I, we provide background information on asthma. Section II summarizes hazards and exposures common to health care facilities that have been linked to asthma, and provides suggestions for eliminating or reducing these exposures. The final section, Section III, provides guidance about decision-making processes and policies that can help reduce asthma by promoting healthier indoor environments in hospitals and other health care settings.

SECTION I: A PRIMER ON ASTHMA



"Indoor levels of pesticides are often higher than those outdoors because they do not diffuse, and because pesticides applied outdoors can be tracked indoors."

Asthma: A Chronic Disease Out of Control

Asthma is a chronic inflammatory disorder of the airways that causes recurrent episodes of wheezing, dyspnea (difficult or labored respiration¹), breathlessness, chest pain or tightness, and/or cough. The symptoms are usually associated with widespread but variable airflow limitation. Once asthma develops, it causes an increase in airway responsiveness to a variety of stimuli.^{2,3}

Asthma is now understood to be a disease of airway inflammation that results from a complex interplay of environmental exposures with genetic and other host factors. If untreated, the inflammation may lead to irreversible changes in lung structure, known as airway remodeling.⁴ Asthma is among the most common diseases in the US today, and is a major

public health concern. In 2002, it was estimated that 30.8 million people in the US, including 8.9 million children, had had asthma diagnosed at some point in their lives.⁵ Alarming, the prevalence of diagnosed asthma and asthma symptoms in children and adolescents is reported to have increased by 25-75% per decade since 1960.⁶ The disease is estimated to affect as many as 300 million people worldwide.⁷

Asthma often begins in childhood, and is the leading cause of childhood morbidity as measured by hospitalizations and school absenteeism.⁸ Even when asthma is relatively well controlled, it can significantly impair quality of life. Children with asthma are often reluctant to participate in sports, and their sleep is frequently interrupted.

Among adults, asthma attacks interfere with daily activities. For example, in 2003, adults missed 24.5 million work-days due to asthma. Asthma ranks within the top ten conditions causing limitation of activity, and costs our nation \$16.1 billion annually in health care, loss of work productivity, and premature deaths.⁹ Since 1980, asthma caused or significantly exacerbated by work exposures has emerged as the most commonly reported occupational lung condition.¹⁰ The overall prevalence of adult asthma related to the work environment is unknown, but recent studies estimate that occupational asthma accounts for 5%-37% of all asthma.¹¹ In the US, studies have estimated that 10-23% of new adult onset asthma is due to occupational exposures.¹² Many argue that a more specific estimate is difficult to ascertain because, although the development of *de novo* asthma is

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relatively common in adults, the role of the workplace is routinely overlooked. In addition, the development of respiratory symptoms may result in patients leaving a work environment before a diagnosis of occupational asthma can be made.¹³

Onset of Asthma: Allergic vs. Non-allergic (Irritant) asthma

Asthma, both occupationally and non-occupationally mediated, is commonly classified either as allergic asthma or irritant (non-allergic) asthma.¹⁴ These two major types of asthma reflect differing exposures and pathologic mechanisms. Allergic asthma (also known as immunologic or sensitizer-induced asthma) is the most common form of asthma, and involves an immune-mediated allergic trigger that produces symptoms such as coughing, wheezing, shortness of breath, etc.¹⁵ Allergic asthma has a strong link to a family

history of atopy (i.e. individuals produce an increased amount of antibodies against allergens and often have several allergic conditions including asthma, allergic rhinitis, urticaria, and/or eczema). Common environmental allergens include dust mites, animal dander, pollen, mold, and other high molecular weight substances found in the workplace. Allergic asthma is characterized by an asymptomatic period of sensitization. Although the immunologic mechanism is not known for all agents, most sensitizing agents (allergens) produce asthma through an immunoglobulin E (IgE)-mediated mechanism. An IgE-mediated response has also been implicated for some sensi-

tizing agents. Sensitizers act as complete antigens, and bind with IgE antibodies to produce a cascade of events causing activation of inflammatory cells and the synthesis and release of several mediators that control the inflammatory reaction in the airways.¹⁵ Although lower molecular weight occupational agents, such as medicinal drugs, are also known to react through a similar immune mechanism in most cases of allergic asthma,ⁱ reactions with other proteins are necessary to form the complete allergenic compound. T cells also appear to play an important role in the inflammatory process.¹⁶

Irritant asthma does not involve the immune system, although individuals may experience the same symptoms (coughing, wheeze, breathlessness, etc.) triggered by bronchospasm. Since irritant asthma is not mediated by the immune system, allergic sensitization does not occur, and asthma may be caused from a single exposure to the irritant. Irritant asthma is commonly triggered by physical factors such as exercise and cold air, as well as exposure to chemicals, gases or fumes.

ⁱ In some studies of workers exposed to known agents that cause asthma, such as plicatic acid and diisocyanates, specific IgE compounds either have not been found or have been found in a subset of workers affected with asthma. Thus it appears that some substances are capable of causing asthma by more than one mechanism.¹⁶

An important sub-set of irritant induced asthma is Reactive Airway Dysfunction Syndrome (RADS), which is characterized by acute onset often due to exposure to high levels of irritants.¹⁷ Although the mechanisms of irritant asthma are largely unknown, the literature suggests that a localized airway inflammatory response and/or reflex bronchoconstriction are likely involved.¹⁶

Asthma Exacerbations (Attacks)

Subsequent exposure to the causal agent in allergic-asthma may trigger bronchospasm, perpetuate airway inflammation, and progressively increase the degree of nonallergic airway responsiveness, resulting in a worsening of the disease.¹⁵ Early separation of individuals from the sensitizing agent has consistently been found to be associated with a better outcome.¹⁸ However, an important feature of both allergic and irritant asthma is the hyperreactivity of the airways to non-specific irritants and bronchoconstrictor agents.¹⁶ Thus, an asthma attack can be triggered in individuals already diagnosed with asthma by exposure to: 1) the same agents that caused the disease and/or 2) other sensitizing agents and/or 3) other non-sensitizing agents. In a long-term follow-up study of workers with occupationally-induced allergic asthma, 70%

continued to have asthma symptoms after they were no longer exposed to the sensitizing agent.¹⁸ Therefore, once asthma manifests, subsequent asthma attacks can be caused in a non-specific manner to a host of allergens or irritants.

Most of the occupational health literature distinguishes asthma aggravated or triggered by work exposures from asthma *caused* by work exposures, reserving the term “occupational asthma” only for asthma “acquired *de novo* from a specific workplace exposure.”¹⁹ Examples of factors that can trigger an asthma attack in people already diagnosed with the disease include: allergens, chemicals, fumes, dusts, exercise, work exertion, emotional stress, cold or heat, humidity, air pollutants, tobacco smoke, and plant or animal products. Other factors that can contribute to the severity of asthma symptoms include sinusitis, rhinitis, gastroesophageal reflux, some medications (including aspirin and related nonsteroidal anti-inflammatory drugs), and viral respiratory infections. Exposure to certain triggers provokes an asthma attack by generating further inflammation and narrowing of small airways. How people with asthma respond to agents that exacerbate their condition is highly variable. An agent may trigger an asthma attack in one per-

son, but not in another. Some individuals are sensitive to only a few triggers, while others react to many. Asthma attacks can range from mild to life-threatening. Asthma symptoms may not occur immediately after exposure; an individual’s reaction to an agent known to exacerbate asthma depends on the type of trigger and how sensitive the person is to it.

Exposures and Response

The interplay between agents that cause and exacerbate asthma and the individual is complex. Characteristics of the individual—the form of asthma (e.g., allergic or non-allergic), the person’s sensitivity to particular substances, genetic make-up, physiologic status at the time of the exposure, and history of exposures to the same or other allergens or irritants—play roles in one’s response to a given exposure. Characteristics of the substance and factors affecting the exposure are also important, including chemical physical properties, duration, job type and tasks performed, concentration of the substance, etc.²⁰ The complexity of the disease, including its diverse mechanisms, its variation across individuals, and the distinction between exposures that exacerbate versus those that cause *de novo* asthma, makes characterization of risk from exposure to particular substances especially difficult.

Characteristics of exposure associated with irritant-induced asthma have not been well studied,²¹ and controversy exists regarding whether occupational asthma can be caused by intermittent high level exposure or chronic low level exposure to irritants (although some argue that both scenarios are possible²²). With regard to allergic asthma, the higher the degree of exposure to an agent, the higher the prevalence of asthma, as observed in both occupational²³ and non-occupational²⁴ settings. Although levels of exposure required to cause allergic-asthma vary across individuals and substances, once sensitized, extremely low levels of either irritants or allergens can trigger an asthma attack in some individuals. Duration of exposure is only somewhat important in the development of allergic-asthma in workers; 40% of patients with occupational asthma have symptoms within 2-years of exposure, while 20% of patients have symptoms after 10-years of exposure.² For both irritant and allergic asthma, reduction of exposure to asthma triggers has been shown not only to decrease asthma symptoms and the need for medication, but also to improve lung function. The earlier the diagnosis is made, and the earlier exposures are removed, an individual has a higher likelihood of recovery. However, many patients suffer from chronic

disease even after the exposure has been removed.^{4-5,25}

In summary, although it is unclear whether exposure to low levels of irritants or allergens initiates asthma in susceptible individuals, low-level exposure to irritants or allergens does exacerbate asthma, regardless of whether the initial stimulus for asthma development was mediated by allergic or non-allergic mechanisms. In addition, irritants can increase the sensitivity to allergens when there are co-exposures, for example, exposure to both ozone and pollen. There appears to be a dose-dependent relationship between exposure to both allergens and irritants and asthma symptoms; research on some substances has shown that as levels of exposure increase, rates of asthma in exposed populations also increase. In contrast to many other chronic diseases, no clear threshold levels of exposure to substances has been demonstrated, below which there is minimal risk of onset or exacerbation in susceptible individuals, though levels required to exacerbate existing asthma are likely one to two orders of magnitude less than those shown to initiate asthma.¹⁷ Thus, a particularly strong case can be made for efforts to eliminate exposure to substances associated with the onset or exacerbation of

asthma, acknowledging that measures to reduce (rather than to completely eliminate) exposure will diminish risk in some individuals.

The number of people who can benefit from reducing their exposures to agents that cause and exacerbate asthma is even greater than the number of people with diagnosed asthma. Although significant strides have been made to better define asthma, it remains a disease that is difficult to diagnose. Since the diagnosis depends on clinical observation of both intermittent respiratory symptoms and physiologic evidence of reversible airway obstruction or hyperresponsiveness,¹⁶ many people with asthma-like symptoms are not treated and/or are not diagnosed with asthma. However, repeated experience of asthma-like symptoms is an important risk factor for the development of asthma, and reduction of known triggers will improve the health of these individuals, as it will in people with diagnosed asthma.

SECTION II: HEALTH CARE FACILITIES, ENVIRONMENTAL EXPOSURES, AND ASTHMA: INFORMATION TO GUIDE DECISION-MAKING



“Virtually everyone in a hospital building will be exposed to cleaning products and their vapors.”

Many of the substances known or suspected of initiating asthma or causing asthma attacks are present in hospitals, nursing homes, and other health care facilities. Some of these substances were noted earlier and include biological agents, such as mold, cockroach allergens and pollens, as well as some chemicals. Some of them are not specific to the health care setting, but are often found in indoor environments, including health care facilities, while others might be used as pharmaceuticals or in hospital laboratories.

Both the occupational and non-occupational literature are relevant to exposures in health care facilities. Higher levels and more frequent exposures are most likely for workers in the hospital setting such as janitors and lab technicians, but the potential for exposures to cause or exacerbate asthma compels hospital deci-

sion-makers to consider risks to patients and visitors as well. Although the literature on associations of indoor exposures with disease in both occupational and non-occupational settings is extensive and growing, there remains a paucity of information on chemical causes of asthma in non-occupational settings. Research in non-occupational settings—including homes, office buildings and schools—has focused primarily on biological rather than chemical agents.

Three Factors to Consider in Reducing Risks of Asthma from Exposures in Health Care Facilities

As noted earlier, the conclusion of this document is that, for a subset of many contaminants found in indoor air, potential risks and availability of alternatives

make a compelling case for swift action to reduce or eliminate exposures. For other substances, the appropriate decision may be less clear-cut. In developing a plan for reducing risk of asthma from exposures in hospitals or other health facilities, decision-makers should take into account the following:

- A) Evidence about the potential for a given substance to initiate or exacerbate asthma in people exposed to it, including sensitive individuals
- B) The potential for people in health care facilities to be exposed
- C) The availability of safer materials or processes.

In this section, we review available information on these three factors for categories of substances found in the health care setting that are known to cause and/or exacerbate asthma. For some substances,

we also discuss the vulnerability of certain subgroups to asthma onset/exacerbation and special considerations that should be taken into account as strategies are developed to ensure that health care facilities do not contribute to the burden of asthma among workers, patients, and visitors.

A. Scientific Evidence of Potential Harm

The body of evidence on the role of specific agents in asthma onset and exacerbation continues to grow. For some agents, the evidence is strong, and multiple studies, often from more than one discipline, show consistent results. For others, fewer studies have been undertaken, but the evidence that does exist is strong. For a subset of agents discussed in this document, the science is either limited or conflicting. This guide presents information on agents capable of causing and exacerbating asthma found in health care settings, drawing on three evaluations that summarize the scientific literature:

- The list of asthmagens prepared by the Association of Occupational and Environmental Clinics,²⁵ which draws largely on case reports and follow-up clinical tests of workers
- A 2004 review by scientists associated with the Collaborative on Health and the Environment, which summarizes

information primarily in textbooks on links between environmental and occupational exposures and human diseases²⁶

- The Institute of Medicine's 2000 "Clearing the Air" report,²⁷ which focuses on non-occupational exposures.

Because these three sources have distinct purposes, the lists of allergens and irritants they review are not identical. Some substances or categories of substances are addressed by only one of the sources. For some substances that appear on more than one of the lists, information presented is consistent across sources. For others, conclusions are inconsistent. We draw on additional peer-reviewed literature to help explain the findings from the three sources and to add to the information that can be considered when data from the three sources are minimal or outdated.

Details on the AOEC, CHE, and IOM State of the Science Reviews

The Association of Occupational and Environmental Clinics (AOEC) developed a database intended to provide clinical guidance about previously demonstrated causes of asthma. The focus of the database is primarily on agents found in workplace environments including chemical agents, biological sources, and

physical hazards. The AOEC follows a protocol to determine which substances in the exposure database should be designated as occupational asthmagens (capable of causing asthma). The AOEC's protocol defines occupational asthma as, "...asthma which is acquired *de novo* from a specific workplace exposure. This may occur through an immunologic sensitization, another form of sensitization, or due to the induction of a chronic asthma state due to non-sensitizing inflammatory stimuli. This is limited to asthma which would not have occurred in the complete absence of that specific exposure." The AOEC's criteria for identifying a substance as a cause of asthma are based on 1) whether the agent can be identified as a discrete workplace substance and is present in the air of workplaces; and 2) a number of clinical criteria (major and minor) such as challenge tests (specific and workplace) and positive IgE antibody response to the suspected antigen by skin or serologic testing (see Appendix A for complete list of review criteria). The AOEC currently lists over 350 agents associated with the onset of asthma. The AOEC does not provide information about whether or not those substances exacerbate asthma, but it is likely that many of the 350 substances shown to initiate asthma can also trigger

an attack in some people already suffering from asthma.

Researchers on behalf of the Collaborative for Health and the Environment (CHE) recently published an updated database of agents known to cause environmentally mediated disease, including asthma. The authors evaluated the state of the scientific evidence in 2004 and again in 2005, and created a database of diseases—including allergic and irritant asthma—associated with toxic agents present in workplaces, out of doors, in homes, and during fetal development. The authors based their review on three major textbooks of environmental medicine and toxicology, literature reviews of epidemiologic studies, and reviews of disease topics. They ranked the science as: 1) “Strong Evidence” if a causal association between the agent and the disease is well-accepted by the medical community; 2) “Good Evidence” if some epidemiologic studies and strong corroborating animal evidence demonstrate an association; and 3) “Limited or Conflicting Evidence” if evidence is limited to case reportsⁱⁱ or conflicting information from

epidemiologic studies (see Appendix A for a complete description of criteria). One limitation of the CHE database is that it does not distinguish between agents that are known initiators of asthma versus those that appear only to exacerbate the disease.

In 2000, the Institute of Medicine (IOM) published a seminal report, “Clearing the Air: Asthma and Indoor Air Exposures,” which reviewed the strength of the evidence associating 26 biological and chemical agents in indoor air with the onset and/or exacerbation of asthma. The report was based on an extensive review of the scientific literature up to 1999, including epidemiologic studies, clinical research, animal studies (where appropriate) and engineering, architecture and physical sciences literature on airflow and humidity in buildings. The review committee categorized each association as: 1) “Sufficient Evidence of a Causal Relationship” if it satisfied criteria regarding strength of association and other causal criteria designated by Sir Bradford Hill, among them a dose-response relationship, consistency of association,

etc.; 2) “Sufficient Evidence of an Association” if there is sufficient evidence after accounting for factors such as chance, bias, and confounding;ⁱⁱⁱ 3) “Limited or Suggestive Evidence of an Association” if chance, bias, and confounding cannot be ruled out as a competing explanation; 4) “Inadequate or Insufficient Evidence to Determine Whether or Not an Association Exists” if no available studies exist or are of insufficient quality, consistency or statistical power to permit conclusions regarding the presence or absence of an association; and 5) “Limited or Suggestive Evidence or No Association” if several adequate studies affirmatively and consistently show no association between the agent and asthma (see Appendix A for a full description of the criteria).

Table 1 summarizes the findings from these three review sources that are relevant to exposures found in health care settings and asthma. Although chemicals listed in Table 1 are often used for multiple purposes and in multiple products, we categorize each by their primary use in a hospital setting and describe other

ⁱⁱ Without corroborating information from other sources, case reports are generally considered less robust evidence than epidemiological studies or animal data. In the case of asthma, an association between a chemical or other substance and a disease can be corroborated with clinical tests. Together, positive case reports and clinical tests—as required for inclusion on the AEOC list—constitute strong evidence of a causal relationship between a substance and asthma symptoms.

ⁱⁱⁱ IOM’s second level of evidence differs from the first, in that the first reflects causation while the second reflects an association that may or may not be causal.

TABLE 1. Agents Used or Found in Health Care Facilities Capable of Causing or Exacerbating Asthma

Characterizations of the relationships between exposure to a substance and asthma onset or exacerbation:

- ✓ Indicates that the substance is considered to cause or exacerbate asthma, or that strong evidence exists that the substance is associated with asthma onset or exacerbation.
- + Indicates that evidence of an association between a substance and with asthma onset or exacerbation is “good” (CHE only).
- ? Indicates that evidence of association between the substance and asthma onset or exacerbation is limited or conflicting.
- i Indicates that evidence of an association between the substance and asthma onset or exacerbation is inadequate (IOM only).
- NR Indicates not reviewed

Product Category/ Chemical or Biological agent	AOEC	CHE	IOM*	Product Category/ Chemical or Biological agent	AOEC	CHE	IOM*
I. Cleaners (including floor strippers), Disinfectants & Sterilants			NR	IV. Volatile organic compounds (VOCs)			?
Chloramine-T		?		Formaldehyde and Formalin (aqueous solution of formaldehyde)	✓	+	i
Chlorine bleach	✓	✓		V. Baking Flour	✓	NR	NR
Chlorhexidine	✓			Buckwheat	✓		
Ethanolamines:		✓		Gluten	✓		
Monoethanolamine (2-Aminoethanol or Monoethanolamine)	✓			Rye flour	✓		
Triethanolamine	✓			Wheat flour	✓		
Aminoethyl Ethanolamine (Aminoethyl Ethanolamine or Ethanol Ethylene Diamine)	✓	✓		Soya flour	✓		
Dimethylethanolamine (Dimethylaminoethanol or Dimethylethanolamine)	✓			VI. Acrylics			NR
Diethanolamine (DEA)	✓			Methyl methacrylate	✓	✓	
Paraphenylenediamine		✓		VII. Perfumes/Fragrances	NR	?	?
Ethylene Oxide	✓	+		VIII. Phthalates		?	i
Formaldehyde (note primarily discussed below under VOCs)	✓	+	i	Dibutyl phthalate		?	
Glutaraldehyde	✓	✓		Dicyclohexyl phthalate		?	
Hexachlorophene	✓	+		IX. Environmental Tobacco Smoke		✓	✓
Quaternary ammonium compounds:		✓		X. Biologic allergens			
Benzalkonium Chloride	✓			Animal allergens (in general)		✓	
Dodecyl-dimethyl-benzylammonium Chloride	✓			Mouse allergen	✓		?
Lauryl Dimethyl Benzyl Ammonium Chloride	✓			Cockroach allergen			✓
Benzalkonium chloride	✓			Dust mite allergen			✓
II. Natural Rubber Latex	✓	✓	NR	Cat allergen			✓
III. Pesticides	✓	+	i	Dog allergen			✓
Organophosphates		+		Pollen indoors			?
Diazinon	✓			Fungi/molds			✓
Malathion	✓			XI. Drugs		NR	NR
Acephate (synonym: Orthene)	✓			Penicillins/Ampicillin		✓	
Carbamates		+		Cephalosporins		✓	
Pyrethrin / Pyrethoid		+		Pysllium		✓	
Piperonyl Butoxide (synergist)	✓			Methyldopa		✓	
				Tetracycline		✓	
				Isonicotinic acid hydrazide		✓	
				Hydralazine		✓	
				Cimetidine		✓	

* We gave a ✓ to IOM's category of "sufficient evidence of a causal relationship." (Evidence in this category is strong enough to conclude that an allergen or irritant causes symptoms to develop in predisposed individuals or to worsen in known asthmatics.) We also gave a ✓ to IOM's category of "sufficient evidence of an association." (Evidence in this category is sufficient to conclude there is an association, but it stops short of a higher standard of proof needed for causality.)

relevant uses in the later discussion. When reviewing Table 1, it is important to keep several issues in mind. First, since health care facilities are workplaces for health care professionals and other personnel, and also non-workplace settings for patients and visitors, the scope and focus of the CHE database is perhaps most relevant to concerns of readers of this guide. Both the AEOC list and the IOM report contain important information that is also relevant, however. The AOEC list is the most comprehensive list of asthmagens found in workplace settings, derived in part from occupational case reports. Since these case reports may not have been published, state of the evidence summaries and syntheses such as those conducted by the CHE or the IOM would not include all of them. The IOM report is widely considered a seminal analysis of associations between indoor air quality and health problems in non-occupational settings. Together, these three sources supplemented with information from individual journal articles and other reviews of the literature provide a comprehensive description of the current understanding of the state of the evidence linking asthma to substances found in health care facilities.

Second, the methods used by the AOEC, CHE and IOM differ, and these differences likely explain some of the divergence in the information they present. The AOEC's list reflects a "yes" or "no" system, based on whether specific clinical criteria were met in classifying an agent an asthmagen capable of initiating asthma. In contrast, the reviews undertaken by the CHE and the IOM characterize the strength of the evidence of the peer-reviewed literature.

Third, although the CHE and the IOM both draw on the scientific literature, they use different schemes for classifying the strength of the evidence. We have not attempted to integrate these classifications, and instead present the evidence in Table 1 verbatim from each source. For the purposes of this guide, we do merge two of the IOM categories, as described at the bottom of Table 1.

