Flood-Related Cleaning

Draft Report

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This report was prepared for the U.S. Environmental Protection Agency (EPA) by Terry Brennan (Camroden Associates) and Gene Cole, Ph.D., under EPA contract number EP-D-04-069 with The Cadmus Group, Inc.

Contents

Executive Summary

This document addresses approaches to cleaning up residences flooded after a hurricane or other weather event. It is based on a literature search conducted using PubMed, Science Direct, the Morbidity and Mortality Weekly Report search engines, and the files of the co-authors. The report considers the types of illnesses associated with such flooding; the effectiveness, selection, use, and hazards of biocides for cleaning and decontaminating surfaces affected by the presence of microorganisms and their biofilms; and available guidance documents that provide recommendations for cleaning up after floods, hurricanes, and related events.

The literature search found the occurrence of a wide range of illness and injury due to floods. These adverse health effects include physical injuries such as cuts and abrasions; infections due to contact with contaminated flood water and contaminated surfaces; exposure to non-biological contaminants such as carbon monoxide, heavy metals, and pesticides, which can lead to health impacts; allergic or asthmatic episodes triggered by exposures to mold; and emotional trauma and post-traumatic stress.

Guidance documents related to flood cleanup are available from government agencies and non-governmental organizations. The primary federal sources of guidance are the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), and the Federal Emergency Management Association (FEMA). Non-governmental sources include the American Red Cross, the American Lung Association, the National Center for Health Housing, and the Institute of Inspection, Cleaning, and Restoration.

The guidance documents available from these sources vary in length and depth of coverage. The EPA and CDC documents tend to be shorter than the others and to provide simple, direct guidance with only brief discussion of the issues involved. All the guidance documents reviewed in this report agree that a flooded house should be dried quickly. They also agree that porous materials that contact flood water should be removed. And while all recommend the use of water and detergents to clean hard surfaces, they differ on whether bleach and other biocides should be used. Approaches to cleaning flood-contaminated heating, ventilation, and air conditioning systems are also addressed by many of the guidance documents.

This report also considers reported cases of injury due to the use of sanitizers, particularly bleaches and disinfectants. The health effects of mixing cleaners and disinfectants are also discussed.

The literature review supports a number of findings:

- The literature documents a number of hazards in flood water residue including pathogens, parasites, and chemicals.

- Illnesses that might have been contracted during cleanup of indoor spaces after floods are reported in the literature, but very few cases can be conclusively attributed to exposures to flood residue on environmental surfaces in buildings.

- The literature documents that exposures to endotoxins and fungal spores in flooded buildings is significantly elevated compared to exposures in non-flooded buildings after floods.

- CDC *Guidelines for Environmental Infection Control in Health-Care Facilities* recommends using ordinary environmental cleaning protocols after sewage spills. Although this procedure may include the use of a combination cleaner/disinfectant, high-level disinfectants are ruled out, and a solution of detergent and water is recommended for cleaning surfaces outside of patient-care areas.

- “Extraordinary cleaning and decontamination of floors in health-care settings is unwarranted. Studies have demonstrated that disinfection of floors offers no advantage over regular detergent/water cleaning and has minimal effect on the occurrence of health-care-associated infections.”—CDC *Guidelines for Environmental Infection Control in Health-Care Facilities*

- Sodium hypochlorite is implicated in numerous health endpoints, including tens of thousands of visits to poison control centers each year.

- Exposure studies support these conclusions:
    - The use of gloves when mixing, preparing, wiping, or spraying wet products greatly reduces dermal exposures.
    - The use of respirators reduces exposures to airborne particles.
    - Wash and rinse water should be changed frequently to avoid cross-contamination when mopping or wiping.

Introduction

This document addresses potential adverse human health effects and their risk reduction relative to post-flooding cleanup activities in residential environments. It aims to address two questions:

- What is the best way to clean up after a flood resulting from a hurricane or other contaminated water situation?
- Is there sufficient information in the literature to refine EPA's current guidance for cleaning up after floods?

Although this document emphasizes the importance of minimizing exposures to microbial contamination during cleanups, most flood-related injuries are due to trips, falls, scrapes, or infected wounds. Preventing those injuries is paramount. Responding to the hazards that can cause those injuries will also have a large impact on pathogens, allergens, and irritants. For example, while the use of sanitizers may reduce biological exposures via inhalation or contact with skin or mucous membranes, so can aspects of the cleanup protocol, such as use of personal protective equipment (gloves and respirators), proper hand washing, and the availability of good-quality water. How thoroughly a surface is cleaned using hot water, detergent, and physical agitation is inextricably linked with how effective a sanitizer or disinfectant will be at inactivating residual microbes. Cleanup protocols and personal protective equipment (PPE) can also reduce the risk of exposure to non-biological contaminants in flood water, such as heavy metal, pesticide, and residues of hydrocarbons.