Finally, the CHE database was updated in 2005, and the AOEC routinely updates its

list of asthmagens. The IOM report drew on research published as of 1999. Thus, the CHE and AOEC databases contain more recent evidence of associations between certain substances and asthma for which the IOM characterized the evidence five years ago as "inadequate" or "insufficient."

B. Considerations Regarding Exposure of People in Health Care Facilities

Many of the substances found in health care settings have the potential to be harmful, and their presence should be cause for concern, but the extent of harm that such substances will cause depends upon conditions of exposure. In the process of prioritizing action to reduce or eliminate agents that are capable of causing or exacerbating asthma, it is important to consider factors that influence those at greatest risk. Yet, as we will reiterate in this guide, exposure assessment is complex, and requiring robust exposure information before decisions can be made

^{iv} Some research attempts to characterize exposure and can draw connections between levels of contaminants or other conditions of exposure and their impacts on health, but other studies do not. It may be feasible in some settings to measure levels of contaminants; in other settings, methods may not exist for tracking certain chemicals. For some contaminants, robust monitoring of exposure may have little utility, i.e. knowing which kind of mold spores are present in what numbers is irrelevant if science has not yet discerned risks associated with particular kinds of mold versus others.

TABLE 2. Potential Exposures to Agents Known to Cause or Exacerbate Asthma by Job Type

Substance	Cleaners, Disinfectants & Sterilants											Env. Tobacco Smoke (designated smoking areas)	Biologic Allergens	Medicinal Drugs		
	Cleaners	Disinfectants (can include glutaraldehyde, formaldehyde)	Floor Finish strippers	Glutaraldehyde	Formaldehyde*	Ethylene Oxide	Latex	Pesticides	Flour	Acrylates	VOCs				Phthalates	Fragrances
Location – Jobs																
Radiology																
X ray tech	✓			✓			✓								✓	
Dark room tech	✓			✓											✓	
Laboratory																
Chemists	✓	✓		✓	✓		✓								✓	
Techs	✓	✓		✓	✓	✓	✓								✓	
Animal Care																
Researchers	✓	✓		✓	✓		✓								✓	
Lab Workers	✓	✓		✓	✓	✓	✓								✓	
Animal Handlers	✓	✓					✓								✓	✓
Cage Washers	✓	✓					✓								✓	
Nursing																
Patient Care	✓	✓					✓					✓			✓	✓
Special Procedures	✓	✓		✓			✓					✓			✓	
Surgery	✓	✓		✓			✓			✓		✓			✓	
Orthopedics	✓	✓					✓			✓					✓	
Cardiology	✓	✓		✓			✓								✓	
Dental Clinics	✓	✓					✓			✓						
Facilities																
Maintenance	✓						✓			✓	✓	✓			✓	
Painters	✓						✓			✓	✓	✓			✓	
Housekeeping																
Floor Care	✓	✓	✓				✓				✓	✓	✓		✓	
Grounds							✓	✓	✓						✓	
Room Cleaning	✓	✓					✓				✓	✓	✓		✓	
Mortuary																
Medical examiners	✓	✓			✓	✓	✓								✓	
Support	✓	✓			✓	✓	✓								✓	
Central Sterile																
Techs	✓	✓		✓			✓									
Maintenance	✓	✓					✓									
Supervisors	✓	✓		✓			✓									
Dietary																
Bakers	✓								✓							
Endoscopy																
Nurses	✓	✓		✓		✓	✓									
Techs	✓	✓		✓		✓	✓									
Surgery																
Nurses	✓	✓		✓	✓		✓			✓						
Physicians	✓	✓		✓	✓		✓			✓						
Techs	✓	✓		✓	✓	✓	✓			✓						
All employees [including administrative], patients, and/or visitors**	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	

*Discussed primarily when considering exposure to VOCs; **Exposures often well-diffused in the workplace

about reducing exposure is often neither realistic nor appropriate.^{iv}

Exposures can be modified by the use and location of substances that can cause or exacerbate asthma. Table 2 shows where within a health facility chemicals associated with asthma are typically used, and where biological asthmagens are typically found. In the indoor health care environment, exposures to sensitizing agents and irritants of concern generally fall under one of two categories: 1) those that occur in common areas used by hospital staff, patients, and visitors, or 2) those that occur in specific locations or during specific functions, therefore affecting selected individuals or groups. We have indicated common exposures to specific facility functions or areas within the body of Table 2. Where exposures tend to be ubiquitous (although typically at lower levels than those indicated for specific areas), we have indicated so by a bold check within the final row. For example, although floor stripper exposure will be highest for those utilizing the substance, everyone within the building will likely be exposed to some degree. This concept applies to several of the agents we discuss.

Concentrations of chemicals can widely vary over space and time, even in the

Concentrations of chemicals can widely vary over space and time, even in the same room or under similar ventilation conditions, or when the same activities are being performed.

same room or under similar ventilation conditions, or when the same activities are being performed. Although these heterogeneous factors need to be considered when assessing hazard levels, decision-makers can keep general principles of exposure in mind as they consider steps to reduce risk. Higher exposures are expected for those performing specific functions (examples: janitors using cleaning agents, or technicians using lab chemicals), but people working in nearby areas, patients, and visitors may also be exposed. These people, as well as administrators and others who work in facilities over many years, have longer-term exposures. At the same time, depending on general physical properties, some concentrations and levels will diminish over time, such as chemicals in new building materials. Greater volume of chemicals will likely pose a greater risk than will

lesser amounts; numbers of people, in addition to proximity, are also important to consider. Other factors relevant to exposure include building ventilation and exchange rates. A specific potential source of exposure to take into account is the location of outdoor sources of pollutants—such as truck loading docks—relative to air intake vents.

Additional factors to think about when considering exposure to asthmagens are characteristics of people exposed that may make them more or less vulnerable to asthma onset or exacerbations. Children, in particular, may be more susceptible to exposures. Current ongoing research is testing hypotheses about associations between chemical exposures and the development of asthma in children, including *in utero* exposure, but the evidence base is not yet well developed.

C. The Availability of Alternatives

The first step to preventing workplace hazards is elimination or substitution of the hazard at its source. Any other form of control leaves the hazard available for potential exposure. Yet finding and implementing suitable alternatives can be difficult. Thus, a third consideration in successfully reducing exposures to hazardous substances is the availability of alternatives. A strategy for implementing and evaluating alternatives in hospitals was developed for the Sustainable Hospitals Program. The program involves activities such as developing a multi-disciplinary alternatives assessment/pollution prevention team composed of decision-makers and hospital staff who work with the substances of concern, in addition to worksite assessments, research, screening, and pilot testing of alternatives.²⁸

Some hazards are present because of flaws in design or maintenance of the facility. These problems, such as leaks that can result in mold or pest infestations, can be addressed at their sources. Other allergens and irritants have explicit functions that are usually important, directly or indirectly, in the delivery of health care. In some of these cases, safer substances that perform an identical or nearly identical function can be substituted for

a substance known to cause or exacerbate asthma. Engineering changes, such as “closed loop” systems for some chemicals, or restricting entry to certain areas, can significantly reduce exposures. Under conditions when someone is experiencing symptoms, and the means of eliminating a job hazard have not yet been identified, it may be necessary to remove the person from a particular job task. This is not considered a long-term solution, however, because the hazard remains in the workplace for others to be exposed. Given that many substances used in health care facilities are known not only to exacerbate, but also to cause asthma, this strategy should be considered a last resort and an unacceptable solution when demonstrably safer and effective products or processes are available.

The suggested alternative products and procedures described below are intended to help a facility select alternatives to evaluate. It may be wise to ask an industrial hygienist to assess potential substitutes for additional occupational health risks before implementation. These alternatives have been suggested because they may reduce or eliminate exposure to the identified asthmagen or respiratory irritant in the product; however, they have not necessarily been evaluated to determine if

they pose other occupational health risks. In addition, because new information about which chemicals cause asthma is constantly emerging, and most chemicals are not tested for this feature before being released into the market, replacement of one product for another cannot necessarily guarantee lower asthma incidences, and thus should be considered carefully.

Asthmagens Found in Health Care Facilities and What You Can Do About Them

In the following pages, we present information about the three factors—strength of evidence, exposure considerations, and availability of alternatives—for substances found in the health care setting that are capable of causing or triggering asthma. The most detailed discussion of alternatives is provided for cleaners, disinfectants and sterilizers, and the same approach is taken for subsequent examples; readers are urged to explore further alternatives from the listed references and links to other information sources.

Guide to the Use of Table 3: Alternatives to Agents of Concern

Table 3 is a comprehensive directory of the current available resources that suggest or supply substitutions for the products containing problematic agents noted in this guide. It is important to understand that we have chosen to be inclusive of products for which the evidence may be limited with respect to potential to cause or exacerbate asthma. However, because of additional health risks and the increasing availability of alternatives, we have incorporated information relative to their alternatives as a precautionary approach.

Table 3 is organized alphabetically by both product type (e.g. janitorial cleaners, bedding) and specific chemicals (e.g. cyanoacrylate, formaldehyde). The table serves as an information bank for some preferable products and practices, and for resources that will maintain current lists of product alternatives. Product substitutions are not extensively denoted within the table for two main reasons: 1) products change on a constant basis; and 2) the decision to replace a substance is multifactorial, based on considerations of efficacy, ease of implementation, and health risks other than asthma or ecological risks posed by the substitution. Readers will also notice a thread of repetition throughout the *Resources* column of Table 3. We chose to repeat information throughout the table so that readers looking specifically for alternatives to a specific agent can effortlessly find comprehensive access to alternative information. Finally, VOC-free alternatives are referenced widely within Table 3. In the few studies available, though VOCs as a class (with the major exception of formaldehyde) were not definitely identified as agents that cause or exacerbate asthma, evidence linking airway reactivity to specific VOC exposures in people with established asthma is present in the literature. VOC-free products are among the

most broadly available alternatives in the marketplace because of additional health concerns, and may represent appropriate substitutions for selected substances.

Health Care Without Harm does not endorse any of the products listed in this report, has not tested them for safety or efficacy, and does not take responsibility for the accuracy of the information or product performance. Listing of products here is based solely on information provided by the manufacturer. This report contains a number of web addresses. For convenience, this report is available as a pdf with clickable links at www.noharm.org. Links confirmed active as of date of publication.

**Table 3.
Alternatives
to Agents of
Concern**
(part 1 of 21)

Product	Problematic Compound	Alternative	Resources
Adhesives (for flooring, tile, carpeting, paneling, etc.) and seam sealants	Formaldehyde, other VOCs	Formaldehyde-free, low-VOC adhesives	<p>Ask your vendor or installer about the availability and performance of mechanical fasteners, dry adhesives (peel and stick), and water-based wet adhesives that are zero- to low-VOC (under 50 grams/liter); check MSDSs for presence of formaldehyde, other VOCs and overall respiratory irritation potential of products.</p> <p>California's South Coast Air Quality Management District (SCAQMD) has set VOC limits on a wide range of adhesive and sealant product types under its Rule 1168 (http://www.aqmd.gov/rules/reg/reg11/r1168.pdf). SCAQMD has restricted the following VOCs from adhesives and sealants: chloroform, ethylene dichloride, methylene chloride, perchloroethylene, and trichloroethylene. Specify Rule 1168-compliant adhesives and sealants except in freeze/thaw conditions or when moisture can exist. In wet freeze/thaw conditions, specify adhesives that meet the Bay Area AQMD's Rule 51, which is less stringent but achievable in non-arid climates (http://www.baaqmd.gov/dst/regulations/rg0851.pdf).</p> <p>The Carpet and Rug Institute (CRI) has certified at least 10 manufacturers of adhesive products for carpeting, flooring and multi-purpose uses that meet its Green Label Plus criteria, which limits emissions of formaldehyde and 14 other chemicals; see www.carpet-rug.org. (Note: CRI also has adhesives that meet its less-stringent Green Label criteria.) A fact sheet on CRI's Green Label Plus criteria is available at http://www.carpet-rug.org/pdf_word_docs/CRI_GLP_factsheet.pdf.</p> <p>GreenGuard's website lists over 30 Indoor Air Quality Certified adhesives for flooring, tile, carpet and other materials. These products meet its standard for low-emitting products, which limits emissions of formaldehyde and other VOCs. For more information, see http://www.greenguard.org.</p> <p>GreenSpec Directory lists several water-based low- and zero-VOC flooring adhesives. This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gscfm.</p> <p>King County, Washington published a webpage developed by the National Park Service on Environmentally Responsible Carpet Choices; it contains a listing of water-based, low-VOC carpet adhesives. See http://www.metrokc.gov/procure/green/carpet.htm#13.</p> <p>Austin, Texas' Sustainable Building Sourcebook has a section on Construction Adhesives that covers products used on flooring, laminate, veneer, wall coverings and other materials. It explains hazards associated with solvent-based adhesives, suggests mechanical installation techniques and exposure reduction strategies, and lists some manufacturers of low- and zero- VOC products. See: http://www.ci.austin.tx.us/greenbuilder/srcbk_5-2.htm.</p>

Product	Problematic Compound	Alternative	Resources
Bedding (chemically treated fabric)	Formaldehyde	Untreated fabric	<p>Ask your vendor about the performance and availability of formaldehyde-free products. The Organic Cotton Directory lists dozens of distributors of organic cotton blankets, linens, towels, mattresses and other textile products, most of which are also formaldehyde-free. Search http://www.organiccottondirectory.net. Formaldehyde-free bedding and other less-toxic textile products can be purchased online at the Children's Health Environmental Coalition Safer Products Store, http://chec.greenhome.com/products/bedding.</p> <p>GreenSpec Directory lists sources of bed linens, mattresses, pillows and other bedding that is made of chemically untreated wool and organic cotton. Note that wool is a common allergen. This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gs.cfm.</p>
Blood pressure cuffs (sphygmomanometers)	Latex	Latex-free cuffs	<p>Latex-free cuffs are widely available. The Sustainable Hospitals Project maintains a list of latex-free aneroid blood pressure cuffs. See Sphygmomanometer at http://www.sustainablehospitals.org/cgi-bin/DB_Report.cgi?px=W&rpt=Cat&id=14. See links under Natural Rubber/Latex below. Additional suppliers can be found online by searching for "Latex-free Sphygmomanometers."</p>
Building products (e.g., cabinets, ceiling tiles, casework, furniture, insulation, wood flooring, laminate, paneling and veneer)	Formaldehyde, other VOCs	Specify formaldehyde-free pressed wood products	<p>Ask your vendor or manufacturers about formaldehyde-free and low-VOC products. Inquire about formaldehyde and VOC emissions from adhesives for glue-down installations, in the surface finishing material, and in the choice of sub floor or backing materials.</p> <p>GreenGuard's Certification Program for low-emitting products has set standards for dozens of building product types; each limits the amount of formaldehydes and other VOCs that can be emitted. GreenGuard has certified hundreds of products that meet these standards, including adhesives, ceiling tiles, flooring, furniture (including office work stations), insulation, paints, sealants, and wall coverings. Some meet even more stringent GreenGuard Standards for Children and Schools. See www.greenguard.org.</p> <p>GreenSpec Directory lists a variety of products such as fiberglass insulation and wood cabinets, paneling and veneers; some are made with low-VOC adhesive. (It is important to read product descriptions and review MSDSs since these products may have other environmental attributes instead). This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gs.cfm.</p> <p>At least two wood laminate and veneer products have met 01350 emissions standards, which set limits on the amount of formaldehyde and total VOCs that are emitted from products (after two weeks of off-gassing); see http://www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350/.</p>

Table 3.
Alternatives
to Agents of
Concern
(part 2 of 21)

TABLE 3.
Alternatives
to Agents of
Concern

(part 3 of 21)

Product	Problematic Compound	Alternative	Resources
Building products (e.g., cabinets, ceiling tiles, casework, furniture, insulation, wood flooring, laminate, paneling and veneer) <i>(continued)</i>	Formaldehyde, other VOCs	Specify formaldehyde-free pressed wood products	<p>Canada's Environmental Choice Program has granted EcoLogos to insulation products that are free of certain ingredients, including formaldehyde, those that are poisonous, corrosive, flammable or explosive. It has also certified two flooring products that "do not emit VOCs, including formaldehyde, at a rate greater than 0.5 mg/m²/hr." See http://www.environmentalchoice.com; click on "Products and Criteria", then "Building and Construction Materials and Products".</p> <p>Additional products can be found online by searching for "low-VOC" + the type of product you are looking for. For example, GreenFlooring.com claims its bamboo flooring products are low-VOC; see http://www.greenfloors.com/HP_Bamboo_Index.htm.</p>
Carpet and upholstery cleaners and shampoo	VOCs, fragrances, disinfectants	Low-VOC carpet shampoo and non-aerosol spot cleaners	<p>The Commonwealth of Massachusetts included on its approved products list several environmentally preferable carpet and upholstery products, including carpet extractors. For a list, see http://www.newdream.org/procure/products/approved.php. Some of the general purpose cleaners and janitorial degreasing products certified by Green Seal may be able to replace harsh carpet and upholstery spot and stain removers. See http://www.greenseal.org/findaproduct/index.cfm#cleaners.</p> <p>The Janitorial Products Pollution Prevention Project (JP4) has published a fact sheet describing "Safe and Effective Carpet Cleaning" techniques that reduce the use and exposure to harmful chemical ingredients. JP4 recommends installation of hard floor surfaces and proper installation of carpeting, dust prevention methods, effective vacuuming, steam extraction and carpet shampooing (using relatively mild substances), enforcement of policies to prevent spills of food and beverages that can easily stain carpets, and sparing use of carpet spotters and other products that tend to be relatively harsh, particularly if they come in aerosol containers. See http://www.wrppn.org/Janitorial/factsheets/carpetcleaning.htm.</p> <p>Canada's Environmental Choice Program has issued a voluntary standard for "Carpet and Upholstery Care Products" that prohibits any ingredients identified as asthmagens by the Association of Occupational and Environmental Clinics, as well as corrosive substances, propellants, fragrances and antimicrobial chemicals. It also set limits on VOCs of 8% for spot and stain removers and 0.1% for cleaners. A copy of this standard (CCD-148) is available at http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_148.pdf. At least two products have been given EcoLogos under this standard.</p>

Product	Problematic Compound	Alternative	Resources
Carpet, carpet cushion, and adhesives	Formaldehyde and other VOCs, phthalates (in PVC)	Low VOC adhesives and low-emitting carpet and carpet cushion	<p>The Carpet and Rug Institute's (CRI's) Green Label Plus program certifies carpets that meet certain criteria for limited off-gassing of formaldehyde and other individual VOCs. Their Green Label Plus program is much more stringent than the Green Label program. CRI's website contains a fact sheet on this program and a list of Green Label Plus-compliant carpet products. There is also a list of carpet cushion products that comply with CRI's less stringent Green Label Program. See http://www.carpet-rug.org. A fact sheet on CRI's Green Label Plus criteria is available at http://www.carpet-rug.org/pdf_word_docs/CRI_GLP_factsheet.pdf (Green Label Plus does not screen for content or emissions of phthalates).</p> <p>The Healthy Building Network Table of PVC-free Building Products, including carpet, is available at: http://www.healthybuilding.net/pvc/alternatives.html.</p> <p>GreenSpec Directory lists several carpet and carpet cushion product lines that include formaldehyde-free or low-VOC adhesives. This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gs.cfm. (Note: Not all listed carpet products are low-VOC; some only have different environmental attributes such as recycled content or natural fibers.)</p> <p>King County, Washington published a webpage developed by the National Park Service on Environmentally Responsible Carpet Choices. It provides details on the types of adhesives and backing used with the carpet lines offered by each manufacturer listed. (Warning: some of these products contain recycled and/or virgin PVC, which may emit phthalates and other chemicals of concern.) See http://www.metrokc.gov/procure/green/carpet.htm.</p> <p>Canada's Environmental Choice Program has certified at least two carpet /tile manufacturers and at least one producer of textile floor coverings that offer products with low formaldehyde and VOC emissions. For copies of the standards and lists of qualifying products, see http://www.environmentalchoice.com (click on "Products and Criteria"; then on "Building and Construction Related"; then on "Flooring Products."</p> <p>Austin, Texas' Sourcebook for Green and Sustainable Building lists many carpet and carpet cushion products with environmental attributes; ask your vendor or manufacturers about availability of formaldehyde-free and low-VOC products; this guide does not list them as such. See http://www.greenbuilder.com/sourcebook/FloorCoverings.html.</p> <p>(Note: see Adhesives section above for information about low-VOC products designed for use with carpet and carpet cushion product.)</p>

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^a Webpage for RiteLok Low Odor Adhesives, <http://www.chemence-us.com/content/view/67/107/>

Product	Problematic Compound	Alternative	Resources
Catheters	Latex, phthalates	Latex-free catheters are made from many materials, including polyurethane, nylon, silicone, and Teflon	Latex-free catheters are widely available. The Sustainable Hospitals Project maintains a list of catheters that are latex- and/or PVC-free. See Catheters at http://www.sustainablehospitals.org/cgi-bin/DB_Report.cgi?px=W&rpt=Cat&id=3 . See additional links under Natural Rubber/Latex below. Additional suppliers of specific types of latex-free catheters can be found online by searching for "Latex-free Catheters."
Chloramine T (Disinfectant)	Chloramine T	Varies	Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed; the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those not connected with asthma, have some hazard associated with them.
Chlorhexidine	Chlorhexidine	Varies	Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed; the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those not connected with asthma, have some hazard associated with them.
Cyanoacrylate ("Super-glue")	Cyanoacrylate	Adequate ventilation, mechanical fasteners	Alkyl cyanoacrylates are found in glues used in certain surgical and dental procedures, as well as in "super-glue" products used in building construction and maintenance. At least one company offers a low-odor cyanoacrylate instant-dry adhesive. According to the manufacturer, this product "reduces the requirement for sophisticated ventilation systems." According to its MSDS ^a , it is made with polymethacrylate and a proprietary cyanoacrylate ester, and can be irritating to the bronchial passage. However, it lacks the stronger warning found on the MSDS for conventional super-glue products: "Prolonged and repeated overexposure to vapors may produce non-allergenic asthma in sensitive individuals." Mechanical fasteners should be considered. Occupational health and personal protective precautions such as enclosures, ventilation systems, and organic vapor respirators should be considered whenever the use of these products is unavoidable.
Deodorizers/air fresheners	VOCs, para-dichlorobenzene, quaternary ammonium compounds	Reduce use of air fresheners and deodorizers	Generally, stick deodorizers may release fewer VOCs than spray or mist deodorizers. Do not use stick deodorizers containing paradichlorobenzene, a suspected carcinogen. Work with maintenance staff to reduce odor problems through effective cleaning and moisture management. Educate building occupants that rooms are clean even when no deodorizer or fragrance odor is present. INFORM's fact sheet, "Respiratory Hazards and Restroom Deodorant Blocks," describes a successful pilot test of deodorant blocks free of paradichlorobenzene and quaternary ammonium compounds; see http://www.informinc.org/padeodorizers.pdf .
Detergent	VOCs	Low- or no-VOC detergent	No- and low-VOC detergents are available for laundry, carpet-cleaning, and dishwashing purposes. Ask your vendor to provide these products when they are appropriate.

Product	Problematic Compound	Alternative	Resources
Drugs	Sensitizing powders (psyllium, selected antibiotics and antihypertensives, and cimetidine)	Clinical substitutions, pre-prepared/ packaged drugs	For sensitized individuals, avoidance of tasks involving the problematic agents is achievable. Hoppers, hoods, or personal protection devices such as airhoods or properly fitting respirators are appropriate.
Epoxy adhesives (adhesive)	Pyromellitic dianhydride, VOCs	Varies	Some workers using an epoxy adhesive containing pyromellitic dianhydride developed respiratory symptoms. In addition, many adhesives contain high levels of VOCs. All adhesives should meet the VOC limits of the South Coast Air Quality Management District Rule 1168, found at http://www.aqmd.gov/rules/reg/reg11/r1168.pdf . VOC limits are different for different types of adhesives. Selection of a safer adhesive should be done in consultation with a qualified industrial hygienist, as many adhesives contain other toxic compounds. See additional resources on adhesives above.
Ethylene Oxide (Sterilization)	Ethylene oxide	Alternative sterilization methods	<p>USEPA Region 9 published a fact sheet demonstrating the cost-effectiveness of replacing ethylene oxide with a safer sterilization process; it also includes a successful case study of a hospital that made the switch. See <i>Replacing Ethylene Oxide and Glutaraldehyde, Environmental Best Practices for Health Care Facilities</i>, November 2002, http://www.epa.gov/region09/cross_pr/p2/projects/hospital/glutareth.pdf.</p> <p>The Toxics Use Reduction Institute published a “Massachusetts Chemical Fact Sheet: Ethylene Oxide” (undated) that lists the advantages and limitations of ethylene oxide and other medical equipment sterilization methods. See http://www.turi.org/content/content/download/179/1430/file/eo.pdf.</p> <p>Hospitals for a Healthy Environment (H2E) included in its October 2004 newsletter, <i>STAT Green</i>, a case study of a hospital that replaced its ethylene oxide process with a low-temperature system that uses hydrogen peroxide gas plasma to sterilize its reusable medical instruments. See http://www.h2e-online.org/docs/h2estatgreen100104.pdf. H2E also maintains a web page with links to multiple resources on ethylene oxide and other sterilants. Some of these resources include information on alternatives or other exposure reduction strategies. See http://www.h2e-online.org/hazmat/steril.html.</p> <p>The Sustainable Hospitals Project maintains an online list of sterilization and high-level sterilization products that are free of ethylene oxide, glutaraldehyde and formaldehyde. Check with your vendor and industrial hygienist to determine whether they will provide an adequate level of sterilization to meet your needs. See http://www.sustainablehospitals.org/cgi-bin/DB_Report.cgi?px=W&rpt=Cat&id=28.</p>

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Product	Problematic Compound	Alternative	Resources
Ethylene Oxide (Sterilization) <i>(continued)</i>	Ethylene oxide	Alternative sterilization methods	The US Occupational Safety and Health Administration's 2002 fact sheet on "Ethylene Oxide" details steps employers and employees can take to minimize ethylene oxide exposures; see http://www.osha.gov/OshDoc/data_General_Facts/ethylene-oxide-factsheet.pdf .
Fabric protector spray	VOCs	Durable fabrics	Ask your vendor about durable fabrics that do not require you to apply a fabric protector.
Floor finish and floor wax	VOCs, phthalates	Low-VOC and phthalate-free floor finishes	<p>In November 2004, Green Seal issued a standard, GS-40, for "Industrial and Institutional Floor Care Products," which prohibits phthalates. A copy of the standard is available at http://www.green Seal.org/certification/standards/gS40.pdf. At least five products have been certified under this standard; a list of brands of Green Seal-certified floor finishes is available at http://www.green Seal.org/findaproduct/index.cfm#floorcare. In June 2004, Green Seal published a ChooseGreen Report on "Floor-Care Products: Finishes and Strippers;" see http://www.green Seal.org/resources/reports/CGR_floorcare.pdf. This publication recommends nine floor-finish products that are free of dibutyl phthalate, ammonia, and 2-butoxyethanol (two other respiratory irritants), and do not have VOCs exceeding 7% by weight.</p> <p>Center for a New American Dream maintains a list of cleaning products meeting a consensus standard that is similar to the Green Seal standard. For a list of approved products, see http://www.newdream.org/procure/products/approved.php#approved.</p> <p>Canada's Environmental Choice Program issued environmental certification criteria for "Hard Floor Care Products," which includes floor finishes, sealers, strippers, neutralizers and restorers. See CCD-147, (revised April 2004), http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_147.pdf. These criteria prohibit dibutyl phthalate as well as isocyanate, urethane polymers, halogenated or aromatic solvents, a pH above 12.5 and VOCs over 7-10%, depending on product type. At least two manufacturers have received Eco-logos for products meeting these criteria.</p> <p>Check MSDS for all floor finish products to determine the presence of other respiratory irritants. Avoid flooring types, such as vinyl composite flooring that requires the use of floor finishes and strippers. A floor finish monitoring method can reduce the frequency of finishing and stripping. See http://www.cmmonline.com/article.asp?indexid=6633860.</p>

Product	Problematic Compound	Alternative	Resources
Floor finish removers/ strippers	Monoethanolamine, VOCs, phthalates, fragrances, ammonia, potassium hydroxide (and other corrosive ingredients)	Low-VOC strippers	<p>Canada's Environmental Choice Program has issued an environmental standard for floor care products that prohibits ammonia and several glycol ethers, and limits the pH of strippers to below 12.5. Only one product has received an EcoLogo under this program (Enviro-Solutions Limited, which offers products in both the US and Canada). For more information on this standard, see http://www.environmentalchoice.com/English/ECP%20Footer/About%20Us/Criteria/Cleaning%20and%20Janitorial%20Products/Cleaning%20Products/Strippers%20and%20Neutralizers.</p> <p>Green Seal's June 2004 Choose Green Report, "Floor-Care Products: Finishes and Strippers," recommends six brands of low-VOC (<7%) floor strippers that are free of ammonia (a severe respiratory irritant) as well as dibutyl phthalate, and several glycol ethers that can also irritate the respiratory tract; see http://www.greenseal.org/resources/reports/CGR_floorcare.pdf. (Note: These products may contain other respiratory irritants such as monoethanolamine, which are not on Green Seal's prohibited ingredients list.) In November 2004, Green Seal issued GS-40, a standard for institutional floor care products. Products certified under this standard cannot have more than 7% VOCs, be corrosive to eyes and skin, or contain phthalates or fragrances. (It does not prohibit monoethanolamine or any other respiratory ingredients.) See: http://www.greenseal.org/certification/standards/g40.pdf. Green Seal has certified at least six floor strippers that meet this standard but a review of the MSDSs shows that many contain monoethanolamine and other respiratory irritants. See http://www.greenseal.org/findaproduct/index.cfm#floorcare.</p> <p>Ask your vendor about monoethanolamine-free and non-ammoniated floor strippers. Read all MSDSs for floor strippers carefully to see if they contain other respiratory irritants of other chemicals of concern.</p>
Formaldehyde	Formaldehyde	Formaldehyde-free fixatives	The Sustainable Hospitals Project lists suppliers of fixatives and other laboratory chemicals that are free of formaldehyde and glutaraldehyde. See Formaldehyde-Free Products under Laboratory Chemicals and Equipment at http://www.sustainablehospitals.org .
Fragrances	Fragrance, phthalates	Fragrance-free products	Request fragrance-free products from your vendors. Include in your purchasing policy a preference for fragrance-free products. The Access Board, an independent federal agency whose mission is to promote accessibility to federal facilities for people with disabilities, developed a "Board Policy to Promote Fragrance-Free Environments" in July 2000. It requires facilities to refrain from using fragrance-emitting devices in meeting rooms and to post notices at public meetings encouraging attendees not to wear fragrances, etc. See http://www.access-board.gov/about/policies/fragrance.htm . Fragrance-free policies have been adopted by the State of Missouri (http://www.gcd.ia.mo.gov/scentfree.shtml), Kaiser Permanente (http://internalmemos.com/memos/memodetails.php?memo_id=2361) and numerous other entities. The Fragranced Products Information Network maintains a website listing policies, studies and other resources relating to the use of perfume and other products with fragrances; see http://www.fpinva.org/Access%20Issues/policies_wordage.htm .

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Product	Problematic Compound	Alternative	Resources
Gloves	Latex, phthalates (in PVC gloves)	Depending on the glove use, alternatives may be made of nitrile rubber, polyurethane, neoprene, or other materials	<p>The Sustainable Hospitals Project (SHP) lists a large variety of latex- and PVC-free examination and surgical gloves at http://www.sustainablehospitals.org/cgi-bin/DB_Report.cgi?px=W&rpt=Cat&id=8. Most of these gloves are made of nitrile, polyurethane, and other chlorine-free elastomers; a few are made of neoprene (aka, chloroprene, a chlorinated plastic), which is recommended only when chlorine-free replacements are unavailable for a specific application. SHP indicates when it has received documentation that the glove passes ASTM viral penetration tests for bloodborne pathogens. This organization also has developed some fact sheets on this topic, including "Selecting Medical Gloves," see http://www.sustainablehospitals.org/HTMLSrc/IP_Latex_GloveFacts.html, "Vinyl Medical Gloves: What are the Concerns," see http://www.sustainablehospitals.org/PDF/Vinyl_Gloves_Concerns.pdf, and "Questions to Ask When Selecting Medical Gloves for Handling Chemotherapy Drugs," see http://www.sustainablehospitals.org/PDF/ChemotherapyGloves.pdf.</p> <p>See additional links under Natural Rubber/Latex below. Additional suppliers of latex-free gloves can be found online by searching for "Latex-free Gloves."</p> <p>Hypo-allergenic/low-powder latex gloves may reduce but not eliminate exposure to latex. There is no safe use of natural rubber latex products on patients or by workers who have an allergy (type 1 immunoglobulin E hypersensitivity) to latex.</p>
Glutaraldehyde (disinfectant)	Glutaraldehyde	Various commercial systems are available	<p>The Sustainable Hospitals Project (SHP) links to suppliers of drop-in chemical replacements for glutaraldehyde (such as hydrogen peroxide, peracetic acid and ortho-phthaldehyde) as well as other technologies capable of performing high-level disinfection (such as Steris, Sterrad and Sterilox). See Disinfectants at http://www.sustainablehospitals.org. Note that many replacements are also hazardous, and so care should be taken to select a system that reduces worker exposure. The SHP also lists glutaraldehyde neutralizers, enclosures, and other safety equipment designed to prevent exposures to this high-level disinfectant in cases where complete elimination is not practical. See http://www.sustainablehospitals.org/HTMLSrc/IP_Glutcontrol.html#table2.</p>
Hand cleaners/ disinfectants	Chlorhexidine, hexachlorophene	Varies	<p>Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed, the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those that are not connected with asthma, have some hazard associated with them.</p>
Hexachlorophene	Hexachlorophene	Varies	<p>Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed, the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those that are not connected with asthma, have some hazard associated with them.</p>

Product	Problematic Compound	Alternative	Resources
Janitorial Cleaners	Monoethanolamine, VOCs	Low-VOC cleaners without monoethanolamine	<p>Massachusetts is the first state to require potential vendors to disclose whether their products contain compounds that may aggravate asthma. For information on this bid, see http://www.mass.gov/epp/products/cleaning.htm and http://www.newdream.org/procure/products/MassRFP.pdf. Request and review MSDSs for products listed here and ask the vendor directly and specifically whether these products contain monoethanolamine and other asthmagens listed in the Cleaners section of this report, as formulations change frequently and the products listed were not subjected to a certification process.</p> <p>Green Seal established a standard (GS-37) for environmentally preferable cleaners (updated on March 15, 2005). It covers general purpose, bathroom, glass and carpet cleaners used in institutional settings. It prohibits ingredients that are corrosive to the skin and eyes, many of which are also likely to be severely irritating to the respiratory system. It also sets limits on VOCs in approved products, and prohibits dibutyl phthalate, but not other respiratory irritants. A copy of GS-37 can be found at http://www.greenseal.org/certification/standards/g37.pdf. Green Seal has certified over 100 products under this standard; see http://www.greenseal.org/findaproduct/index.cfm#cleaners. The Center for a New American Dream lists additional products that meet equivalent “green” cleaning specifications; see http://www.newdream.org/procure/products/approved.php and http://www.newdream.org/clean/.</p> <p>Read MSDSs carefully if you are concerned about the presence of asthmagens and respiratory irritants because these products are not necessarily free of these substances, and some contain agents that can irritate the respiratory tract.</p> <p>Health Care Without Harm’s fact sheet, “Cleaning Chemical Use in Hospitals,” June 4, 2004, discusses the health effects – including asthma – linked to the use of janitorial cleaning chemicals in hospitals. It also identifies specific practices that increase exposure to harmful cleaning chemicals, such as using aerosols, inadequate ventilation, and improper mixing or dilution of formulations. A copy of this fact sheet is available at http://www.noharm.org/details.cfm?ID=606&type=document.</p> <p>INFORM’s 2002 report, <i>Cleaning for Health: Products and Practices for a Safer Indoor Environment</i>, suggests cleaning methods that can improve indoor air quality and reduce unnecessary exposure to janitorial cleaning chemicals; see http://www.informinc.org/CFHIFR.pdf. To order the entire book, go to http://www.informinc.org/cleanforhealth.php.</p> <p>The Toxics Use Reduction Institute has published a fact sheet, “10 Ways to Find Safer Cleaners,” that can help health care facility staff avoid products with potentially harmful ingredients. See: http://www.turi.org/content/content/view/full/3598/.</p>

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Product	Problematic Compound	Alternative	Resources
Janitorial Cleaners (continued)	Monoethanolamine, VOCs	Low-VOC cleaners without monoethanolamine	<p>The Janitorial Products Pollution Prevention Project (JP4) has developed a series of fact sheets detailing safe and effective ways to clean toilets, restrooms, glass, metal and other surfaces. See http://www.wrppn.org/Janitorial/factsheets/carpetcleaning.htm.</p> <p>The Office of the Federal Environmental Executive's Green Janitorial Products and Services webpage provides links to resources including case studies of federal agencies that have switched to less-toxic cleaning products, specifications adopted by state and local governments, PowerPoint presentations, and a model green janitorial service agreement; see http://www.ofee.gov/gp/greenjanitorial.html.</p> <p>The Sustainable Hospitals Project recommends the use of microfiber mops as a way to substantially reduce janitorial cleaning chemical use and its associated hazards. Go to http://www.sustainablehospitals.org and see links to fact sheets, case studies and suppliers of microfiber mops. The US EPA published a fact sheet, "Using Microfiber Mops in Hospitals" (November 2002), that profiles the UC Davis Medical Center's successful switch to microfiber mops; they lowered their janitorial chemical use, shortened their room cleaning times, and reduced custodial staff injuries. For more information, see this fact sheet at http://www.epa.gov/region09/cross_pr/p2/projects/hospital/mops.pdf and a recent newsletter article, "Microfiber Mops: A Better Way to Clean" by the Massachusetts' EPP Program at http://www.mass.gov/epp/EPPUPDATES/volume_19_january_2006.pdf.</p>
Janitorial disinfectants	Quaternary ammonium compounds, chloramine T, phenol rosin, chlorine bleach	Varies	<p>Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed, the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those that are not connected with asthma, have some hazard associated with them. INFORM's fact sheet, "Respiratory Hazards and Janitorial Cleaners," recommends peroxide-based cleaners as an effective and more tolerable alternative to chlorine bleach-based products. See http://www.informinc.org/pacleaners.pdf.</p> <p>INFORM's 2002 report, <i>Cleaning for Health: Products and Practices for a Safer Indoor Environment</i>, has a chapter on "Antimicrobial Cleaning Products," that suggests ways to reduce janitorial disinfectant use and exposure. To order this book, go to http://www.informinc.org/cleanforhealth.php.</p> <p>The Janitorial Products Pollution Prevention Project (JP4) has a fact sheet on "Safe and Effective Disinfecting" that suggests ways to minimize disinfectant use. (Note this resource recommend using "quats," which are asthmagens.) See http://www.wrppn.org/Janitorial/factsheets/disinfectant.htm.</p>

Product	Problematic Compound	Alternative	Resources
Lab chemicals	Formaldehyde	Formaldehyde-free fixatives	See Formaldehyde-Free Products under Laboratory Chemicals and Equipment at http://www.sustainablehospitals.org .
Mattress, box spring, and pillow protectors (vinyl)	Phthalates, latex	Untreated 100% cotton, polyester protectors	<p>The Sustainable Hospitals Project database lists a few PVC-free bedding products, including polyethylene pillow and mattress covers and draw sheets. See http://www.sustainablehospitals.org.</p> <p>Many allergy supply vendors carry mattress and pillow protectors made of 100% cotton that has not been treated with chemicals; some are certified organic. Other non-PVC products are made of polyester, microfiber or blends of these materials. The tight weave of the fabric forms the barrier to dust mites. Among the online suppliers are nationalallergy.com, allergybuyersclub.com, allergybegone.com, safehomeproducts.com. Avoid products made with latex or polyurethane. See information on suppliers of latex-free products listed below.</p>
Methyl methacrylate (bonding cement)	Methyl methacrylate (MMA), phthalates	MMA-free bonding adhesives and resins for the dental, health care and construction industry	<p>Occupational health and personal protective precautions should be taken if an alternative cannot be found for specific applications. Several companies offer MMA-free dental adhesives and other prosthetic products:</p> <ul style="list-style-type: none"> Dental Arts Laboratories offers PermaSoft, an MMA-free soft denture liner that “chemically bonds to any acrylic surface without secondary adhesives or primers.” See http://www.dentalartslab.com/denture.htm. Dentsply makes a bio-compatible prosthetic resin for making dentures called Eclipse, which is free of ethyl, methyl, butyl or propyl methacrylate monomers. See http://www.trubyte.dentsply.com/prod_eclipseprs.shtml. GC America, Inc. makes a Hard Denture Chairside Reline Material that is MMA-free. This manufacturer of dental products claims that benefits of this product include reduced odor and less chemical irritation. For more information, see http://www.gcamerica.com/gcdent.html. (Read MSDS, which indicates that this product may cause respiratory effects.) ProdX offers COMPOSITRepair, a dental composite bonding agent that is MMA-free. See http://www.alldentalprodx.com/composit_repair.htm. <p>MMA is found in construction adhesives that are capable of permanently attaching difficult-to-bond substrates such as metals, ceramics, and plastics. GreenSpec Directory lists at least two environmentally multipurpose construction adhesives that can bond to both porous and nonporous materials such as plastic, metal, cement and brick. Check with the manufacturer of these products to determine whether they meet your performance needs. GreenSpec Directory is available only by online subscription or purchase at http://www.buildinggreen.com/ecommerce/gscfm.</p> <p>Ask your vendor whether any of the GreenGuard-certified or other formaldehyde-free adhesives can replace an MMA-based adhesive you are currently using. (See links to low-VOC adhesives above.)</p> <p>Note: a chemical company in China has developed acrylate-free resins for architecture and other applications, but it is unclear whether they have penetrated the US marketplace. See http://www.emgchina.com/cn/prfitem.asp?id=1754.</p>

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Product	Problematic Compound	Alternative	Resources
Natural Rubber/latex	Latex	Latex-free products	<p>The Sustainable Hospitals Project maintains links to suppliers of latex-free products, including electrodes (also PVC-free), self-adherent wrap, and other products listed elsewhere in this table. See http://www.sustainablehospitals.org. It also has developed fact sheets on “Key Steps for Reducing Latex Allergy”, ways to detect latex exposures, and strategies for finding safer alternatives. See http://www.sustainablehospitals.org/HTMLSrc/IP_factsheet_contents.html#latex.</p> <p>The American Latex Allergy Association maintains several online databases of links to suppliers of latex-free medical, dental and consumer products. Its hospital products list includes items such as latex-free airway masks, blood pressure cuffs, casts, catheters, contraceptives, crutches, dressings, elastic bandages, gloves, IV tubes, lab coats, manual resuscitators, medication vial stoppers, operating room hair and shoe covers, oxygen masks, rubber sheets, stethoscope and suction tubing, syringes, adhesive tape, tourniquets, and vascular stockings. Its dental products list includes some products unique to dentist use such as latex-free dental dams, impression material, and orthodontic rubber bands. See http://www.latexallergyresources.org/ResourceManual/Section1/medicalProducts.cfm. Its consumer list includes products that may also be used in healthcare facilities such as latex-free art supplies, balloons, erasers, rubber yoga/exercise mats and other athletic equipment, food storage wrap and bags, pacifiers, teething rings and other maternal nursing supplies, toys, non-skid pads for rug underlays, rubber pants for babies and incontinent adults, shower and swim caps, swimwear and undergarments. See http://www.latexallergyresources.org/ResourceManual/Section1/consumerProducts.cfm.</p> <p>Rescue House maintains an online list of latex-free products used by paramedics, emergency medical technicians, and other first-responders at http://www.rescuehouse.com/content/ems-equipment/cat_latex_free_supplies.php.</p> <p>The Spina Bifida Foundation maintains an extensive list of alternatives because 70%+ of all children with SB develop a latex allergy; see http://www.spinabifida.us for contact information.</p> <p>The Tempe, Arizona Fire Department published a paper detailing the procedures its staff should follow for managing patients with suspected latex allergies. It includes a list of products to include in its latex-free medical kit. See http://www.tempe.gov/fire/Policies%20and%20Procedures/PDF%20Files/210.13.pdf.</p> <p>The Vanderbilt Medical Center Reporter published an article in August 2005, “Children’s Hospital Makes Move to Latex-free Materials,” describing how this facility is finding alternatives in order to reduce allergic reactions by patients and staff. See http://www.mc.vanderbilt.edu/reporter/?ID=4148.</p>

Product	Problematic Compound	Alternative	Resources
Natural Rubber/latex <i>(continued)</i>	Latex	Latex-free products	<p>The American Nurses Association maintains a web page called “Latex Allergy: Protect Yourself, Protect Your Patients,” which lists several strategies for reducing exposures to latex and finding safer alternatives. See http://www.nursingworld.org/osh/wp7.htm#10.</p> <p>Additional products such as latex-free can be found by searching for “latex-free” online. Avoid latex-free products that contain polyvinyl chloride (PVC).</p>
Paint strippers and graffiti removers	Sodium hydroxide, potassium hydroxide, methylene chloride, monoethanolamine, 2-butoxyethanol, d-limonene, xylene, n-methylpyrrolidone, VOCs	Low-VOC paint strippers	<p>Most paint strippers contain hazardous chemicals, even those designated as biodegradable, low-VOC or less-toxic. Follow all recommended occupational health precautions and consult an industrial hygienist when selecting a paint stripper. Review MSDSs for all products; avoid the respiratory irritants listed, and evaluate inhalation hazards of products you are considering buying. Look for those with the least corrosive ingredients. Avoid mechanical paint removal processes in indoor environments due to the difficulty in controlling dust from such operations. Avoid paint strippers in aerosol containers, since the fine mists they release can easily penetrate the lungs with hazardous chemicals. Use adequate ventilation and physical boundaries in areas where paint strippers and graffiti removal chemicals are being applied. If using these products outside, ensure they are not near open windows or air intake valves.</p> <p>Compare VOC content when selecting a paint stripper and select the one with the least VOCs appropriate for your application. All paint strippers should have less than 350 grams of VOCs per liter, which is the VOC limit established for paint strippers by the South Coast Air Quality Management District Rule 1136, found at http://www.aqmd.gov/rules/reg/reg11/r1136.pdf.</p> <p>Canada’s Environmental Choice Program has issued a standard for “Paint and Varnish Remover” that is free of methylene chloride, contains no more than 250 mg/g of VOCs, and is readily biodegradable; see http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_051.pdf. At least two companies have received an EcoLogo under this standard.</p> <p>In areas where graffiti is common, consider using paints and other wall coverings that facilitate easy removal of graffiti, gum, and other foreign substances. For information on safer graffiti removers, see the Center for a New American Dream’s Graffiti Remover Research and Field Test Report: The Search for Safer Products (October 2003), http://www.newdream.org/procure/graffiti.php.</p>