Literature reviews were conducted using PubMed, Science Direct, the Morbidity and Mortality Weekly Report (MMWR) search engines, and the files of the co-authors. Our review focused on:

- Reported illnesses and injuries associated with floods and related storm damage.
- Effectiveness, selection, use, and hazards of chemical germicides (biocides) for cleaning and decontaminating surfaces and materials contaminated by microorganisms and their biofilms.
- Current guidance documents for cleaning up after floods, hurricanes, and other storm events.

Flood waters resulting from hurricanes, tropical storms, rising rivers, or tsunamis may be significantly more contaminated than flood waters from clean sources such as potable water or rainwater that leaks into buildings. The *S500 Standard and Reference Guide for Professional Water Damage Restoration*, published by the Institute of Inspection Cleaning and Restoration (IICRC), categorizes water by level of contamination, from potable water (Category 1) to grossly contaminated water (Category 3) (IICRC 2006). The IICRC considers all water originating from sea water, ground or surface water, rising rivers and streams, and wind-driven rain from hurricanes and tropical storms to be Category 3.

1. Illness and Injury after Floods

Our literature search identified injuries and illnesses associated with residential flood damage, the risk of which might be reduced through proper cleanup practices. Over 60 documents addressed illnesses and injuries during times of flooding, hurricanes, or tsunamis. It is clear that many people are injured, become ill, or die during or shortly after hurricanes and floods (CDC 1983, CDC1992 Sep, CDC 1993 Apr, CDC 1993 Sep, CDC 1993 Oct, CDC 1993 Dec, CDC 1994 Jul 6, CDC 1994 Jul29, CDC 1996 Jan, CDC 1996 Feb, CDC 2000 May, CDC 2005 Oct 14b, CDC 2005 Sep, CDC 2005 Oct 21, CDC 2006 20d, CDC 2006 Mar 10c, FEMA 1992, IICRC 2006, Todd 2006). Much of the loss occurs during the flood event itself.

It is also clear from published reports that people suffer illness and injury while at evacuation sites and during cleanup and restoration activities (CDC 2004 Dec, CDC 2005 14a, CDC 2006 Jane, CDC 2006 Apr 21, Sullivent 2006, Todd 2006). Health problems reported include:

- Physical injury
    - Drowning, physical trauma, cuts, abrasion (Sullivent 2006, IICRC 2006, FEMA 1992)
    - Animal bites (mammals, insects, reptiles) (CDC 2006 Apr 21)

- Infection (primarily infected wounds and gastro-intestinal or respiratory infections) (Todd 2006)
    - From contact with flood waters, which carry organisms found in sewage, soils, and animal waste (CDC 2006 Apr 21)
    - During cleaning activities (from contact with or aerosolization of flood residues) (CDC 2006 Feb)
    - From conditions in the flooded area or at evacuation locations (from contaminated water, food, strained sanitation services and crowded conditions) (CDC 2005 Oct 14a, CDC 2006 Mar 10b)

- Exposures to non-biological contaminants
    - Carbon monoxide from gas-powered equipment, such as generators, pressure washers, or water pumps, used indoors (CDC 2006 Mar 10a, CDC 2006 Apr 21)
    - Heavy metals
    - Pesticides
    - Organic compounds such as petroleum or PAH (CDC 2006 Apr 21)

- Allergic or asthmatic episodes while occupying or cleaning damp, moldy buildings (CDC 2006 Jan 20c, CDC 2006 Jun)

- Emotional trauma and post-traumatic stress (CDC 1996 Feb, CDC 2002 May 3, CDC 2006 Apr 28)

Illnesses Associated with Floods and Water Damage

This project focuses on health impacts that can be affected by cleanup methods including the use of biocides. Not all illnesses and injuries occurring after flooding events can be linked to flood residue or secondary mold or bacterial growth. Only illnesses that might be caused by environmental exposure to pathogens or secondary microbial growth are considered in our search.

The literature shows over 50 references regarding illnesses associated with biological contamination from floods and other types of water damage. The illnesses fall into two major categories:

- Illnesses caused by pathogens encountered in flood waters, in conditions faced by evacuees following the flood, and in flood residue during cleaning and reoccupying buildings.

- Allergic and irritant effects (possibly related to secondary microbial growth) experienced in buildings after flood waters recede.