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Product	Problematic Compound	Alternative	Resources
Paints	VOCs	Low- or zero-VOC paints	<p>Ask your vendor to supply zero or low-VOC paint products that meet your needs. All coatings should meet the VOC limits of the South Coast Air Quality Management District Rule 1113, found at http://www.aqmd.gov/rules/reg/reg11/r1113.pdf. A list of zero-VOC paint manufacturers is available at http://www.delta-institute.org/publications/paints.pdf. Additional products may be found by typing “zero-VOC paint” into your Internet browser. Note that the “zero-VOC” paint label only signifies that the VOC content is below a certain threshold, but is not necessarily zero.</p> <p>Green Seal issued voluntary standards for environmentally preferable interior and exterior paints and coatings in 1993. It set limits on VOCs (based on paint type), restricted aromatic compounds to 1%, and prohibited substances such as formaldehyde, methylene chloride, and phthalates, some of which are respiratory irritants. A copy of this standard is available at http://www.greenseal.org/certification/standards/paints.cfm. Paint products made by at least 17 manufacturers have been certified by Green Seal under this standard; they can be found at http://www.greenseal.org/findaproduct/index.cfm#paints.</p> <p>The GreenGuard Institute has issued a standard for low-emitting paint products that limits formaldehyde, VOCs, and a few other toxic substances. See http://www.greenguard.org/DesktopDefault.aspx?tabindex=3&tabid=16#paint. Only one product line has been certified under this standard. Canada’s Environmental Choice Program has issued a voluntary standard for paint (CCD-047) that prohibits methylene chloride, 2-butoxyethanol, formaldehyde, phthalates, and other chemicals of concern, some of which are respiratory irritants. It also sets limits on VOCs for paint products based on type (e.g., interior flat, etc.). See http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_047.pdf. It has certified several products under this standard. Be aware that these products have not been screened for all potential respiratory irritants. Check the MSDSs of these (and other paint products) for potential health effects associated with inhalation (and other routes of exposure).</p> <p>The US EPA published a report, <i>Painting the Town Green: Aberdeen Proving Ground’s Paint Pilot Project</i>, November 1999, that details the environmental benefits, lessons learned, and cost savings one federal facility experienced by switching to environmentally preferable paint; see http://www.cleanairecounts.org/resource%20package/A%20Book/paints/paints.pdf.</p>
Patient identification bracelets (PVC) and cards	Phthalates	PVC-free patient ID bracelets and cards	<p>The Sustainable Hospitals Project lists three types of available non-PVC patient ID bracelets; two are made of Tyvek, and the other is non-stretch polyester. The Tyvek bracelets are appropriate only for short hospital stays. It also includes a website explaining the benefits of Tyvek ID bracelets; see http://www.sustainablehospitals.org/HTMLSrc/IP_Tyvek_ID.html.</p>

Product	Problematic Compound	Alternative	Resources
Pesticides (including insecticides, herbicides, rodenticides, etc.); lindane for lice control	Organophosphate pesticides, captifol, pyrethrins, pyrethroids, n-methyl carbamate, and other pesticides	Minimize pesticide use with an Integrated Pest Management (IPM) Program	<p>Many commercial companies provide IPM services. For a list of companies that offer IPM services; see Beyond Pesticide's Safety Source for Pest Management provider directory at http://www.beyondpesticides.org/infoservices/pcos/index.htm. Beyond Pesticides and Health Care Without Harm published a handbook on this topic for health care facilities, "Healthy Hospitals: Controlling Pests Without Harmful Pesticides." It walks hospital staff through the steps they can take to implement an IPM program, including adopting a policy with IPM clearly defined; develop and follow guidance directing staff and contractors to use pesticides only after non-toxic pest control methods have been tried and determined to be ineffective; provide staff and contractors with IPM training, and include IPM requirements in pest management contracts. A copy of this publication is available at http://www.beyondpesticides.org/hospitals/Healthy_Hospitals_Report.pdf.</p> <p>Health Care Without Harm has a webpage with other IPM resources, including successful case studies and links to other organizations' informational materials; see http://www.noharm.org/pesticidesCleaners/pesticides.</p> <p>The Veterans Health Administration published The Integrated Pest Management Program Guide for Environmental Managers (October 1998), which offers "guidelines for administering an effective in-house or contracted integrated pest management program." See http://www1.va.gov/vhapublications/ViewPublication.asp?pub_ID=1093. Model IPM contracts for schools may be useful for hospitals; they are posted on the University of Florida's School IPM website at http://schoolipm.ifas.ufl.edu/doc/model_contract.htm and Virginia Cooperative Extension's School IPM website at http://www.ext.vt.edu/schoolipm/. These organizations offer additional technical resources on this topic as well.</p> <p>The IPM Institute of North America operates a program that enables hospitals and other types of organizations and businesses to become an IPM Certified Organization; see http://www.ipminstitute.org/IPM_Star/ipmstar_organizations.htm.</p> <p>The Office of the New York State Attorney General published a report, Pest Management in New York State Hospitals: Risk Reduction and Health Promotion (December 1995), which presents recommendations relating to the adoption of IPM policies, notifying the hospital community, and maintaining records about facility pesticide use. See http://www.oag.state.ny.us/environment/hospital95.html.</p> <p>San Francisco Department of the Environment's website highlights key IPM activities its program has undertaken; see http://www.sfenvironment.com/aboutus/innovative/ipm/getting_past_pesticides.pdf.</p>

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Product	Problematic Compound	Alternative	Resources
Polyvinyl chloride (PVC)	Phthalates	PVC-free products	<p>Most flexible PVC products contain phthalates. Ask your vendor for PVC-free alternatives. When PVC-free products are unavailable, use DEHP-free PVC products. Direct your suppliers to the Sustainable Hospitals Project (http://www.sustainablehospitals.org), a comprehensive resource that includes a listing of manufacturers of alternative materials and processes. The Sustainable Hospitals Project website links to suppliers of numerous PVC-free and DEHP-free medical supplies, including blood bags, body bags, catheters, dialysis solution products, electrodes (also latex-free), enteral feeding products, neonatal medical products, respiratory therapy supplies, and total parental nutrition bags.</p> <p>Health Care Without Harm publishes a fact sheet, "Alternatives to Polyvinyl Chloride (PVC) and Di(2-ethylhexyl) phthalate (DEHP) Medical Devices," which also contains a detailed listing of non-PVC alternatives for medical devices and supplies including bags, body bags, blood and dialysis products, enteral feeding sets, catheters, gloves, intravenous products, irrigation and drainage products, medical film, respiratory therapy products, sequential compression devices, splints, sump tubes and total parental nutrition products. A copy of this fact sheet is available at http://www.noharm.org/details.cfm?type=document&id=591.</p> <p>The Sacramento Business Journal published an article, "Hospital System to Use PVC IV Bags," November 21, 2005, which describes how a chain of hospitals in California, Arizona and Nevada have launched a plan to purchase \$70 million worth of PVC-free IV bags and tubing over the next five years. See http://www.bizjournals.com/sacramento/stories/2005/11/21/daily8.html?from_rss=1.</p>
Pressed wood products (including particleboard, medium-density fiberboard (MDF) and other engineered wood products)	Formaldehyde, other VOCs	Specify formaldehyde-free pressed wood products	<p>Ask vendors to supply formaldehyde-free and low-VOC pressed-wood products.</p> <p>Advanced Building's online guide to environmentally appropriate technologies and practices has a page on "Formaldehyde-free MDF," which describes the costs, benefits, and limitations of particleboard devoid of formaldehyde adhesives and links to a few manufacturers of these products; see http://www.advancedbuildings.org/main_t_finishes_formaldehyde.htm.</p> <p>INFORM's 2003 fact sheet, "Respiratory Hazards and Pressed-Wood Products" explains why formaldehyde-free particleboard is environmentally preferable and identifies a few suppliers. See http://www.informinc.org/papressedwood.pdf.</p> <p>Green Seal's 2001 ChooseGreen Report, "Particleboard and Medium-Density Fiberboard", lists formaldehyde-free pressed wood products made from agricultural waste or recycled fiber. See http://www.greenseal.org/resources/reports/CGR_particleboard.pdf.</p>

Product	Problematic Compound	Alternative	Resources
Pressed wood products (including particle-board, medium-density fiberboard (MDF) and other engineered wood products) <i>(continued)</i>	Formaldehyde, other VOCs	Specify formaldehyde-free pressed wood products	<p>Austin Texas' Sourcebook for Green and Sustainable Building contains a chapter on Engineered Sheet Materials; some of the listed products are made with formaldehyde-free and/or low-VOC adhesives and resins. See http://www.greenbuilder.com/sourcebook/EngSheet.html.</p> <p>GreenGuard's Certification Program for Low-Emitting Products has certified at least one engineered wood product; see http://www.greenguard.org.</p> <p>GreenSpec Directory lists several "Engineered Lumber Products," "Wood Fiberboard and Particleboard," and "AgFiber Particleboard" that include formaldehyde-free binders or other green features (not all are low-VOC). This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gs.cfm.</p> <p>Canada's Environmental Choice Program has established a standard for bamboo, virgin wood, and other wood-substitute flooring products with low emissions of formaldehyde and other VOCs. It has also certified at least two Canadian products that meet these standards. See http://www.environmentalchoice.com.</p>
Resilient flooring, PVC	Phthalates	Non-PVC flooring	<p>Healthy Building Network has published a table of PVC-free resilient flooring products, which is available at http://www.healthybuilding.net/pvc/PVCFreeResilient.html. It lists flooring products such as linoleum, chlorine-free polymers, cork, bamboo, and rubber. (Warning: not all of these products are free of other respiratory irritants; check before ordering.)</p> <p>The Collaborative for High Performance Schools (CHPS) lists in its Low-Emitting Materials Table several brands of resilient flooring that meet 01350 emissions tests. Beware that many of these products contain PVC, and hence, phthalates. Look for products made of non-PVC materials such as chlorine-free polymers, linoleum, and rubber. See http://www.chps.net/manual/lem_table.htm.</p> <p>GreenGuard lists dozens of resilient floor products that are certified as low-emitting. Beware that many products on this list contain PVC/phthalates. The PVC-free products are linoleum, laminate, and rubber. GreenGuard's searchable product guide can be found at http://www.greenguard.org.</p> <p>FloorScore lists dozens of resilient floor products that are certified as low-emitting. Beware that many products on this list contain PVC/phthalates. The PVC-free products are linoleum and polymeric. FloorScore certified products can be found at http://www.scs-certified.com/iaq/floorscore_1.html.</p>

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Product	Problematic Compound	Alternative	Resources
Quaternary ammonium compounds (janitorial disinfectant)	Quaternary ammonium compounds	Varies	Work with hospital industrial hygienist and infection control officer so that disinfectants are used only where needed, the safest disinfectant is selected for each application, and occupational health protections are in place. All disinfectants, including those that are not connected with asthma, have some hazard associated with them. See resources under Janitorial Disinfectants, above.
Shower curtains and liners	Phthalates	Tyvek or nylon shower curtains, others	<p>The Healthy Building Network's PVC-free materials list includes contact information for vendors of several types of PVC-free shower curtains including nylon, Tyvek, polyethylene, PEVA (a chlorine-free/phthalate-free plastic), polyester, cotton (preferably organic), canvas, and cotton duck. It also suggests installing durable shower doors and designing functional open showers that do not need a curtain. See http://www.healthybuilding.net/pvc/alternatives.html.</p> <p>The Sustainable Hospitals Project recommends Tyvek and nylon shower curtains, which dry quickly, reducing the formation of mold, another asthmagen. See their listing at http://www.sustainablehospitals.org.</p> <p>Additional suppliers, including some that cater to institutional buyers, offer PVC-free shower curtains made of nylon/polyester, cotton, linen, hemp, rayon, Tyvek, and blends of these materials. Some include Target, Ikea, Instawares, Bed Bath and Beyond, Restoration Hardware, Macy's, etc.</p> <p>Avoid shower curtains pretreated with Teflon, fungicides or polyurethane coatings.</p>
Silicone caulk	VOCs	Low- or zero-VOC caulks	Compare VOC content when selecting a caulk, and select the one with the least VOCs appropriate for your application. Zero VOC caulks are available for some applications. All caulks should meet the VOC limits for architectural sealants of the South Coast Air Quality Management District Rule 1168, found at http://www.aqmd.gov/rules/reg/reg11/r1168.pdf . The current limit for architectural sealants is 250 grams per liter. Canada's Environmental Choice Program has issued a standard for "Sealants and Caulking Compounds" (CCD-045), which allows up to 4% VOCs by weight. At least one company has received the EcoLogo under this standard. See http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_045.pdf . Zero-VOC caulks can be found online using your Internet browser. Selection of a safer caulk should be done in consultation with a qualified industrial hygienist, as many caulks contain other toxic compounds.

Product	Problematic Compound	Alternative	Resources
Solvents	VOCs	Depends on use	<p>Solvents are used for multiple purposes, and the selection of an appropriate lower-VOC alternative requires knowledge of the use and purpose of the solvent. SAGE, a comprehensive guide designed to provide pollution prevention information on solvent and process alternatives for parts cleaning and degreasing, is available at http://clean.rti.org/altern.cfm/. EPA offers an Integrated Solvent Substitution Data System at http://es.epa.gov/issds/. Many states offer assistance to businesses in reducing the use of solvents and other toxic ingredients. Find your local assistance program at http://www.p2.org/inforesources/p2rxpd.cfm.</p> <p>Green Seal and the Commonwealth of Massachusetts have certified several environmentally preferable degreasing agents that may be able to replace conventional solvents in some applications. For a list of approved products, see http://www.greenseal.org/findaproduct/index.cfm#cleaners and http://www.newdream.org/procure/products/approved.php.</p>
Treated fabrics	Formaldehyde, other VOCs	Untreated fabric	<p>Ask your vendor about the performance and availability of formaldehyde-free products.</p> <p>GreenGuard's Certification Program for Low-Emitting Products established a low-emissions standard for textiles that limits formaldehyde and other VOCs. Its website lists more than two dozen fabrics used to make draperies, upholstery, cubicles, and other products that meet this standard. For more information, see http://www.greenguard.org.</p> <p>GreenSpec Directory lists natural and synthetic fiber fabrics, many of which are free of chemical treatments that can contribute to poor indoor air quality. This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gscfm.</p> <p>GreenSage.com, an online supplier of sustainable furnishings and buildings supplies, offers organic cotton and other fabrics with other environmental attributes that are designed for draperies and furniture upholstery; many of these fabrics are formaldehyde-free and low-VOC; see http://www.greensage.com/12050FabricsIndex.html. Other suppliers of formaldehyde-free fabric (that can be used to make draperies) may be listed on http://www.OrganicCottonDirectory.net.</p>
Wall coverings	Phthalates, VOCs and mold (because vinyl wall coverings are not breathable and trap moisture underneath them)	PVC-free wall coverings with low-VOC adhesives	<p>The Healthy Building Network's PVC-free Materials List includes about a dozen manufacturers of PVC-free wall coverings, with links to company websites and product descriptions. See http://www.healthybuilding.net/pvc/alternatives.html.</p>

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Product	Problematic Compound	Alternative	Resources
Wall coverings (continued)	Phthalates, VOCs and mold (because vinyl wall coverings are not breathable and trap moisture underneath them)	PVC-free wall coverings with low-VOC adhesives	<p>GreenGuard's database of Indoor Air Certified Products lists hundreds of low-emitting wall coverings. While some contain vinyl, others are made of polyester, PVC-free polymer, and other materials. In some cases, these ingredients are listed (check manufacturer websites for more detail).</p> <p>GreenSpec Directory profiles dozens of PVC wall coverings, including some that are scrubbable, paintable, and/or flame retardant. The products are made from materials including woven polyester and textile glass, nylon, plaster, recycled paper, wood chips, and blends containing agricultural fibers, acrylic, and other substances. This book must be purchased or accessed online at http://www.buildinggreen.com/ecommerce/gscfm.</p> <p>Consider durable wall coverings made from bamboo and other sustainably harvested materials. Specify low-VOC/formaldehyde-free wall coverings and adhesives; see Adhesives, above.</p>
Window treatments (durable press drapes)	Formaldehyde	Untreated fabric	<p>Ask your vendor about the performance and availability of formaldehyde-free products.</p> <p>Gaiam, a green products company, offers natural cotton drapes; see: www.gaiam.com. Other suppliers of formaldehyde-free draperies (or fabric that can be used to make draperies) are listed on http://www.OrganicCottonDirectory.net.</p>
Wood stains and varnishes	VOCs	Low-VOC wood stain	<p>Compare VOC content when selecting wood stains and varnishes, and select the one with the least VOCs appropriate for your application. All wood stain and varnishes should meet the VOC limits of the South Coast Air Quality Management District Rule 1136, found at http://www.aqmd.gov/rules/reg/reg11/r1136.pdf. It sets a limit of 250 grams/liter for wood stains and 350 grams/liter for varnishes.</p> <p>Green Seal published a Choose Green Report on "Wood Finishes and Stains" (February 2005) that provides background on the human health and environmental hazards associated with these products. It also recommends products that are low-VOC and free of phthalates and aromatic solvents. See http://www.greenseal.org/resources/reports/CGR_wood_finish.pdf. Canada's Environmental Choice Program has issued a voluntary standard for wood stains and varnishes (CCD-047) that prohibits methylene chloride, 2-butoxyethanol, formaldehyde, phthalates, and other chemicals of concern, some of which are respiratory irritants. It also sets limits on VOCs of 250 grams/liter for varnish and 175 g/l for stain. See http://www.environmentalchoice.com/images/ECP%20PDFs/CCD_047.pdf. It has certified several products under this standard.</p> <p>Read MSDSs for these products, as they may contain other respiratory irritants and additional chemicals of concern.</p>

I. Cleaners, Disinfectants and Sterilizers

A range of chemical cleaning products is used in health care facilities. Hospitals also employ a variety of methods to disinfect and sterilize surfaces and equipment in order to eliminate pathogens, a concern of particular importance in health care settings. Many of the chemicals in these products present a variety of human health and environmental concerns, including general respiratory effects, the development of new-onset asthma, and the exacerbation of existing asthma. Comprehensive lists of chemicals found in cleaning and disinfectant products used in hospitals are difficult to compile because the types of products used vary depending on the size and needs of the hospital, and because new chemicals, cleaners, and disinfectants are constantly being introduced into the marketplace.

A. Scientific Evidence of Potential Harm

As shown in Table 1, the IOM did not review cleaners, disinfectants, or sterilants associated with asthma. However, the AOEC found causal evidence relative to the development of asthma. Likewise, the CHE found either good or strong evidence associated with these substances and asthma (although the CHE does

not distinguish which are capable of causing vs. exacerbating the disease). In addition, reviews of research identified through Medline prior to January 2002 substantiate associations between asthma and quaternary ammonium compounds, benzalkonium chloride, chloramine T, chlorhexidine, ethanolamines, ethylene oxide, formaldehyde, glutaraldehyde, and hexachlorophene.²⁹

Cleaners (Including Floor Strippers) and Disinfectants

- **Chlorine bleach:** Active agent in bleach is the chlorine releasing agent sodium hypochlorite in amounts equivalent to 3-10% chlorine, a strong irritant gas.³⁰
- **Quaternary ammonium compounds (quats):** Active ingredients in various disinfectants used in health care settings; also found in agents that are included in the last rinse in laundering in some health facilities.
- **Ethanolamines:** Found in a variety of detergents; also an active ingredient in floor strippers.

Specialty Disinfectants

- **Chlorhexidine:** Active ingredient in antiseptic cleaners used as surgical scrubs, skin wounds, germicidal hand rinses, and antibacterial dental rinses.

- **Hexachlorophene:** Also known as Nabac, hexachlorophene is a broad-spectrum antiseptic agent found in hospital scrubbing agents.
- **Chloramine-T:** In addition to use as a disinfectant used on surfaces and instruments, Chloramine-T has also been used as a disinfectant treatment for burns, wounds, and as an oral mouthwash.

Disinfectants/Sterilants

- **Glutaraldehyde:** Most frequent use is for high-level disinfection and the cold sterilization of instruments; also used as a tissue fixative (embalming agent) in histology and pathology labs, and as a hardening agent in the development of X-rays.
- **Ethylene oxide:** Antimicrobial pesticide used in the health care setting to sterilize heat- and moisture-sensitive medical supplies, such as surgical equipment.
- **Formaldehyde:** Used as a disinfectant in operating rooms, a sterilizing agent, and a tissue fixative. It is also a widespread volatile organic compound (VOC). Further discussion of this agent is found under the VOC section.

A study in Finland found an increased risk of persistent adult-onset asthma among female cleaners relative to female administrative workers

Additional scientific evidence demonstrating concern for asthma related to cleaning, disinfectant, and sterilizing agents is also worth noting. INFORM (a research organization on purchasing for pollution prevention) notes specifically that janitorial cleaners containing ammonium quaternary compounds, chlorhexidine and chloramines-T have caused or can cause asthma in some workers.³¹ INFORM also lists a number of other compounds that may pose a risk of asthma to janitors.^v Although the US government does not require pre-market testing of cleaning products or their ingredients for their ability to cause IgE-mediated reactions and/or asthma,³² occupational surveillance systems and case reports of

asthma-related outcomes from exposure to chemicals found in cleaning, disinfecting, and sterilization products have helped to identify the products and individual chemicals of concern. Between 1993 and 1999, the Sentinel Event Notification System for Occupational Risk (SENSOR) found that the second most frequently associated category of agents associated with work-related asthma cases was cleaning materials, which were linked to 11.6% of all work-related asthma cases.³³ Cleaning materials were the most commonly reported exposure for cases of work-related asthma among health care workers in the four states covered by SENSOR.³⁴ Cleaning agents identified by SENSOR as associated with occupational asthma can be found in

Appendix B. Another review of SENSOR data found that janitorial cleaning staff comprised 22% of work-related asthma cases (new onset, work aggravated, and occupational asthma) that were associated with exposure to cleaning products at work.³² A study in Finland found an increased risk of persistent adult-onset asthma among female cleaners relative to female administrative workers³⁵ (women employed in administrative, managerial, and clerical departments). Glutaraldehyde was one of the most commonly identified agents that caused asthma reported by the 1998 United Kingdom Surveillance of Work-Related and Occupational Respiratory Disease (SWORD) system.³⁶ The prevalence of work-related lower respiratory tract symptoms in hospital endoscopy nurses exposed to glutaraldehyde in addition to other exposures (e.g. latex) has been reported to be 8.5% and 66.6% in current and former employees, respectively.³⁷ Interestingly, as a result of decreased use of glutaraldehyde in the UK, economic forces removed it from the market.

It is important to acknowledge that many of these agents are associated with other problematic health risks. In particular, ethylene oxide is a known reproductive toxin and a human carcinogen, according to the National Toxicology Program.

^v Although not confirmed by the principal sources used in this report, INFORM also lists the following agents found in cleaners/disinfectants, used in medical institutions as associated with asthma: parasterol, cetalkonium chloride, cetrinide, cetylpyridinium chloride and benzyldimethylstearylammonium chloride.

B. Exposure Considerations

The harmful effects from exposure to chemical cleaning agents are a serious concern for janitors and others who are responsible for cleaning activities.³² Other hospital employees, such as laboratory technicians, also use cleaners. Non-janitorial employees, patients, and visitors are exposed indirectly to vapors from cleaning activities or spills of cleaning agents. According to George O'Conner, MD of the Boston University Medical Center, (personal communication, 12/20/05), patients have been reported to have experienced asthma attacks after their rooms were cleaned. Because hospitals are high-traffic areas and disinfection is necessary, they tend to require more cleaning than other building environments, resulting in greater exposure to these agents.

Virtually everyone in a hospital building will be exposed to cleaning products and their vapors. Some individuals will have more exposure than others, such as maintenance staff, as noted above, and those who work or spend time in areas with low ventilation. Because of the potential for near universal exposure, hospitals may wish to make a high priority of changing cleaning products and processes. It is particularly important that hospitals with staff members experiencing asthma

symptoms associated with their exposure to cleaners look closely at these products.

According to the National Institute for Occupational Safety and Health (NIOSH), exposure to glutaraldehyde is of concern to hospital staff who work in areas with cold sterilization processes that employ glutaraldehyde (gastroenterology and cardiology departments) and who work in operating rooms, dialysis departments, endoscopy units, and intensive care units where glutaraldehyde formulations are used for infection control procedures. Exposure is also of concern to central service (supply) workers who use glutaraldehyde as a sterilant; research technicians, and pharmacy personnel who either prepare the alkaline solutions or fix tissues in histology and pathology labs; laboratory technicians who sterilize bench tops with glutaraldehyde solutions; and workers who develop X-rays.³⁸ Patients, visitors, and hospital staff may also be exposed to glutaraldehyde vapors in patient rooms and clinical areas. Although glutaraldehyde exposure in hospitals is a recognized cause of occupational asthma in many industrialized nations, studies demonstrate that adverse respiratory health effects may occur at levels below 0.2 ppm, the current NIOSH Recommended Exposure Limit.³⁹

Exposure to ethylene oxide may occur primarily to hospital technicians operating sterilization equipment. Exposure occurs through the pressurized ethylene oxide gas cylinder from: leaky valves, fittings, piping, and sterilizer door gaskets; the opening of the sterilizer door at the end of a sterilization cycle; and improper ventilation of the sterilizing equipment and aerators.⁴⁰ In addition to workers, patients may also become exposed to ethylene oxide from the sterilized equipment, as demonstrated by a study of dialysis patients which found that elevated levels of IgE antibodies specific to ethylene oxide were associated with anaphylactic reactions during dialysis and in those who had asthma.⁴¹

Based in part on findings regarding the carcinogenicity of ethylene oxide, the Occupational Safety and Health Administration (OSHA) promulgated a health standard in 1984 that limited employee exposure to ethylene oxide to one part ethylene oxide per million parts of air measured as an 8-hour time-weighted average.⁴² A recent analysis of long-term ethylene oxide exposure trends in US hospitals found that hospital worker exposures to ethylene oxide declined after the declaration of this exposure limit and a subsequent short-term exposure limit (5

parts ethylene oxide per million parts of air measured as a 15-minute time-weighted average), which was implemented in 1988. The study also found that from 1996 through 2001, there was an increase in exposures exceeding the short-term limit.⁴³ A survey conducted in the early 1990s of 90 Massachusetts hospitals found that the median number of full time equivalent workers in the sterilization department was 7.6 (range 1.5-45), and the median number of sterilization loads using ethylene oxide processed was 7 (range 1-182) per week.⁴⁴

Summary Interpretation of Hazard and Exposure Evidence in Health Care Settings

Given the strong or good evidence linking the above agents to asthma onset and exacerbation, the likelihood that large numbers of workers, patients, and visitors will be affected by current usage makes the transition to alternative products and processes a high priority for health care facilities. Risks of other non-asthma health problems resulting from the use of agents like ethylene oxide should also be considered.

C. Alternatives

This section begins with general considerations and recommendations, followed by more specific alternatives to problematic chemicals. For each of the five categories of options listed below, it is helpful to begin by identifying which chemicals are producing concern. In order to enhance access to alternative resources, we have placed relevant websites directly within the body of the *Alternatives* sections, rather than as endnotes.

1) Eliminating/Reducing Use of Cleaning Chemicals: A variety of choices exist in this category of eliminating/reducing chemical usage. Use of microfiber mops and cloths may dramatically reduce the use of general cleaning chemicals for many facilities. These products are made from special fibers that trap dirt without the use of chemicals. A number of case studies on use of microfiber mops have been published, and can be reviewed to assist a hospital in determining whether this would be an appropriate option for them. Multiple references and resources regarding use of microfiber mops may be found at the following web addresses:

- <http://www.sustainablehospitals.org/PDF/MicrofiberMopCS.pdf>
- <http://www.ciwmb.ca.gov/WPIE/HealthCare/EPAMicroMop.pdf>

- <http://www.hpnonline.com/inside/2004-05/h0405CE%20Test%20for%20web.pdf>
- http://www.hfmmagazine.com/hfmmagazine/hospitalconnect/search/article.jsp?dcrpath=AHA/PubsNewsArticleGen/data/0401HFM_DEPT_EnvirServices&doMain=HFMMAGAZINE
- <http://www.sustainablehospitals.org/PDF/tenreasonsmop.pdf>

Careful planning of cleaning is also important; chemical use reduction can be achieved by paying attention to when surfaces need to be cleaned instead of setting an arbitrary schedule that has not been based on a true needs assessment. For instance, some surfaces may be cleaned daily, in spite of infrequent use, improbable infection transmission, and no evidence of requiring a cleaning. Surveying the various areas of the hospital and setting a schedule based on necessity may reduce the use of cleaning chemicals. The infection control officer could review disinfecting practices of the janitorial and other staff members, the scientific literature, and the data from the hospital to determine whether any surfaces currently being routinely disinfected do not require disinfection. Certain areas of the hospital may require harsh cleaners because they

rapidly accumulate dirt, but are cleaned infrequently. Cleaning these areas more frequently with less hazardous cleaners may also reduce exposure to more toxic cleaning chemicals. Some facilities use a harsh, toxic cleaner for all general cleaning, even though most jobs do not require such a harsh cleaner. Using a milder cleaner for routine cleaning and a harsh cleaner only when necessary can also reduce exposure. Much of the information in this section is garnered from *Cleaning for Health*, Culver, et al., INFORM, 2002, available through <http://www.informinc.org/cleanforhealth.php> and from the Janitorial Pollution Prevention Project at <http://www.wrppn.org/Janitorial/jp4.cfm>.

Implementation of certain preventive measures can reduce the burden of cleaning chemicals. Placing doormats at each entryway can reduce the amount of dirt tracked into a facility, and thus reduce cleaning frequency in some cases. If janitorial staff members are frequently cleaning up spills in certain areas of the hospital, changing work practices to reduce the incidence of spills can reduce cleaning chemical use. For example, if a certain reagent is frequently spilled as a laboratory worker transports it across the hallway, changing work practices to eliminate the need to transport the sample, or

Careful planning of cleaning is also important; chemical use reduction can be achieved by paying attention to when surfaces need to be cleaned instead of setting an arbitrary schedule that has not been based on a true needs assessment.

using different containers or transport mechanisms can reduce the incidence of spills.

For new buildings or significant remodels, considering cleaning requirements during the design stage can result in a building which requires fewer cleaning chemicals and enhances opportunities for using less toxic chemicals. More information on this approach is available in “Design for Cleanability,” Alex Wilson, *Environmental Building News*, Volume 14, Number 9, <http://www.buildinggreen.com/articles/IssueTOC.cfm?Volume=14&Issue=9>. Specific suggestions include integrating dirt track-off systems at each entryway (including entries from parking garages or industrial spaces within the building), and designing landscaping outside of

doors to minimize dirt tracking. Properly designed entryway track-off systems significantly reduce the amount of dirt and chemicals tracked into buildings on people’s shoes; such systems are typically underutilized in spite of their low expense. Given estimates that 85% of the dirt entering most commercial buildings is tracked in on building occupants’ feet, implementation of a good dirt track-off system could substantially reduce cleaning requirements.

2) Finding Chemical Substitutions: A second option is to seek substitutions for problematic cleaning chemicals, an endeavor that requires some time to determine which products currently used contain troubling ingredients. See Table 2, which lists certain chemical ingredients

that have caused or are suspected of causing occupational asthma. Some hospitals may wish to reduce the number or volume of products utilized that contain these chemicals, or hospital policies may be specified to avoid products containing ingredients to which certain individuals have been shown to be sensitive. Because Material Safety Data Sheets (MSDS) are not required to list all the ingredients in a product, it may be necessary to contact the manufacturer of the products in use, provide the manufacturer with the list of chemicals the hospital wishes to avoid, and to request a chemical review for a list of products offered without the undesired chemicals. In some cases, the problematic ingredient may not be the “active” or antimicrobial ingredient in the product. It can be important to communicate with the manufacturer that they are expected to review their entire ingredient list for each product, not just the MSDS, which does not contain all ingredients; many sales representatives are unaware that all ingredients would not be listed on the MSDS.

No central database exists for products that are known not to contain the problematic ingredients listed above. When it is clear that a certain ingredient should be avoided, the industrial hygienist and infection control officer can collaborate with

their vendors to find cleaning products that meet the required efficacy without the problematic ingredient. When seeking alternative products, it is necessary to work closely with vendors, provide them with the list of chemicals that should be avoided, and ask them if they have products that do not include those ingredients. Some staff members are responsible for ordering the disinfectants used in their area directly from the vendor. Administrative controls such as a restrictive agreement with the vendor or a requirement to purchase through a central administrative hospital department can help enforce prohibition of certain ingredients.

While a number of lists of “environmentally preferable cleaners” exist, none explicitly exclude products containing the ingredients listed above. However, companies that have taken the time to ensure that their products meet other environmental criteria may be willing to work with customers to provide products that reduce the risk of asthma. Green Seal, a nonprofit organization that facilitates the development of environmental standards and then certifies products that meet those standards, lists certified cleaners at <http://www.greenseal.org/findaproduct/index.cfm#cleaners>. The Center for a New American Dream lists products that

are on contract with states that have used their consensus environmental standards at <http://www.newdream.org/clean/>.

3) Isolation of Cleaning Chemicals: If only certain individuals are sensitive to a particular cleaner, use of that cleaner (if it cannot be eliminated) could be limited to areas where the sensitive individual does not work. If the best solution is determined to be to use certain products only in particular areas, training and enforcement are crucial for a successful outcome. Regular training of new janitorial staff and signs posted at the entrances to the area where use of a particular product is prohibited can assist in this effort. One employee on each shift should be made responsible for enforcing this control. Application of cleaning chemicals during certain shifts when fewer visitors and staff are present (i.e. the night shift) is another strategy to consider.

Some staff members bring in their own cleaning or janitorial products, which they use in their work area. An administrative policy prohibiting this practice and directing all staff members to contact the maintenance department when specialized cleaning is required can help ensure that only products determined to be appropriate for the hospital are used.

If it is determined that a sensitive individual experiences a problem exclusively during the application of a cleaning chemical, one solution may be to use those chemicals during a shift when that individual is not present. However, it should be considered that the residue left by the cleaning chemical might continue to cause a problem during subsequent shifts after cleaning.

4) Enhancing Engineering Controls: If the hospital has inadequate ventilation in certain areas, improving the ventilation in these areas or increasing the ventilation while cleaning chemicals are used in these areas may reduce the exposure of staff and patients to these chemicals.

5) Personal Protective Equipment (PPE) for sensitive individuals could be considered where all of the above options are not adequate. However, this is generally impractical, and care should be taken that the equipment does not interfere with performance of the individual's duties. PPE is typically the last option recommended in the hierarchy of controls that industrial hygienists and government agencies follow.

Who Should Be Involved in Addressing Problems with Cleaners

The director of facilities, janitorial staff, health-affected staff members or their representatives, the staff industrial hygienist, and infection control officer may all need to be involved in selecting and implementing the plans for control outlined above.

In addition, other staff or patients may need to be notified of any changes that will affect their perception of the hospital and its cleanliness. For instance, if the alternative involves cleaning a particular area less frequently, staff members and patients in that area should be notified of the change and its rationale, and should be invited to comment. Otherwise, they may conclude that the maintenance department is lagging in its responsibilities or is indifferent to the cleanliness of certain areas. Also, staff members may notice that they no longer detect the odor of the original cleaning product, which they might typically associate with a clean area, and conclude that it is unclean.

Alternatives to Specific Chemical Agents

In addition to the specific chemicals listed below, refer to Table 3: Alternatives to Agents of Concern.

Floor Finishes and Floor Finish Strippers: As with other janitorial products, floor finishes and strippers with reduced VOC levels may contribute to improved indoor air quality and reduced risk of respiratory irritation. Ask your vendor about the availability of floor strippers and finishes free of respiratory irritants such as ammonia, monoethanolamine, phthalates, potassium hydroxide, fragrances, and high concentrations of VOCs.

The Janitorial Products Pollution Prevention Project published a fact sheet on “Safe and Effective Use of Floor Finish Strippers,” which offers safety tips and recommendations for reducing the quantity of stripper needed to maintain floors; see <http://www.wrppn.org/Janitorial/factsheets/floor.htm>. A floor finish monitoring method can reduce the frequency of finishing and stripping. See “Never Strip Floors Again!” in *Cleaning and Maintenance Management Online* at <http://www.cmmonline.com/article.asp?indexid=6633860>.

Additional resources, including standards for and suppliers of environmentally preferable floor care products, are listed in Table 3.

Glutaraldehyde: A variety of alternatives to glutaraldehyde disinfectants for medical devices are available, although these alternatives should be carefully considered because some carry their own risks to workers. It is important to involve industrial hygienists and other staff in decisions about which high-level disinfectants (HLDs) to use and how to do so most safely. See <http://www.h2e-online.org/hazmat/steril.html> and <http://www.sustainablehospitals.org> for case studies and lists of alternative products.

In November 2002, the US Environmental Protection Agency published a fact sheet on “Replacing Ethylene Oxide and Glutaraldehyde” that delineates steps that health care facilities can take to record their uses of glutaraldehyde, prioritize practical applications for safer substitutes, involve employees in training programs, and monitor progress on minimizing use and exposures. It also includes a case study of a medical facility that eliminated glutaraldehyde from its highest use area (gastroenterology). After switching to ortho-phthalaldehyde (OPA), this facility experienced less frequent health complaints from workers, as well as a shorter disinfection time, which saved an hour of endoscope disinfection processing time daily. A copy of this fact sheet is available

at http://www.epa.gov/region09/cross_pr/p2/projects/hospital/glutareth.pdf.

One independent study compared the respiratory and dermal toxicity data for glutaraldehyde and other high-level disinfectants, including OPA, hydrogen peroxide, peracetic acid, and solutions containing combinations of these substances. It concluded that “Peracetic acid-hydrogen peroxide solutions may be the safest choice because they are not believed to cause allergic reactions or asthma.” In addition, the study concluded that while OPA has the potential to be a respiratory and dermal sensitizer, “the active ingredient concentration in the currently available OPA-based high-level disinfectants is much lower than that in glutaraldehyde solutions.” See “Considering Risks to Healthcare Workers from Glutaraldehyde Alternatives in High-level Disinfection,” *Journal of Hospital Infection* (2005) 59, 4-11 at <http://www.trudeau-foundation.ca/pdf/RideoutJournalHospitalInfection.pdf>.

The Sustainable Hospitals Project’s fact sheet, “Glutaraldehyde Control in Hospitals,” describes several options for health care facilities to eliminate or reduce their use of or exposure to this high-level disinfectant. These include: using glu-

taraldehyde-free disinfecting chemicals and technologies; centralizing, enclosing and/or ventilating glutaraldehyde soaking stations; training workers to identify exposures and follow better industrial hygiene practices; and using personal protective equipment and glutaraldehyde neutralizing solutions. A copy of this fact sheet is available at http://www.sustainablehospitals.org/HTMLSrc/IP_Glutcontrol.html. Similarly, NIOSH provides tips on how workers can prevent exposure to glutaraldehyde such as using fume hoods or other ventilation equipment; wearing nitrile or butyl-rubber gloves, goggles and face shields; and covering containers between use. See “Occupational Hazards in Hospitals: Glutaraldehyde,” May 2001, at <http://www.cdc.gov/niosh/pdfs/01-115.pdf>.

One way to reduce glutaraldehyde exposure is to switch to digital x-ray equipment, which eliminates the need for chemical fixatives. Several case studies of health care facilities that have replaced traditional x-rays with digital imaging can be found online by searching for “digital x-rays.” For example, Southeast Missouri Hospital reported that it reduced its costs by about 70 percent by switching from traditional x-rays to digital imaging technology, and dramatically lowered chemi-

cal and film storage costs. This facility reported other benefits such as faster access to the images, enhanced viewing, and the ability to share digital images so that many physicians can review and consult immediately and simultaneously. See “With Digital Imaging, Future is Now in Southeast’s Radiology Department,” Southeast Missouri Hospital, at <http://www.southeastmissourihospital.com/vi-mandvigor/fall2003/imaging.htm>.

Additional resources, including suppliers of products to replace or reduce exposures to glutaraldehyde, can be found in Table 3.

Chlorhexidine, Hexachlorophene: Alternatives to chlorhexidine and hexachlorophene may pose other occupational health risks. Ask your vendor for information on disinfectant products that are effective against the particular infection concerns for the particular process where these chemicals are now used. Work with your hospital industrial hygienist and infection control officer to review benefits and risks of options for your applications.

Ethylene Oxide (EO): For information and case studies on replacing ethylene oxide, see <http://www.ciwmb.ca.gov/WPIE/HealthCare/EPAEtOGLut.pdf> and

the NIOSH publication: <http://www.cdc.gov/niosh/pdfs/89-120-a.pdf>.

Several ethylene oxide-free sterilizing and high-level disinfecting technologies have recently emerged in the marketplace. They often rely on periacetic acid or hydrogen peroxide, and are also free of glutaraldehyde and formaldehyde. Ask vendors of these technologies to verify the types of equipment on which they have been approved for use, and what level of disinfection or sterilization they provide. In addition, ask your medical instrument supplier whether any non-EO processes have been approved for use on their equipment. Ask your industrial hygienist to review case studies of hospitals that have reduced or completely eliminated EO to determine whether they would be transferable to your facility (see Table 3).

Conduct an inventory on ethylene oxide usage in your facility to determine where it is being used, by which employees, and on which equipment. Prioritize for replacement those cases in which complete sterilization (as opposed to disinfection) is not needed, and in which the medical instruments to be sterilized are not sensitive to heat or moisture (since many more replacements are available for those applications). For cases in which EO cannot

be replaced, ask your industrial hygienist to help minimize exposures through the use of appropriate respirators, gloves, and other safety equipment. Infection control professionals can also help determine what type of disinfection is needed and whether sterilization is required.

For information on the feasibility and cost of replacing ethylene oxide, as well as links to suppliers of alternative sterilizing technologies and chemicals, see Table 3.

II. Natural Rubber Latex

Natural rubber latex (NRL) is used in a variety of hospital products, including latex gloves, balloons and catheters, crutches, dental dams, electrodes, exercise mats, needle plunger tips, medication vial stoppers, syringe plungers, adhesive tape, tourniquets, pacifiers and other maternal nursing products, rubber pants for infants and incontinent adults, stretchy bandages, EKG pads, aneroid sphygmomanometers, and many other items. Building supplies, such as rubber flooring and furniture, are additional sources of latex.

A. Scientific Evidence of Harm

Although the IOM did not review the science on latex, the AOEC states that latex is a cause of asthma, and the CHE found

One of the most important steps to reduce or eliminate airborne NRL is to substitute latex gloves with non-latex or powder-free NRL gloves.

strong evidence to support associations between exposure to latex and allergic asthma (the CHE does not distinguish between onset and exacerbation). Additional reviews of the literature also demonstrate that latex exposure causes allergic asthma.²⁹

As is the case with the majority of allergic asthma cases, there is a greater risk of NRL allergy among individuals who are atopic,⁴⁵ and the prevalence of latex sensitization is higher among individuals who are occupationally exposed to NRL.⁴⁶ In Massachusetts, NRL was associated with almost 10% of the occupational asthma cases reported to the SENSOR program between 1993 and 1998, and almost one third of the occupational asthma cases reporting a hospital as the industry were exposed to latex.⁴⁷ Another review found that latex exposure was one of the leading causes of occupational asthma in recent years.⁴⁸ Increased avoidance of latex

and use of powder free gloves has been recently reported to decrease the number of cases, as shown by fewer claims for occupational asthma due to latex.^{45,48}

The prevalence of NRL allergy has been estimated to be 5-18% in health care workers.⁴⁸ In the hospital setting, exposure to NRL gloves is associated with the greatest prevalence of allergic reactions to the substance.⁴⁹

B. Exposure Considerations

NRL exposure from gloves can be direct from dermal contact or indirect as a result of inhalation of latex aeroallergens--most often adhered to respirable powder (cornstarch) in latex gloves. Studies have demonstrated that cornstarch powder used to lubricate latex gloves acts as a carrier for the latex protein; when the gloves are removed, the latex protein in dust particles becomes airborne and can be inhaled, even by individuals not

wearing the gloves.⁴⁸ In the US, health care workers are the largest group with occupational NRL exposure, but hospital staff, patients, and visitors may all be exposed to the latex allergen.⁵⁰ Latex is a ubiquitous exposure in most health care facilities, and has been the focus of much recent work to reduce asthma risk from this source. NRL products cannot be used safely in patients or workers with a type I (IgE mediated) hypersensitivity to latex (a true latex allergy) because of their potential to induce anaphylaxis in susceptible individuals.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Natural Rubber Latex is an established risk factor associated with asthma onset and exacerbation. Given the high opportunity for exposure to NRL in health care settings, facilities should seek to reduce this known asthma risk.

C. Alternatives

One of the most important steps to reduce or eliminate airborne NRL is to substitute latex gloves with non-latex or powder-free NRL gloves. This substitution strategy has been proven to be an effective prevention strategy to reduce the incidence of suspected latex allergy

and specifically latex-related occupational asthma.⁴⁸ This is one of the clearest success stories where suitable alternatives are available and have been widely adopted, thereby reducing risk for health care staff, patients and visitors.

Many medical supply vendors now offer latex-free catalogs to assist facilities in minimizing latex use. A limited number of office suppliers have similar services. Gloves, for example, may be made of nitrile rubber, neoprene or other materials. More information about latex-free products is available from the Sustainable Hospitals Project at <http://www.sustainablehospitals.org>, the American Latex Allergy Association at <http://www.latexallergyresources.org>, and other sources. See Table 3 for further details.

III. Pesticides

Pesticides are products used to kill, repel or otherwise control insects, weeds, rodents, fungi, or other pests. Pesticides represent a broad category encompassing a range of products including herbicides, fungicides, insecticides, and rodenticides.

A. Scientific Evidence of Harm

The CHE determined that several classes of pesticides found to be in regular use by a majority of hospitals surveyed have been shown to be linked with asthma.⁵¹ These include organophosphates, carbamates, and pyrethroids. Organophosphate and carbamate pesticides are known to produce an irritant effect through the inhibition of cholinesterase.

The AOEC also examined specific pesticides commonly used by hospitals and other health facilities. They found evidence suggesting that the organophosphate insecticides diazinon (currently be-

ing phased out), malathion and acephate (also known as Orthene) as well as the synergist piperonyl butoxide have initiated *de novo* asthma in workers. Other reviews have also found evidence that these organophosphate pesticides—with the exception of acephate—cause asthma, although the occurrence is rare.²⁹ The IOM concluded there was inadequate or insufficient evidence in population-based studies to demonstrate risk of asthma exacerbation associated with non-occupational exposure to pesticides.

The evidence linking asthma with pesticides comes primarily from occupational case reports. Although some population-based studies have demonstrated increased risk of chronic respiratory symptoms among both children and workers exposed to pesticides,^{52,53} studies have not generally examined risk associated with asthma specifically. A few studies that have examined emergency room visits

The CHE determined that several classes of pesticides found to be in regular use by a majority of hospitals surveyed have been shown to be linked with asthma.

after a community mosquito eradication program found no elevations in asthma visits.⁵⁴ Some researchers have argued that reports from detailed case histories collected by astute clinicians, rather than population-based studies, will improve the level of evidence demonstrating risk of asthma associated with pesticides.⁵⁵

B. Exposure Considerations

Exposure to pesticides in hospital environments is generally highest among hospital employees who apply the pesticides. Other staff, patients, and visitors can be exposed if they spend time in areas where pesticides have been applied. Depending upon the compound, residues can persist for hours, days, or months following application.⁵¹ Indoor levels of pesticides are often higher than those outdoors because they do not diffuse, and because pesticides applied outdoors can be tracked indoors.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

At high levels, the above pesticides have been shown to cause asthma in occupational settings. However, the evidence on risks of asthma from lower levels of exposure is limited. Although pesticides may not pose a substantial risk of asthma

onset or exacerbation to patients and visitors, workers mixing and applying these agents are at higher risk.

C. Alternatives

Health care facilities have adopted Integrated Pest Management (IPM) programs for both building interiors and the grounds, in order to minimize pesticide use and exposure for staff, patients, and visitors. IPM is a program of prevention, monitoring, and control that eliminates or substantially reduces the need for pesticides, and thus has the potential to reduce health impacts associated with exposure to pesticides. IPM approaches include techniques such as augmented sanitation, structural repairs, improving soil health, and using non-chemical pest control devices such as mechanical traps, vacuuming, etc. In many settings, IPM itself has proven to be a cost-effective measure for preventing pest problems.⁵¹

Many commercial companies offer IPM services, which include pest monitoring, staff education, and other components that help to reduce pesticide use. A model IPM contract is available at http://schoolipm.ifas.ufl.edu/doc/model_contract.htm. More information on IPM is accessible at <http://www.noharm.org/pesticidesCleaners/pesticides>, and informa-

tion on selecting an IPM contractor may be found at <http://www.beyondpesticides.org/infoservices/pcos/index.htm>.

Respiratory symptoms are not the only health problems related to pesticides. Facilities should implement IPM programs for both the building interior and the grounds, to minimize pesticide exposure to patients, staff, and other building occupants. No regular staff should be permitted to bring in or apply pesticides in the building. According to a report “Healthy Hospitals: Controlling Pests Without Harmful Pesticides” (see <http://www.noharm.org/details.cfm?ID=864&type=document>), hospitals should adopt IPM policies, develop guidance materials, implement programs, provide training, include specifications in their contracts, and take other actions to promote IPM practices in their facilities. If pesticides are needed, health care facilities can also prevent exposure to these hazardous chemicals by notifying building occupants and neighbors before and after pesticides are applied, tracking pesticide use, reporting allergic reactions and other adverse health effects resulting from pesticide exposure, and offering pesticide-free areas as refuge places for sensitive populations.

More information on IPM is available from Health Care Without Harm at <http://www.noharm.org/pesticidesCleaners/pesticides>. See Table 3 for more information and resources on IPM.

IV. Volatile Organic Compounds

Volatile organic compounds (VOCs) are a group of organic chemicals characterized by their tendency to evaporate easily (i.e., at room temperature). Numerous common sources of VOCs in health care facilities include paints; adhesives; combustion sources; deodorizers (release p-dichlorobenzene and terpenes); showering and washing (releases chloroform, a disinfection by-product in chlorinated water); recently dry cleaned fabrics; caulks and sealants (release tetrachloroethylene); building materials such as particle board (formaldehyde); and interior surface coverings, including carpets, resilient flooring, wall coverings, ceiling tiles, and furniture. VOCs from the outdoor environment, such as benzene from automobile exhaust, can also enter indoors. VOC exposure from cigarette smoke (which releases aromatic and aliphatic hydrocarbons) is not likely in health care facilities that prohibit smoking.

The AOEC states that formaldehyde is an asthmagen in occupational environments, and the CHE found good evidence associating formaldehyde with allergic asthma.

Although compounds in fragrances can be considered VOCs, we discuss these substances later in a separate section. Formaldehyde, a commonly encountered VOC, is also discussed more specifically below.

A. Scientific Evidence of Harm

Formaldehyde is the most studied of the VOCs. It is a component of many building materials, consumer products, tobacco smoke and other combustion gases. Notable sources include urea-formaldehyde foam insulation (banned in 1982 by the Consumer Products Safety Commission); glues in plywood and pressed-board products; paper products including tissues, towels and bags; cosmetics and detergents; and emissions from gas stoves. In health care facilities, formaldehyde is used as a tissue preservative (fixative) and as a disinfectant in laboratories, dialysis units, and other areas.³⁴

The AOEC states that formaldehyde is an asthmagen in occupational environments, and the CHE found good evidence associating formaldehyde with allergic asthma (although the literature is unclear with respect to whether the mechanism is immunologic or irritant⁵⁶). Other reviews of the literature have also found that formaldehyde causes asthma, and roughly 30% of exposed individuals may be affected.²⁹ However, the IOM determined that there was inadequate or insufficient evidence to conclude that either the development of asthma or the exacerbation of existing asthma was due to formaldehyde exposure. The IOM's conclusion about the state of the evidence is that most population-based studies of formaldehyde in the indoor non-occupational environment have been unable to isolate formaldehyde as the causative agent in reported associations with asthma.

Additional relevant studies have been published since the IOM's review, however. One study included a detailed assessment of exposure to formaldehyde, and found increases of childhood asthma associated with formaldehyde levels.⁵⁷ A second study found that formaldehyde exposure was associated with atopy, that increasing formaldehyde exposure was associated with severe allergic sensitization, and that among children suffering from respiratory symptoms, more frequent symptoms were noted in those exposed to higher levels of formaldehyde.⁵⁸ A third study found a significant relationship between exposure to formaldehyde at residential concentrations and the exacerbation of symptoms in children with wheezing illness, as well as evidence of an exposure-response relationship and increased susceptibility in atopic subjects.⁵⁹ Although these last two studies add to the weight of evidence regarding the potential for formaldehyde to act as a respiratory irritant at lower levels of exposure, their conclusions are not entirely specific to asthma.

Very few studies have examined associations of asthma with exposure to VOCs other than formaldehyde or with exposure to a mixture of VOCs, often measured as TVOC (total volatile organic

compound). VOC exposures are usually complex mixtures from many sources. The exact composition will vary depending on the environment. The studies that have been done conclude that VOCs at levels typically found in homes may result in increased airway reactivity and decreased lung function in some individuals with previously diagnosed asthma, but research has not found that VOCs cause asthma in people previously free of the disease.^{60,61} However, a recent study with good control over numerous confounding risk factors did observe a dose-response relationship such that the greater the exposure to VOCs—in particular, benzene and toluene—the greater the risk of having asthma.⁶² The AOEC, IOM, and CHE have not found evidence to suggest risk of asthma (either onset or exacerbation) associated with these particular VOCs.

B. Exposure Considerations

Formaldehyde

Ubiquitous sources of formaldehyde exposure in areas within the indoor hospital environment include bedding, durable press drapes and other chemically treated fabrics; carpets, carpet cushions, and adhesives (used on carpeting, flooring, paneling, wall paper and other applications); pressed wood products such as

particle board; acoustical ceiling tiles and other fiberglass products; furniture, cabinets and other fabricated wood products; and paint, primers and other coatings. Workers are more likely to be exposed to formaldehyde if it is used in pathology labs and other areas as a fixative agent and in areas that might use disinfectants with formaldehyde as the active ingredient.

Formaldehyde releases from materials and products over time, with the highest rates of emission occurring when the material or product is new. Higher temperature and relative humidity increase the emission rate of formaldehyde from materials.⁶³ EPA's Building Assessment, Survey and Evaluation study measured indoor formaldehyde concentrations in 100 randomly selected office buildings, and found that mean and median indoor formaldehyde concentrations in office environments were lower than levels in homes, but similar to levels found in ambient outdoor air.⁶³ Formaldehyde levels specific to indoor hospital environments have not yet been summarized in the literature.

Other VOCs

Ubiquitous VOC exposures in indoor hospital environments include emissions from carpets, carpet cushions, carpet

adhesives and other interior building materials; furniture; deodorizers/air fresheners (which we distinguish here from fragrant janitorial cleaning products); fabric protectors (i.e., sprays); floor finishing, floor wax, floor finish removers/strippers; and paints, varnishes, and wood stain. Patients, workers, and visitors may all be exposed to these materials. Certain materials and associated practices are more likely than others to be a source of VOC exposure for hospital maintenance staff, including: carpet shampoo, detergent, epoxy adhesives, furniture polish, janitorial cleaners, paint strippers, silicone caulk, and solvents.

There are several factors that influence exposure to VOCs. The age of the material is an important determinant of the rate of release of VOCs; the newer the product, the higher the rate of off-gassing. Similarly, wet paint and new carpets result in higher levels of exposure to VOCs. Good ventilation and air conditioning tend to reduce concentrations of indoor VOCs.

VOC levels in the indoor environment can be several times higher than levels outdoors, and new buildings often have VOC levels that are hundreds of times higher.⁶⁴ Depending on the location, evaporated gasoline emitted from parked

cars in a health care facility parking garage can contaminate the indoor environment.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Although recent studies suggest that exposure to VOCs may be associated with asthma, the evidence as a whole is insufficient to conclude that total VOCs cause or trigger asthma. This is not surprising, however, because total VOC exposure in one workplace can differ considerably from that in another workplace. Various mixtures of individual VOC components will have differing propensities to cause or trigger asthma.

The evidence is clearer for individual VOCs. Studies have concluded that formaldehyde can cause asthma in occupational settings when workers are exposed to high levels. Research suggests that lower levels of exposure to formaldehyde can trigger asthma attacks in people already diagnosed with the disease, but the current base of evidence does not support the hypothesis that formaldehyde causes the initial onset of asthma in non-occupational settings. Given the likelihood for ubiquitous low-level exposure to formaldehyde from consumer products and the

potential that health care workers can be exposed to higher levels, concern regarding formaldehyde exposure in health care facilities is warranted. It is also important to note that formaldehyde is reasonably anticipated to be a human carcinogen, according to the National Toxicology Program. Thus, other health concerns strengthen the case for seeking alternatives for formaldehyde.

C. Alternatives

VOCs

Off-gassing of VOCs increases as temperature increases. Thus, VOCs can be a particular problem in indoor environments with hot, stuffy air and VOC containing building materials. Most products contributing to the VOC levels in a building are under the control of environmental services, maintenance, building services, and similar departments. When possible, building materials and furnishings should be selected that do not off-gas VOCs. Increased general ventilation can often reduce these widely diffused indoor VOC exposures, whereas the specific VOC sources (e.g. from paints, white board markers, office products, etc.) can be substituted. Purchasers should ask vendors for low or no-VOC alternatives to their products. See the California Air

Quality Management District Rule 1136, found at <http://www.aqmd.gov/rules/reg/reg11/r1136.pdf> for VOC limits on such products as wood stain, varnishes, and caulks. See SAGE, a comprehensive guide designed to provide pollution prevention information on solvents, at <http://clean.rti.org>. The EPA offers an Integrated Solvent Substitution Data System at <http://es.epa.gov/issds/> and many states offer assistance to businesses in toxics use reduction. See, for example, the Massachusetts Toxics Use Reduction Institute at <http://www.turi.org>. For information on and listings of low-VOC cleaners, see the Center for a New American Dream at <http://www.newdream.org/clean/> and Green Seal at <http://www.greenseal.org/findaproduct/index.cfm#cleaners>.

When purchasing or specifying products such as bedding (and other chemically

treated fabrics), carpets, carpet cushions, carpet adhesives, pressed wood products, treated fabrics, and window treatments, ask vendors about the availability and performance of low- or no-VOC and formaldehyde-free alternatives for these products. Avoid VOC-containing paints, adhesives and other products that are in aerosol cans, as these can increase inhalation exposure risks. Choose water-based products instead of those made with solvents. Also, favor low-emitting products (such as adhesives, carpeting, ceiling tiles, flooring, furniture, insulation, paint, pressed-wood products, textiles, wall coverings, etc.) that are certified by GreenGuard (their Children & Schools Standard is the most protective), Green Seal, the Carpet and Rug Institute's Green Label PLUS Program, Scientific Certification System's Indoor Air Quality Performance, or another program based upon

the CHPS 01350 standard. Read their standards relating to your product area for more information. Specify adhesives and sealants that comply with California's South Coast Air Quality Management District (SCAQMD) Rule 1168 (<http://www.aqmd.gov/rules/reg/reg11/r1168.pdf>) except where freeze/thaw conditions exist or direct exposure to moisture can occur. In such cases, these products should meet the Bay Area Air Quality Management District's criteria under Regulation 8, Rule 51. Look for draperies, upholstery, bedding, and linens that are made with untreated or organic fabric. See Table 3 for more specific information about alternative products.

Be aware that not all "green" products are formaldehyde-free or low VOC. Some may be considered environmentally preferable because of other reasons, such as the presence of forest-friendly wood, recycled content insulation, or organic textiles. Review product labels, technical specification sheets, and materials safety data sheets (MSDSs) for all products under your consideration. Look for chemical ingredients such as formaldehyde and other VOCs. Review the risks associated with inhalation as well as the precautions suggested by the manufacturer.

Be aware that not all "green" products are formaldehyde-free or low VOC. Some may be considered environmentally preferable because of other reasons, such as the presence of forest-friendly wood, recycled content insulation, or organic textiles.

Formaldehyde

Ask vendors about the availability and performance of formaldehyde-free alternatives in products such as bedding and carpeting. See Formaldehyde-free Products under Laboratory Chemicals and Equipment at <http://www.sustainablehospitals.org> for alternatives, and consider engineering controls when suitable substitutes to formaldehyde do not exist. GreenGuard, Green Seal, the Carpet and the Rug Institute's Green Label PLUS Program, Scientific Certification System's Indoor Air Quality Performance, and other programs based upon the CHPS 01350 standard limit formaldehyde content or off-gassing for particular products.

If formaldehyde-containing pressed wood cannot be avoided, avoid cutting these products inside the health care facility, in order to prevent exposure to formaldehyde-containing wood dust. Allow all formaldehyde- and VOC-containing products to off-gas (unwrapped) for as long as possible (at least two weeks) prior to bringing them inside the facility where exposures will occur. Store them in a dry place to prevent the formation of mold.

Substitutes are available for many uses of formaldehyde as a disinfectant and fixative. Consult your industrial hygienist and vendors to record your use and determine which substitute is appropriate for each of your applications. The California Department of Health Services published a fact sheet in 2003 on "Formaldehyde" that describes actions health care personnel can take to monitor and reduce exposures to formaldehyde. It suggests switching to formaldehyde-free disinfectants, fixatives, and embalming fluids, whenever possible. It also recommends installing fume hoods and other ventilation systems and automatic dispensing equipment in work areas where formaldehyde cannot be avoided, using face shields and other personal protective equipment, and establishing other safety procedures. This fact sheet is available at <http://www.dhs.ca.gov/ohb/HESIS/formaldehyde.pdf>.

Currently the Toxics Use Reduction Institute at the University of Massachusetts, Lowell is examining safer alternatives to formaldehyde as fixative agents in laboratories. A report to the Commonwealth of Massachusetts on their findings is expected in June 2006.

V. Baking Flour

Flours made from a number of different grains are an established cause of occupational asthma among bakers and kitchen staff.

A. Scientific Evidence of Harm

According to the AOEC, several types of flours are considered occupational asthmagens, including:

- Flour, not otherwise specified
- Buckwheat
- Gluten
- Rye Flour
- Wheat Flour
- Soya Flour

Neither the IOM nor the CHE reviewed flour in relation to asthma. A separate review of the literature found similar agents responsible for causing asthma.²⁹ However, a number of additional sources provide strong evidence of links between exposure to flour and both the onset and exacerbation of asthma.

Baker's asthma is one of the most frequently reported causes of occupational asthma. The prevalence of asthma among bakers and millers who work with wheat, rye, soya flour, and buckwheat is 20% to 100%, based on a review of studies in individual workplaces.¹¹ Case reports

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from the beginning of the 20th century established the concept of baker's asthma, and later epidemiologic studies identified the allergens associated with the disease.⁶⁵ Baker's asthma and rhinitis have also been associated with other substances,⁶⁵ including:

- Cereal flours (barley, hops, rice, maize)
- Additives:
 - enzymes (amylase, cellulase, xylanase, papain, other proteases, glucose oxidase)
 - color (carmine red)
 - spices
- Egg powder
- Nuts (almonds, hazelnuts)
- Milk powder
- Insects (flour beetle, flour moth, cockroach, granary weevil)
- Molds (alternaria, aspergillus)
- Sesame seeds

B. Exposure Considerations

Exposure to flour and other ingredients in food are primarily of concern in health care facilities with on-site bakeries or other food service departments where these products are used. Ubiquitous exposures to flour and other sources of bakery dust are not a concern for individuals who do not work in these food preparation departments. Controlling bakery dust using good exhaust ventilation is an important consideration in reducing exposure.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Flour made from the above grains and additional allergens found in kitchens represent an established cause of asthma among workers. Workers are at risk only if the health care facility has an on-site bakery and food service preparation unit.

C. Alternatives

Exposure to bakery dust can be reduced by using mechanical flour sprinklers and ventilation systems such as exhaust fans and enclosures for machinery used to pour, sift or measure flour. Bakers can further minimize flour dust by shaking bags that are sealed, starting mixers on a slow speed until dry ingredients are combined with wet ingredients, wearing a dust mask, and cleaning up spills immediately with a vacuum or wet mop, not with a brush or broom. Air quality around bakery operations and worker health should be monitored regularly; workers exhibiting sensitization to bakery dust should be reassigned to other tasks. These and other recommendations for detecting and preventing exposure to bakery-related asthmagens can be found in a 2005 fact sheet, "Baker's Asthma," published by the Canadian Industrial Accident Prevention Association, http://www.iapa.ca/pdf/2005_bakers_asthma.pdf, and in a news release issued by the United Kingdom's Health and Safety Executive on May 4, 2004, World Asthma Day, <http://www.hse.gov.uk/press/2004/e04059.htm>.

Health care facilities can also offer fresh-baked items made by local bakeries. The most drastic measure to eradicate baker's asthma among health care workers is to

eliminate on-site operations in which baked goods are made from dry ingredients. However, whoever is doing the baking for the hospital is still at risk for baker's asthma, regardless of where it is being performed. Another option is the utilization of ready-to-bake frozen, fresh or aseptically packaged dough ("pre-proofed" for items that need to rise). A fact sheet by the Oklahoma Cooperative Extension Service (see <http://osuextra.okstate.edu/pdfs/FAPC-111web.pdf>) notes that refrigerated or frozen bakery products can include: canned refrigerated biscuits, croissants and sweet rolls; frozen bread, rolls, pastries and other sweet goods; and refrigerated and frozen pizza crusts. These dust-free products may be useful in some cases, but could also include additives that make the products less healthy overall. Pre-combined dry ingredients, "low-dust" flours, liquid enzymes, and recipes with minimal allergenic additives may all be successfully implemented in addition to the above suggestions.

VI. Acrylics, including Methyl Methacrylate and Cyanoacrylate

Methyl methacrylate and other acrylate compounds are monomers of acrylic resin that are widely used in the indoor hospital environment. Methyl methacrylate (MMA) is used in certain dental, medical and industrial applications, including dental and medical polymers and cements.

A. Scientific Evidence of Harm

The AOEC states that methyl methacrylate can cause asthma, and CHE found strong evidence associating methyl methacrylate with asthma. The IOM did not review these materials. Acrylates are known sensitizers⁶⁶ and can induce respiratory hypersensitivity.⁶⁷ Evidence of harm primarily comes from case reports demonstrating asthma among dental personnel exposed to acrylates.^{67,68} Acrylic monomers are cross-reactive; allergic sensitization precipitated by one acrylic compound extends to one or more other acrylic compounds.⁶⁶ As a result, individuals sensitized to one acrylic compound are often multi-allergic. Case reports have demonstrated that cyanoacrylate found in commercial adhesives are responsible for the development of asthma in non-occupational as well as

occupational settings.^{69,70} Another review of the literature did find causal evidence linking both MMA and cyanoacrylate with asthma onset. However, these authors suggest that the incidence of asthma due to these agents is low compared to their widespread use.²⁹

B. Exposure Considerations

The MMA compound is created by mixing a powder and a liquid together, and the highest concentrations of MMA are usually found immediately after this mixing process.⁷¹ Other acrylic monomers used in dentistry include multifunctional methacrylates such as ethyleneglycol dimethacrylate and triethyleneglycol dimethacrylate.⁶⁶ In addition to working at dental facilities, dentists and dental assistants often collaborate with physicians in hospital settings in treating patients. As a result, the hospital setting is a source of potential exposure to methyl methacrylate and other volatile methacrylates used in dentistry, especially in emergency room departments and operating rooms.

Another source of exposure to MMA vapors is polymethylmethacrylate, a synthetic polymer of MMA employed for cranioplasty and orthopedic prosthesis implantation. An additional acrylate compound, cyanoacrylate is used for tis-

sue repair and other surgical procedures. As such, physicians, nurses, and patients involved in reconstructive surgery may be exposed to methacrylates and/or cyanoacrylate compounds used in tissue repair or to bond bones to artificial limbs or other types of prostheses.

Hospital maintenance workers may be exposed to acrylates in their work if they use certain brands of lacquers, paints, floor waxes and coatings, instant-dry glues (such as Superglue) sealants, and/or other types of adhesives.⁶⁷

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Methyl methacrylates are an established cause of occupational asthma and cyanoacrylate adhesives have caused asthma in both domestic and occupational settings. The scientific evidence warrants adopting substitute products wherever possible.

C. Alternatives

Mechanical methods should be utilized to replace chemical adhesives whenever possible. Ask your vendors and manufacturers about the availability and suitability of adhesives, resins, denture-making materials, and other products that are free of methyl methacrylate (MMA), cyanoacrylate, and

other acrylate compounds. An online search for MMA-free products revealed several made for dental applications. See Table 3 for details. We are not aware of any MMA-free prosthetic resins and adhesives. At least one company offers a low-odor cyanoacrylate “Superglue” that may be able to replace conventional instant-dry adhesives in some applications.

When substitutes are unavailable for a specific application, look for opportunities to minimize exposures by isolating, enclosing, and automating processes involving these substances. Prevent evaporation of pre-mixed acrylates by covering containers tightly. Several MSDSs for products containing methyl methacrylate recommend local and/or general exhaust ventilation to maintain employee exposures below OSHA’s Permissible Exposure Limit (PEL) of 100 ppm. A NIOSH-approved organic vapor respirator is recommended when engineering controls are not feasible or when the PEL is exceeded. For more information on how to reduce exposures and find alternatives to MMA, see the California Department of Health Services, Health Evaluation System and Information Service, Fact Sheet: Methyl Methacrylate (MMA), February 1990, <http://www.dhs.ca.gov/ohb/hesis/mma.htm>.

VII. Perfumes/Fragrances

Fragrance exposure in the hospital environment includes scented cleaning products, fragrance-emitting devices and sprays, individuals who are wearing perfume, cologne, aftershave, scented cosmetics, skin lotions or hair products, and clothes that have been laundered with scented detergents, fabric softeners, or dryer sheets.⁷²

A. Scientific Evidence of Harm

Both the CHE and the IOM found limited or conflicting evidence to associate asthma onset with fragrances. The IOM also found that there was limited or suggestive evidence of an association between exposure to certain fragrances and the elicitation of respiratory symptoms in asthmatics sensitive to such exposures. The AOEC did not report fragrances as an occupational asthmagen. Although some studies have been unable to document bronchial hyperreactivity associated with perfumes,⁷³ several studies have concluded that fragrances can trigger respiratory distress and asthma attacks in some individuals.⁷⁴ Evidence that volatile compounds in fragrances can trigger asthma attacks has prompted organizations like the American Academy of Allergy and Immunology and the National Asthma Education and Prevention Program of the

National Health Lung and Blood Institute to inform asthmatics to avoid exposure to these agents.^{75,2}

Many new fragrances are developed each year, using a variety of different chemicals (sometimes new to the marketplace). Although the Food and Drug Administration is responsible for regulating fragrances, the majority of these products are not tested for human health effects prior to entering the marketplace.⁷⁶ In addition, since the formulations of most perfumes are considered trade secrets, the individual constituents of most fragrances are unknown to researchers, making it difficult to discern which components are problematic for asthmatics.⁷⁴

B. Exposure Considerations

The number of people exposed to fragrances in the indoor hospital environment and the amount of exposure depends on the number and amount of fragrance-containing products present in the setting of interest. Maintenance or housekeeping staff who work with scented cleaning chemicals are exposed to higher levels of fragrances than are other employees. Certain other individuals and groups such as administrative staff may also be at increased risk of exposure (due to interaction with numerous visi-

Although the Food and Drug Administration is responsible for regulating fragrances, the majority of these products are not tested for human health effects prior to entering the marketplace.⁷⁶ In addition, since the formulations of most perfumes are considered trade secrets, the individual constituents of most fragrances are unknown to researchers, making it difficult to discern which components are problematic for asthmatics.

tors, patients, and other staff who may be wearing scented products).

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Currently, there is insufficient evidence to support the hypothesis that fragrances cause asthma. However, studies do demonstrate that fragrances can exacerbate asthma in some individuals. Given the widespread use of scented products, health care facilities should limit the use of products containing fragrances and encourage a non-fragrance environment as a precautionary measure.

C. Alternatives

The most promising alternative is to become fragrance-free, and many vendors offer fragrance-free versions of their products. Some hospitals have successfully implemented fragrance-free policies, especially in waiting rooms. Many building occupants may associate the fragrance of a product with a perception that a room is clean. Thus, when switching to fragrance-free janitorial products, it can be important to notify building occupants of the change and to explain that the building is being cleaned just as effectively without scented products.

Include in your purchasing policy a preference for fragrance-free products. Many vendors offer fragrance-free versions of their products. You can find fragrance-free products online by searching for “fragrance-free” products using your Internet browser. For a large enough customer, a manufacturer may even be willing to manufacture a special fragrance-free batch of product.

Beware that some unscented or fragrance-free products may still contain allergenic chemicals. The Consumers Union Guide to Environmental Labels finds “fragrance-free” labels to be meaningless because there is no standard definition governing this term. It also notes that products labeled “fragrance-free” may deceptively contain substances used to mask the chemical odor of other product ingredients. See <http://www.eco-labels.org/label.cfm?LabelID=182&mode=text>. Ask vendors to provide a list of all chemicals contained in a product, not just those listed on the MSDS. Additional resources on fragrance-free policies and products are listed in Table 3.

VIII. Phthalates

Plasticizers are chemical compounds used to soften rigid materials. Phthalates are widely used plasticizers for polyvinyl (PVC) plastic and cosmetics.⁷⁷ In the health care setting, exposure to phthalates is ubiquitous; sources include PVC plastics, which are widely used in the following medical devices: IV/blood bags, body bags, catheters, dialysis containers, electrodes, feeding tubes/bag/pumps, gloves, IV sets, patient ID bracelets, respiratory therapy tubes and masks, and sequential and compression devices. Phthalate exposure also results from consumer products made of PVC softened with the di (2-ethylhexyl) phthalate (DEHP), found in carpet backing, fragrances (such as air freshener), mattress covers and protectors, office supplies (e.g., media storage sleeves, report covers, sheet protectors, etc.), PVC (vinyl) coated ceiling tiles, PVC resilient flooring, PVC upholstery, PVC wall coverings and wallpaper, shower curtains, and vinyl blinds.

A. Scientific Evidence of Harm

The AOEC does not find evidence to support phthalates as occupational asthmagens. Similarly, the IOM found the evidence inadequate or insufficient to support conclusions regarding the role of phthalates in either causing or exacerbat-

ing asthma. The CHE characterized the evidence as limited or conflicting.

Some more recent studies, however, have found that residential exposure to PVC flooring and wall surfaces were associated with bronchial obstruction and asthma symptoms in children.^{78,79} The authors state that DEHP may constitute up to 40% by weight of the PVC in a particular product. Although some have argued that these studies were limited because they did not directly measure phthalates, a more recent study found an association between the prevalence of asthma in children and levels of phthalates, specifically DEHP, measured in samples of residential dust.⁸⁰ Although this study was not able to control for the presence of other risk factors for asthma, it does add to the weight of the evidence that DEHP may be associated with asthma in children. Earlier evidence has also demonstrated that preterm infants exposed to DEHP from respiratory tubing systems had a higher risk of asthma.⁸¹ Animal studies have additionally provided evidence that DEHP induces bronchial hyperreactivity, and have suggested possible pathologic mechanisms.⁸²

B. Exposure Considerations

Phthalates can leach out of PVC products into air, water, and soil because they are not covalently (strongly) bound to the PVC polymer. Humans inhale phthalates in air, ingest them through food, water, or contaminated dust, and receive them intravenously via blood products, medical solutions, and other medical treatments delivered in PVC medical devices such as plastic tubing and intravenous (IV) bags.⁸³

Indoor air is generally the second highest source of exposure to DEHP, after food.⁷⁷ Documented indoor DEHP concentrations in the range of 10 to 100 ng/m are typical,^{3,84} and exposure to phthalates via inhalation indoors is higher in environments in which there is extensive use of PVC products.⁸³ Conditions favoring the release of phthalates from building materials into the indoor environment are not fully understood. Studies have found that moisture or dampness can contribute to chemical emission rates from building materials, including PVC flooring.⁸⁵ However, it is unclear whether the emissions from the PVC products include phthalates, other PVC degradation products, or both.⁸⁵ Although a recent summary report on damp indoor spaces and health concluded that the available data are insufficient to draw conclusions about the

Indoor air is generally the second highest source of exposure to DEHP, after food.

health implications of such dampness-related emissions,⁸⁶ the IOM report found sufficient evidence of an association between damp indoor environmental and asthma or asthma symptoms.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

The scientific literature on the effect of plasticizers on asthma is small, but growing. To date there is some indication that DEHP may be associated with asthma, especially in young children. Given this evidence, health care facilities should evaluate whether DEHP is in products where infants and children could be exposed.

C. Alternatives

Many phthalate sources are flexible PVC products used in medical equipment, office equipment, building fixtures and accessories. In addition, phthalates may be in fragrant cleaners, air fresheners, and resilient floor finishes used by janito-

rial staff. Many resilient floor finishes also contain dibutyl phthalate. Using fragrance-free products and specifying phthalate-free floor finish can reduce the potential for exposure from these types of products. See Table 3 for information on finding alternatives. Ask for phthalate-free medical and office products from vendors; see <http://www.sustainablehospitals.org> for a list of such products. See also <http://www.healthybuilding.net/pvc/alternatives.html> for alternative flooring and wall coverings.

Currently, the Toxics Use Reduction Institute at the University of Massachusetts, Lowell is examining safer alternatives to DEHP-free products in hospital neonatal and infant care units. A report to the Commonwealth of Massachusetts on their findings is expected in June 2006.

IX. Environmental Tobacco Smoke

Environmental tobacco smoke (ETS) exposes non-smokers to many of the same toxins inhaled by active smokers.⁸⁷ Tobacco smoke is an indoor irritant, and is a known risk factor for allergy development.

A. Scientific Evidence of Harm

There is a large body of research that has investigated the role of ETS exposure in asthma. The CHE characterized the evidence of a link between ETS and irritant asthma as “strong.” The IOM concluded that there is 1) sufficient evidence regarding an association between ETS exposure and asthma onset among young children; 2) sufficient evidence for a casual relationship between ETS exposure and exacerbations of asthma among preschool-aged children; and 3) limited or suggestive evidence for an association between ETS

and asthma exacerbation among both children and adults. The AOEC does not list ETS as an occupational asthmagen.

According to the IOM’s review, evidence is sufficient to conclude that ETS can cause asthma in younger children—an effect that is seen more strongly as a result of maternal smoking—but not to draw similar conclusions about school-age children and adults. However, evidence does suggest that ETS exacerbates asthma in both adults and children. There have been a number of additional reviews of the epidemiologic evidence on the effects of parental smoking and children’s respiratory health.^{88,89} Consistently found across the reviews are associations of parental smoking with a higher prevalence of asthma and respiratory symptoms in children, and more severe disease among children with established asthma.

B. Exposure Considerations

Health care facilities are increasingly adopting policies to ban smoking.⁹⁰ When smoking is permitted, it is usually in designated areas on the hospital campus. However, environmental tobacco smoke can migrate from these designated areas to contiguous non-smoking areas, representing a source of exposure for non-smokers.⁹¹

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Scientific studies demonstrate that ETS likely causes and exacerbates asthma in young children, although the evidence is more limited in older children and adults. Although most health care settings are non-smoking environments, those that are not should become so, and steps should be taken to ensure that smoking areas outside the building are not located where ETS can migrate indoors.

C. Alternatives

Many sources recommend maintaining a smoke-free facility as the most effective way to prevent involuntary exposures to environmental tobacco smoke. Most health care facilities are smoke-free, and there are numerous policies and guidelines available from the Centers

Consistently found across the reviews are associations of parental smoking with a higher prevalence of asthma and respiratory symptoms in children, and more severe disease among children with established asthma.

for Disease Control (CDC) and from state and local health departments. Additional benefits to health care facilities of smoking bans include lowering fire risks, cleaning costs and insurance rates, as well as sending a consistent message encouraging patients, staff, and visitors to change their smoking behaviors. According to the US Centers for Disease Control (CDC), US hospitals voluntarily adopted a nationwide smoking ban in 1991, with 96 percent of the facilities complying by 1993.⁹²

If it is not feasible to ban smoking altogether, facilities can allow smoking only in outdoor sites on the facility property, but these areas should not be adjacent to any common entrance or exit, window, or building air intake. Another option is to assign a designated indoor smoking area, which should be a leak-proof room with a separate ventilation system. This option is likely to be expensive, however, and may expose smokers to even higher risks due to increased concentration of second-hand smoke (unless the room has an air purification system that is under negative air pressure).

X. Biologic Allergens

Many biologic allergens – including mold/fungus, indoor pollen, cockroach, dust mite, mouse, cat, dog, and other animals – are prevalent in homes, as well as other buildings. In addition, these allergens can be transported from homes to public places, often settling in dust (e.g., in upholstered furniture and carpets). Conditions in health care facilities can allow biological agents to flourish, just as they do in homes.

A. Scientific Evidence of Harm

The CHE characterizes the evidence as strong regarding the risk of allergic asthma associated with animal allergens. The AEOC lists mouse allergen as an occupational asthmagen capable of causing asthma *de novo*. The IOM interprets the evidence associating various allergens with asthma exacerbations as “sufficient evidence for a causal relationship” for: cockroach, dust mite, cat, dog, and fungi/molds; and “inadequate or insufficient evidence for association” for mouse and indoor pollens.

Although studies affirm that biologic allergens play an important role in asthma exacerbation and severity in sensitized individuals, less is known regarding associations with asthma onset. Some

studies have examined incident cases of asthma in relation to biologic allergens and found that exposure to dust mites as well as cockroaches result in an increased risk associated with the development of asthma.⁹³⁻⁹⁵

B. Exposure Considerations

Pollens infiltrate indoor environments from outside. The indoor pollen concentration varies, depending on factors such as the building ventilation rate. Water or moisture sources present in hospitals can result in excessive indoor dampness and in growth of molds. Interactions among moisture, building materials, and environmental conditions in- and outside of a hospital facility determine whether potentially harmful levels of dampness-related exposures such as mold and pest infestations will develop in the facility.⁸⁶ There have been no studies reporting dampness prevalence in health care facilities, but anecdotal/case reports indicate that these environments experience dampness (and resultant mold exposure) problems to varying degrees based on the factors noted above.

Individuals who spend time in areas with cats and/or dogs or touch animals can easily transport cat and dog allergens from home environments to other indoor

A study of hospitals in Britain found low levels of dust mite and cockroach allergens, but high levels of cat and dog allergens in upholstered furniture.

environments. The transported allergen settles in dust, and allergen levels can be as high in public places (such as hospitals) as in homes with cats or dogs.⁹⁶ Animals in hospital laboratories are a direct source of exposure for laboratory workers.

A study of hospitals in Britain found low levels of dust mite and cockroach allergens, but high levels of cat and dog allergens in upholstered furniture.⁹⁶ Cockroach allergen, a particularly important factor for asthma exacerbation worldwide, has been detected in schools,⁹⁷ offices, and other indoor workplaces.⁹⁸ Dust mites thrive in warm and humid environments, and dust mite allergen is present in settled dust in public settings (floors, furniture, etc.), though often at low levels.⁹⁹ Mouse allergen is primarily a home-based exposure, but has been detected in studies of allergen exposure in schools, suggesting that it can be present in public locations.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Many biologic allergens are associated with the exacerbation of asthma, and some (in particular dust mite and cockroach) may cause the development of asthma. Although it is difficult to assess exposure to these allergens in hospital settings, good housekeeping measures should result in a reduction of exposure and of asthma risk.

C. Alternatives

The basic approaches to reducing biologic allergens are good housekeeping, building maintenance, and animal care practices. Training and supervision clearly play a critical role, and there are numerous guides and programs available for health care facilities.

Since many biologic asthmagens such as mold, mildew, cockroaches, and even

dust mites thrive in a damp environment, moisture control is often the most effective prevention strategy. Moisture can be reduced by using dehumidifiers or fans, by patching leaks where water can encroach, and sometimes by increasing the temperature or airflow of the building. Inspect your facility regularly to ensure that water is not intruding from a leaky roof or foundation, cracks in windows/doors, or leaky faucets, pipes or duct work, especially in bathroom, kitchen and laundry areas. Ensure that ventilation is adequate to dry out bathing areas between showers. Exhaust from dryers and other moisture-generating activities should be ventilated to the building exterior.

Clean the building regularly to prevent the build-up of dust mites, pollen, and other biological allergens. Use a steam cleaner or an HEPA vacuum on carpeting, upholstery and drapes to prevent allergens from being dispersed during cleaning. Use a damp mop (or damp microfiber mop) rather than a broom or dry cloth to clean floor and surfaces. (Suppliers of microfiber mops are listed on the Sustainable Hospitals Project website at <http://www.sustainablehospitals.org>). Use a dust mask while cleaning; additional respiratory support may be needed if mold is present. Changing the filters on

air conditioners and furnaces can also prevent biological allergens from being dispersed throughout buildings. Avoid building supplies that can trap moisture (such as carpet with impermeable PVC backing or vinyl wall coverings). Once these materials become damp, they are often difficult to dry out, thus creating conditions conducive to mold proliferation. Consider hardwood or resilient flooring, rather than carpeting.

Mold can be prevented by addressing leaks and water damage quickly, and by maintaining indoor humidity between 30 and 60%. Water-damaged items such as carpeting, upholstery and other building materials may need to be removed if mold is allowed to form and cannot be effectively cleaned. Consult a certified mold specialist to determine the best methods to prevent or remediate mold in your facility. The US Environmental Protection Agency (US EPA) has developed general recommendations for reducing exposure to biological allergens; see <http://www.epa.gov/iaq/biologic.html>. Its IAQ Building Education and Assessment Tool (I-BEAM) can help facility managers identify and address a variety of indoor air quality problems; see <http://www.epa.gov/iaq/largebldgs/>.

US EPA also offers mold prevention and remediation tips in two publications, *Mold Remediation in Schools and Commercial Buildings* (March 2001), available at <http://www.epa.gov/iaq/molds/prevention.html> and *Building Air Quality: A Guide for Building Owners and Facility Managers, Appendix C: Moisture, Mold and Mildew*, available at <http://www.epa.gov/iaq/largebldgs/graphics/appenc.pdf>. The National Institutes of Health, Office of Research Facilities, has adopted a *Mold Prevention and Remediation Policy* that prescribes prevention and remediation of mold problems. See <http://orf.od.nih.gov/PoliciesAndGuidelines/ORFPolicies/MoldPrevPolicy.htm>.

To control dust mites, encase mattresses, box springs, pillows and upholstered furniture in covers that are tightly fitting, impermeable to dust mites and other allergens, permeable to air and water, and manufactured free of vinyl, latex or other substances that can release asthmagens. See information on mattress covers in Table 3. Avoid down and wool pillows, to which some patients and staff may be allergic. Wash bedding regularly, preferably in water above 130F. Additional tips for preventing exposure to dust mites can be found on the National Institutes of

Health website at <http://www.niehs.nih.gov/airborne/prevent/mites.html>. Also, the Mayo Clinic has posted recommendations for eradicating dust mites from homes; many of these strategies can be used in a health care setting. See http://www.mayoclinic.com/health/dust_mites/HQ00864/SI=1977.

To reduce cockroach infestations, use non-toxic baits; plug crevices in walls and floors; clean up food spills; and fix leaking plumbing equipment. See information on integrated pest management methods in Table 3.

Finally, wear a clean dust mask, laboratory coat, and gloves when handling laboratory animals.

XI. Drugs

Medicinal drugs are commonplace in health care settings, and some have been found to cause or exacerbate asthma, mostly in occupational settings. These drugs and their common uses include:

- Antibiotics: penicillin, ampicillin, tetracycline, cephalosporins
- Laxatives: psyllium
- Antihypertensives: methyldopa, hydralazine
- Antituberculars: Isonicotinic acid hydrazide
- H2 blockers: Cimetidine

A. Scientific Evidence of Harm

Neither the CHE nor the IOM reviewed the evidence associated with exposure to drugs as causes or exacerbators of asthma. However, the AOEC includes pharmaceuticals in its list of occupational asthmagens, shown in Table 1. Other compendia of occupational agents known to cause asthma confirm these findings.¹⁰⁰ Although cases of occupational asthma associated with medications have primarily occurred in the pharmaceutical industry during the manufacturing of these agents, case reports of asthma among nurses have been observed in hospitals.¹⁰¹

B. Exposure Considerations

Although patients and health care staff both come in contact with medicinal drugs, it appears that the risk associated with asthma from drug exposure is primarily among hospital staff such as pharmacy workers and nurses. Drugs such as psyllium that are prepared for patients in a free rather than contained form (such as in tablets or capsule) place workers at greater risk.¹⁰¹ Although it is unlikely that drugs listed in Table 1 are delivered through inhalation via aerosol therapy, such therapies could result in risks of asthma among susceptible patients.

Summary Interpretation of Evidence on Hazard and Exposure in Health Care Settings

Although several medicinal drugs have been found to cause asthma in pharmaceutical workers and among some nursing staff, the literature does not raise concerns about exposure to patients and other visitors in health care settings. Where the agents associated with asthma are not contained in capsules and tablets, patients and hospital staff may be at increased risk of asthma onset or exacerbation.

C. Alternatives

Where clinical substitutions for the above medicines are not feasible, environmental measures may be implemented. Pharmaceutical workers may transfer powders or other substances from a covered tray into a hopper or hood that contains local exhaust ventilation, thus avoiding respiratory exposure. The pharmaceutical product may then be prepared and packaged directly from the hood. Personal protective equipment such as an air hood or properly fitting respirator may also be used, particularly in sensitized individuals who must come in contact with the problematic agents.

SECTION III. DECISION-MAKING TO ELIMINATE OR REDUCE EXPOSURES



“Many medical supply vendors now offer latex-free catalogs to assist facilities in minimizing latex use.”

Though the contribution of exposures in the health care setting to the overall burden of asthma has not been characterized, the size of the population exposed—hundreds of thousands of people annually—and the potential for reductions in exposures to prevent both the onset and exacerbation of asthma make a compelling case for initiatives by health facilities to effectively control asthma triggers. Policy makers within a health system or at the government level also have a role to play in structuring incentives and disincentives to make a transition from hazardous to safer indoor environments.

In the first two sections, we have provided information to support decision-making regarding the presence of biological, chemical and pharmaceutical agents in health care facilities that can cause or exacerbate asthma. In this section, we present a framework for using this information—

and additional information as it becomes available—to decide on steps to reduce risks to employees, patients, and visitors in health care facilities. We also discuss policy approaches that will help create the conditions necessary for efficient and effective transition away from use of substances that cause and trigger asthma.

A Framework for Decision-Making in Health Care Facilities

Establishing a Working Group

A critical step in making good decisions about shifting to safer products and procedures is the creation of a process that includes a wide range of people affected, for example, a working group that includes representatives of professionals, non-professionals and support staff, administration, and patients or volunteers who work in the facility. This

group can be charged with prioritizing the substances of concern and identifying next steps towards reduction or elimination. Guidelines exist for establishing a working group to identify, implement, and evaluate healthier alternative materials and practices in hospitals.²⁸

Consider Evidence on Hazard, Exposure, and Alternatives

As discussed earlier, three kinds of information are important to consider in the course of taking steps to reduce risks of asthma onset and exacerbation: evidence of potential harm, information relevant to exposure of people in the facility to substances of concern, and the availability of alternatives. Section II summarized literature documenting the capacity for a range of substances found in health care facilities to initiate asthma and trigger asthma attacks. For some substances, the evidence that they are capable of causing or

exacerbating asthma is substantial. Over time, health care facilities should eliminate or substantially reduce the presence of these substances in their indoor environments. For others, the evidence is limited or conflicting; these substances would be lower priorities for immediate action, but decision-makers should carefully track the evolution of relevant science.

Considering exposure information is the least straightforward step in the decision-making process. Exposure assessment is complex, and requiring robust exposure information before decisions can be made about reducing exposure is often neither realistic nor appropriate. Detailed exposure information, when available, should be considered thoughtfully, but when comprehensive exposure data do not exist, proxies for exposure (such as volume of chemicals used, or relative proximity to the source of exposure) can be helpful in prioritizing substances requiring action. The lack of robust exposure information should not preclude decisions to reduce use or exposure; where evidence of a substance's potential to cause or trigger asthma is strong and alternatives are

available, it is only prudent to reduce exposures to that substance.

Careful review of available alternatives is a third and critical component of decision-making to reduce the use of substances that cause or trigger asthma. Resource and technological constraints, as well as the potential for alternative products and processes to introduce new risks, compel decision-makers to proceed thoughtfully and systematically in a process of alternatives assessment. During alternatives assessment, personnel affected by a decision to use or not use a specific hazardous substance must participate in the decision-making process to help determine whether or not the function achieved by the substance is necessary, and review the benefits and potential adverse impacts of replacing it with an alternative.^{vii} The alternatives assessment process does not require quantifying the potential harm of the current or alternative substances or practices, but it should include a broad range of information, including personal, experience-based information from those participating. The goal of alternatives assessment is that all

affected personnel and decision-makers become satisfied that sufficient information was reviewed and discussed to lead to a robust decision that will promote better health for all those affected.¹⁰² Using all three categories of information, the planning group or task force can make sound and transparent decisions aimed at reducing exposure to substances that may cause or exacerbate asthma.

Example of a Decision Tree

The group might adapt a decision-making framework that selects two or three variables for each of the three categories of relevant information discussed above, and suggest decision rules or guides based on these variables. For example, evidence of potential for a substance to cause harm could be classified as strong, good, or limited/conflicting. Estimated numbers of people exposed could be used as a proxy for more complex and nuanced exposure information, and could be further classified as “many” or “few.” Availability of good or suitable alternatives could be characterized by using “yes” or “no.” Table 4 presents these combinations and characterizes possible decision rules for each combination. The first four options, denoted by letters A through D at the top of the table, are the most straightforward; if there are substances in use

^{vii} Experience with alternatives assessment is rapidly growing: the Toxics Use Reduction Institute in Massachusetts, for example, is funded by the state to conduct in-depth assessments of alternatives to five hazardous substances, two of which are discussed in this guide.

for which the evidence of adverse health effects is considered strong or good, and there are alternatives available, then the decision would likely be to recommend the alternative, regardless of how many people are exposed. In the next option, where the evidence of adverse effect is less strong but many people are exposed and alternatives are available (Option E), the decision could still be to recommend the alternative in a precautionary mode; when few people are exposed under the same scenario (Option F), other factors—such as cost or a level of confidence about the viability or hazard of the alternative—might be considered. Where the evidence of adverse effects is strong or good but there are no alternatives available (Options G through J), the decision could be to seek more information about alternatives, or ask vendors to develop alternative products and then revisit the issue at a later time. Finally, the combination of variables in the last two options, denoted by letters K and L, where the evidence of adverse effects is limited or conflicting and there are no alternatives available, would suggest a low priority for action, or a recommendation for further information-gathering. If many people were likely to be exposed, the facility might choose to conduct a health study or otherwise strengthen the evidence base.

TABLE 4. Decision Tree System for Exposure Reduction and Elimination

Option	Decision Opportunity Characterization	Strength of Evidence of Adverse Health Effects	Exposure	Availability of Alternatives
A	Recommend alternative	Strong	Many	Yes
B			Few	
C	Recommend alternative	Good	Many	Yes
D			Few	
E	Recommend alternative	Limited/conflicting	Many	Yes
F	Consider		Few	
G	Priority should be on further alternatives assessment or alternatives development	Strong	Many	No
			Few	
H	Priority should be on further alternatives assessment or alternatives development, but as the evidence is only good and/or few are exposed, there is less urgency for finding alternatives	Strong	Many or few	No
I		Good	Many	
J		Good	Few	
K	Lowest priority for alternatives identification; conduct a health study or remove workers	Limited/conflicting	Many	No
L			Few	

Many hospital employees, in facilities as well as clinical practice, talk to distributors and manufacturers, and can use the purchasing power of their institution as leverage to encourage innovation and an avid search for new alternatives.

The purpose of such a framework is not to prescribe specific rigid criteria for the decision-making process, but instead to provide a tool that facilitates innovation and ensures the transparency of thoughtful discussion among people who will be affected by the decisions. Group tasks may include selecting variables, collecting and evaluating published articles, discussing both personal experience and less formal information where published articles are sparse, reporting back to the group, and discussing and dismissing various options.

A group working in this capacity may be able to play a particularly useful role in working towards alternatives, even where they do not yet exist. Many hospital employees, in facilities as well as clinical practice, talk to distributors and manufacturers, and can use the purchasing

power of their institution as leverage to encourage innovation and an avid search for new alternatives. Hospital employees could engage these people in discussion about the characteristics needed for healthier and safer alternatives, encourage manufacturers to develop them, and then implement them on a pilot basis.

Creating a Climate Conducive to Risk Reduction: Policy Approaches

Although decision trees can serve as simplifying formulae, we acknowledge the complexity of decision-making that accompanies policy change in any institution. We present here an overview featuring vital considerations with respect to asthma risk in health care facilities, followed by a model summary of recommendations.

It is essential to remember that the state of the evidence is constantly changing. Anticipating the emergence of new data is critical in this age of rapid dissemination of information. What we have presented in this guide delineates the extent to which we currently understand the correlation between asthma risk and eleven classes of agents of concern. These agents were investigated specifically because of suspicion raised by the scientific literature. When a substance cannot be definitely identified as producing risk of causing or exacerbating asthma, it is still worth recognizing that insufficient evidence is not equivalent to absence of risk. Also, while asthma is the health concern discussed exclusively in this guide, policymakers would naturally endeavor to focus upon additional health risks relative to agents of concern commonly encountered within their facilities.

Another factor worth pointing out is that we do not tend to experience toxic or allergic exposures in complete isolation. Some investigative models examine reactivity to single exposure challenges as a means to discern meaningful patterns of response. However, as we have discussed repeatedly, people's responses to triggers are highly individualized. In the case of atopic and chemical sensitivities, a certain

burden of triggers (whether a combination of multiple different agents or high quantities of one or more substances) may be pooled before an individual reaches a threshold for symptom production. Since asthmatic response patterns are largely predicated upon individual susceptibility factors rather than defined magnitudes of exposure, it behooves decision-makers to consider the possibility that problematic substances in combination with one another could theoretically pose an increased risk for individuals to develop asthma or become triggered more readily. Therefore, though facilities may not choose to eliminate all risk factors noted in this guide, reducing the total weight of potentially problematic exposures could substantially improve indoor air quality overall.

Utilization of a precautionary approach becomes appropriate when a concern feels justified by the weight of evidence available, but the evidence falls short of meeting criteria for definitive proof. The *precautionary principle* encourages decision makers to consider that “in cases of serious or irreversible threats to the health of humans or ecosystems, acknowledged uncertainty should not be used as a reason to postpone preventive measures.”¹⁰³ A precautionary

approach asks how much harm can be avoided, rather than asking how much is acceptable. Furthermore, “although the precautionary principle is occasionally portrayed as contradicting the tenets of sound science and being inconsistent with the norms of evidence-based decision-making, these critiques are often based on a misunderstanding of science and the precautionary principle...current practice can work against precautionary decision-making by narrowly defining hypotheses or failing to address problems from an interdisciplinary perspective.”¹⁰³ Where credible evidence exists but is not definitive, and alternative practices appear to be safer and viable, a precautionary prescription is fitting, particularly in the health care setting, where patients, visitors, and

staff expect the internal environment to be safe.

Decision trees can be effectively applied as a means of coalescing the evidence to-date with individual institutional concerns and needs. Where gaps of information leave questions, broad thinking and the implementation of precautionary ideology can help institutions thoughtfully reconsider their practices. The decision to modify existing policies and practices is typically based upon four chief elements:

- 1) Scientific evidence of harm
- 2) Quantity of exposed individuals
- 3) Availability of alternatives
- 4) Advantages and disadvantages of alternatives

Where credible evidence exists but is not definitive, and alternative practices appear to be safer and viable, a precautionary prescription is fitting, particularly in the health care setting, where patients, visitors, and staff expect the internal environment to be safe.

We suggest that precedence be given to modifying policies involving agents that have been reported to be asthmagens (i.e. can cause asthma *de novo*) because of the potential to prevent the onset of asthma in a new population of individuals.

The first three elements are self-evident, and comprise the preponderance of information presented in this guide. Deliberate consideration of the advantages and disadvantages of alternative products or practices is critical for producing a safer environment for hospital personnel, patients, and visitors. Particularly in cases of chemicals and building materials, substitute products can pose unforeseen health risks, despite being free of the originally troublesome constituents as they relate to asthma. Logistical impediments will also naturally be factored into each facility's contemplation of alternatives. Motivational interests and challenges unique to each facility will heavily influence policy alteration. For example, some hospitals have chosen to execute fragrance-free policies. We have reported in this guide that fragrances were not identified as asthmagens, but may exacerbate asthma

in some individuals. The evidence is limited. However, large numbers of people may be affected, and fragrances only serve an aesthetic function. The implementation of a fragrance-free policy may be easily accomplished, and the removal of fragrance is more likely to produce a health benefit than any risk. Facilities may be highly motivated to introduce such a policy when the positive effects can be relatively straightforward in this manner. Where fragrance-related health complaints made by patients, staff, or visitors have occurred repeatedly within a facility, a more compelling case may be made for that facility to adopt a fragrance-free policy.

We suggest that precedence be given to modifying policies involving agents that have been reported to be asthmagens (i.e. can cause asthma *de novo*) because of the

potential to prevent the onset of asthma in a new population of individuals. Of the eleven categories of substances investigated, only three—fragrances, VOCs (with the exception of formaldehyde) and phthalates—were not consistently identified or investigated as asthmagens. Still, it would be inappropriate to conclude that these substances are safe or desirable within indoor health care settings. Certain pesticides were reported to be asthmagens, but generally at higher exposure levels. It is important to be aware that not all agents within a specific class of substances are known to be asthmagenic, and readers are encouraged to carefully review our report before implementing specific policy changes. However, where asthmagenic relationships are clear, policy approaches should favor elimination or reduction of these substances. Where exposures are widespread, substances that are not clearly asthmagens may still pose asthma or other health risks to a large population of people; this factor should figure prominently into decision making, as well.

Using the model of the decision tree with respect to the totality of our findings, we offer the following summary recommendations:

Implement alternatives for the following exposures because the scientific evidence of potential to produce harm is strong, the number of exposed individuals is high, and alternatives are available:

- Cleaners, disinfectants, sterilants
- Natural rubber latex
- Environmental tobacco smoke
- Biologic allergens
- Formaldehyde

Implement alternatives for the following exposures because the scientific evidence of potential to produce harm is strong, the number of exposed individuals is low, and alternatives are available:

- Baking flour
- Acrylics
- Drugs

Consider alternatives as appropriate to each facility for the following exposures because, although the scientific evidence of potential to produce harm is inconsistent or limited, the number of exposed individuals is high, some individuals are particularly sensitive, and alternatives are available:

- Pesticides
- VOCs
- Phthalates
- Fragrances

Conclusion

The current state of the evidence indicates considerable cause for concern that substances commonly used or found in health care facilities can generate or exacerbate asthma. We have presented evidence of potential harm with respect to these substances, plus an extensive array of practices and alternative agents that are increasingly available as the demand for safer products escalates. The irony that harm can be caused in a health care clinic

or hospital is obvious. To be purveyors of health care in the truest sense, institutional leaders must administer health care to their own facilities. Patients tend to value health care providers who are compassionate, methodical, interested in learning new information, and willing to re-evaluate standards of care that may no longer be appropriate. These same qualities are fundamental to the appraisal of a facility's status relative to the material presented in this guide. The implementation of alternatives will send a message of caring and commitment not only to patients, staff, and visitors of the facility, but also to the local and global community. Health care facilities should set examples for others by demonstrating practices that are safe for those who spend time in them and sustainable for the environment-at-large.

GLOSSARY OF ASTHMA TERMS

Many terms defined in this list were abstracted from the Allergy and Asthma Foundation of America's website <http://www.aafa.org> (Accessed 1/17/06).

Agents: A generalized term referring to compounds that are derived from chemical, biologic, and other materials.

Allergen: Any substance (antigen), most often eaten or inhaled, that is recognized by the immune system and causes an allergic reaction. Many allergens are responsible for triggering asthma, including dust mites, animal dander, mold, and cockroaches.

Allergic asthma: Also known as immunologic or sensitizer-induced asthma. This is the most common form of asthma and is explained by an immune-mediated mechanism such that symptoms including coughing, wheezing, shortness of breath, etc. are triggered by exposure to an allergen rather than an irritant.

Antigen: A substance that stimulates an immune response, especially the production of antibodies. Antigens are usually proteins or polysaccharides, but can be any type of molecule, including small molecules (haptens) coupled to a protein (carrier).

Asthma: A chronic, inflammatory disorder of the airways characterized by wheezing, breathing difficulties, coughing, chest tightness, and other possible symptoms. People with asthma have very sensitive airways that are prone to over-reacting to asthma triggers.

Asthma management: A comprehensive approach to achieving and maintaining control of asthma. It includes patient education to develop a partnership in management, assessing and monitoring severity, avoiding or controlling asthma triggers, establishing plans for medication and management of exacerbations, and regular follow-up care.

Asthmagen: An agent known to cause asthma in a person who never had asthma prior to exposure to the agent.

Atopy: An individual's propensity, usually genetic, to develop allergic reactions to common environmental allergens, and, therefore, to develop asthma or other allergic conditions.

Bronchospasm: Sudden constriction of the muscles in the walls of the bronchioles (branches of the bronchi) that causes difficulty in breathing.

Causal factors: Agents that cause the development of asthma in people previously free of the disease. Causal factors for allergic asthma are sensitizers that result in the onset of asthma. Causal factors for irritant asthma are those chemical agents or physical factors that initiate asthma.

De novo: A Latin expression meaning “afresh” or “anew.” Asthma *de novo* refers to new onset of disease.

Exacerbation: Any worsening of preexisting asthma. Exacerbation of asthma can be acute and sudden, or gradual over several days and be caused by exposure to either allergens or irritants.

Immunoglobulin E (IgE): A type of antibody that plays an important role in allergic asthma. In people with allergic asthma, inhalation of an allergen causes the body to produce more IgE, which causes a series of chemical reactions (IgE-mediated response) that produce airway constriction and/or airway inflammation.

Irritant: Substances that cause irritation of the respiratory tract, including physical factors such as cold air or exercise, or chemical agents such as gases or fumes.

Irritant asthma: A form of asthma, also called non-allergic asthma, that does not involve the immune system. Onset of asthma occurs without sensitization or latency and may be caused by a single exposure to a causal agent.

Latency: A time delay between the moment something is initiated, and the moment its first effect begins. With allergic asthma, there is a latency period between first exposure to an agent that causes asthma and the presentation of symptoms, because the immune system must first become sensitized to the allergen.

Reactive Airway Dysfunction Syndrome (RADs): A specific type of irritant asthma characterized by acute onset of the disease, typically due to exposure to high levels of irritants.

Risk factor: An agent that increases the probability of disease expression. Risk factors for asthma can be both those agents that 1) cause the onset of asthma and 2) trigger exacerbations of the disease.

Sensitizer: An allergen that initiates the allergic response. During this first exposure, the body begins to produce IgE antibodies specific to the allergen and thus becomes sensitized, though individuals will not experience allergic symptoms until a subsequent exposure.

Trigger: A risk factor (allergens or irritants) that causes exacerbation of asthma; a stimulus that causes an increase in asthma symptoms and/or airflow limitation.

APPENDIX A:

Protocols used in the three major summary evidence reports: the AOEC, CHE, and IOM.

The Association of Occupational and Environmental Clinics (AOEC)

Excerpts from “Revised Protocol”
Criteria for Designating Substances as
Occupational Asthmagens on the AOEC
List of Exposure Codes
http://www.aoec.org/content/Asthmagen_Protocol_4-9-05_revision.pdf
(Accessed 12/27/05)

A substance will meet criteria for inclusion as a cause of occupational asthma if it first meets the test of specificity (it can be identified as a discrete workplace substance) and clinical relevance (it is present in the air of workplaces) and in addition meets sufficient criteria as listed below. To be included as a sensitizing cause of asthma, it must meet one or more of the major criteria, or two or more of the minor criteria. To be included as a

non-sensitizing cause of asthma (reactive airways dysfunction syndrome or irritant asthma), it must meet major criterion 2 or two or more of the minor criteria numbered 1, 3, and 4. (Major criterion 1 and minor criterion 3 do not apply to non-sensitizing causes of asthma).

- a). Specificity: To be included in the AOEC asthmagen list, a substance must be defined in such a way that, if it is a cause of asthma, it can be avoided specifically by the patient without requiring unnecessary avoidance of nonasthmagens.
- b). Clinical relevance: To be designated as AOEC asthmagens, substances must be currently used or have been used in workplaces where there is potential for inhalation exposure. A peer-reviewed case report, outbreak report, or case series report is also required to establish clinical relevance

where circumstances described in the report indicate the possibility of this substance as an asthmagen.

Major Criteria (at least one)

- 1) Specific inhalation challenge indicates occupational asthma (i.e. immediate or delayed fall in FEV1 after exposure) in at least one patient with asthma who appears to have developed the asthma as a result of exposure to the implicated substance. Peer reviewed study should indicate a response to sub-irritant levels of sensitizing substances. Ideally, a positive challenge will be controlled by negative challenges in asthmatic patients who are not believed to be sensitized to the particular substance, but this design is not characteristic of many specific exposure challenges.

2) Workplace challenge with physiologic response (serial spirometry or serial peak expiratory flow) showing reversible expiratory airflow obstruction or changing airway reactivity in relation to exposure, with a comparable control period without significant variable airflow obstruction or airway reactivity. Subjects tested should be reasonably considered to be without asthma prior to testing in the workplace, to exclude work-aggravated asthma. Peer reviewed publication.

OR

Minor Criteria (at least two):

- 1) Non-specific airway hyperresponsiveness is demonstrated in patients with suspected occupational asthma while they are still employed at the workplace in question, based on methacholine, histamine, or cold-air challenge, published in a peer-reviewed journal.
- 2) Work-exposure related reversible wheezing is heard in at least one patient with a compatible clinical picture, published in a peer-reviewed journal.
- 3) Positive IgE antibody (skin test or serologic test) for the suspected antigen in at least two patients, indicating potential IgE sensitization, published in a peer-reviewed journal.

4) Clinical response of remission of symptoms with cessation of exposure and recurrence of symptoms with re-exposure in one or more patients in each of two or more subjects published in a peer-reviewed journal.

Toxicant and Disease Database of the Collaborative on Health and the Environment (CHE)

Excerpts from database description: <http://database.healthandenvironment.org/intro.cfm>. (Accessed 12/27/05)

Data for the database were obtained from three major textbooks on the topic of environmental medicine and toxicology. These sources are:

1. Klaassen CD, Ed. Casarett and Doull's Toxicology: The Basic Science of Poisons, 6th edition. 2001;McGraw-Hill publishing, New York.
2. LaDou J. Ed. Occupational and Environmental Medicine, 3rd edition 2004;Lange Medical/McGraw-Hill, New York.
3. Rom WM, Ed. Environmental and Occupational Medicine, 3rd edition 1998;Lippincott-Raven, Philadelphia, PA.

Literature searches for human epidemiological studies and reviews of disease

topics were carried out to supplement and update textbook information.

Strength of evidence for the association (Criteria)

The “**strong evidence**” category is reserved for chemicals for which a causal association with disease has been verified. The toxicity of these chemicals has been well-accepted by the medical community and is noted in the textbook references as, “It is well known that *x* chemical causes *y* condition” or “There is strong evidence that *x* compound causes *y* disease.” Other chemicals were put into this category by causal associations drawn from more recent large prospective or retrospective cohort studies. Finally, chemicals listed as Group 1 human carcinogens by the International Agency for Research on Cancer (IARC) are included in this category. These are chemicals that have been determined to have sufficient evidence for causing cancer in humans.

The “**good evidence**” category includes chemicals associated with a disease through epidemiological studies (cross-sectional, case-series, or case-control studies) or for chemicals with some human evidence and strong corroborating animal evidence of an association. Textbook statements such as, “There

is evidence for an association between exposure to x compound and y disease.” assumed good evidence. IARC Group 2A chemicals, those with limited evidence for causing cancer in humans and sufficient evidence in animals, also are included in this category.

The “**limited/conflicting evidence**” category contains chemicals weakly associated with human disease by reports from only a few exposed individuals (case reports), from conflicting human epidemiological studies that have given mixed or equivocal results, or in a few cases, from reports clearly demonstrating toxicity in animals where no human data exist. Also included in this category are IARC Group 2B chemicals and EPA Group B2 chemicals. These chemicals show limited or inadequate evidence of causing cancer in humans and limited animal evidence of causing cancer.

The majority of the chemicals in the database fall into the “**limited/conflicting**” evidence category. This is because human epidemiological studies are very complex, difficult to design and interpret, and cannot be easily repeated. Health outcomes linked to exposures to mixtures of compounds, such as pesticides or solvents, sometimes provide hints of causal

associations and direct future research efforts but usually cannot provide strong evidence, especially for one particular chemical. Animal data often provide the supporting evidence of an individual chemical’s toxicity when human data are missing or incomplete.

As more scientific research is done, some chemicals in the database may be found to have stronger evidence for causing disease, new chemicals will be added, and others may be found to have no association with a disease and fall off the list entirely.

Institute of Medicine “Clearing the Air: Asthma and Indoor Air Exposures” Report

Excerpt from report, published in 2000: <http://fermat.nap.edu/catalog/9610.html#toc>. (Accessed 12/27/05)

Sufficient Evidence of a Causal Relationship

Evidence is sufficient to conclude that a causal relationship exists between the action or agent and the outcome. That is, the evidence fulfills the criteria for “Sufficient Evidence of an Association” below and in addition satisfies criteria regarding the strength of an association, biologic

gradient (dose-response effect), consistency of an association, biologic plausibility and coherence, and temporality used to assess causality.

Sufficient Evidence of an Association

Evidence is sufficient to conclude that there is an association, i.e., an association between the action or agent and the outcome has been observed in studies in which chance, bias, and confounding can be ruled out with reasonable confidence. For example, if several small studies that are free from bias and confounding show an association that is consistent in magnitude and direction, there may be sufficient evidence of an association.

Limited or Suggestive Evidence of an Association

Evidence is suggestive of an association between the action or agent and the outcome but is limited because change, bias, and confounding cannot be ruled out with confidence. For example, at least one high-quality study shows a positive association, but the results of other studies are inconsistent.

Inadequate or Insufficient Evidence to Determine Whether or Not an Association Exists

The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of an association, or no studies exist that examine the relationship. For example, available studies have failed to adequately control for confounding or have inadequate exposure assessment.

Limited or Suggestive Evidence of No Association

Several adequate studies are mutually consistent in not showing an association between the action or agent and the outcome. A conclusion of “no association” is inevitably limited to the conditions, level of exposure, and length of observation covered by the available studies. In addition, the possibility of a very small elevation in risk at the levels of exposure studied can never be excluded.

APPENDIX B: Cleaning products (including some individual chemicals) reported to the Sentinel Event Notification System for Occupational Risk (SENSOR) as exposures for work-related asthma cases.⁹²

Cleaning materials, household cleaners (not specified)	Ethylene glycol monobutylether
Bleach	Ethanolamines
Acids, bases, oxidizers	Oven cleaner
Disinfectants (not specified)	Sulfonates
Carpet cleaner	Caustic
Floor stripper/waxes	Phenols
Ammonia	Limonene
Mixing bleach and acid or ammonia	Glass cleaner
Glutaraldehyde	Copier cleaner
Graffiti remover	Iodophors
Soaps	
Ethanol	
Quaternary ammonia	
Formaldehyde	

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