Pathogens in Flood Water

Flood water is often contaminated with pathogens from sewage, farm animal wastes, and wild animal populations, or that occur naturally in bodies of water (IICRC 2006, FEMA 1992, Straub 1993, Berry 1994, Godfree 2005). Although a complete list would be too long to present here, the following biological agents represent the pathogens that can be found in flood water and residue:

- Parasites
    - Giardia
    - Entameba

- Bacteria
    - Campylobacter
    - Salmonella
    - Shigella
    - Norovirus
    - Enterococci
    - E. coli
    - Legionella
    - Leptospira

- Viruses
    - Hepatitis A
    - Rotavirus
    - Adenovirus
    - Enterovirus
    - Parvovirus

The kind and level of contamination found in flood water varies considerably from one location to another and over time. A great deal depends on the nature, size, and location of contaminant sources and the direction and volume of flood waters. During an ongoing study of water quality in the Cape Fear watershed of North Carolina from 1996 to 2000, the area was struck by Hurricanes Fran, Bonnie, and Floyd (Mallin 2002). Mallin reports that different storms had different impacts on the levels of total nitrogen, ammonium-N, Nitrate-N, total phosphorus, orthophosphate, and fecal coliform bacteria. Hurricanes Fran and Floyd had little impact on levels of coliform bacteria in the watershed area under study, while concentrations after Hurricane Bonnie increased from less than 100 colony-forming units per 100 ml (100 cfu/100ml) to between 131 and 16,900 cfu/100ml. (Eight of 10 samples had concentrations greater than 1,000 cfu/100ml.) Similar results were reported for samples following Hurricane Katrina (Pardue 2005).

The MMWR search identified 22 relevant articles describing illnesses associated with floods and 4 articles describing injuries only. Two tables reporting injury and illness are excerpted below, one for Hurricane Katrina and one for Tropical Storm Allison.

The numbers and percentages of post-Katrina illnesses by residency status are shown below. The reported illnesses may not be representative of a more typical flooding situation due to the extreme devastation caused by Hurricane Katrina, which resulted in poor air quality, dust, debris, fires, and other situations. Nonetheless, Hurricane Katrina is useful as a marker of an extreme natural disaster (CDC 2005 Oct 14b). Thousands of people became ill during and after Katrina.

TABLE 1. Number and percentage of persons with selected illnesses after Hurricane Katrina, by residency status — New Orleans, Louisiana area, September 8–25, 2005

	Relief workers		Residents		Unknown		Total	
Selected illnesses	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Infectious-disease–related								
Skin or wound infection	101	(19.1)	192	(12.8)	347	(16.2)	**640**	**(15.4)**
Acute respiratory infection	119	(22.5)	158	(10.5)	228	(10.6)	**505**	**(12.1)**
Diarrhea	11	(2.1)	52	(3.5)	83	(3.9)	**146**	**(3.5)**
Other infectious disease	36	(6.8)	109	(7.3)	143	(6.7)	**288**	**(6.9)**
Noninfectious-disease–related								
Rash	67	(12.7)	87	(5.8)	146	(6.8)	**300**	**(7.2)**
Heat-related	34	(6.4)	80	(5.3)	93	(4.3)	**207**	**(5.0)**
Nondiarrhea gastrointestinal	23	(4.4)	77	(5.1)	108	(5.0)	**208**	**(5.0)**
Renal*	8	(1.5)	44	(2.9)	35	(1.6)	**87**	**(2.1)**
Other classifiable illness†	22	(4.2)	52	(3.5)	88	(4.1)	**162**	**(3.9)**
Other illnesses	107	(20.3)	649	(43.3)	870	(40.6)	**1,626**	**(39.0)**
Total	**528**	**(100.0)**	**1,500**	**(100.0)**	**2,141**	**(100.0)**	**4,169**	**(100.0)**

* Includes kidney stones and renal failure (i.e., chronic and acute).
† Includes diabetes, cardiovascular conditions, obstetric/gynecologic conditions, and dental problems.

Table 2 reports illnesses and injuries following Tropical Storm Alison in Texas in 2001 (CDC 2002 Jun). The significant difference in illness rates between people in flooded and non-flooded locations provides evidence for the link between flood and increased illness. Respiratory and stomach conditions are reported more frequently than other health problems, consistent with the data from Hurricane Katrina shown above. Reported illnesses that might be the result of exposure to flood residues or secondary microbial growth are:

- Gastrointestinal infection.
- Wound infection.
- Respiratory infection.
- Upper respiratory symptoms.
- Skin rash.

TABLE 2. Number and percentage of households with one or more persons reporting illness or injury within 1 week after Tropical Storm Allison, by flood status of home — Houston, Texas, June 16, 2001

Condition	Flooded (n=137) No.	Flooded (n=137) (%)	Nonflooded (n=283) No.	Nonflooded (n=283) (%)	OR*	(95% CI†)	p value§
Illness	35	(25.5)	19	(6.7)	4.7	(1.8– 12.0)	<0.001
Diarrhea/Stomach condition	15	(10.9)	9	(3.2)	6.2	(1.4– 28.0)	0.017
Respiratory symptoms/Cold	14	(10.2)	7	(2.5)	3.2	(0.9– 10.9)	0.046
Headache/Dizziness	10	(7.3)	4	(1.4)	4.4	(0.8– 25.6)	0.056
Anxiety/Distress	5	(3.6)	0	(0.0)	undefined	undefined	0.059
Heart attack/Heart problems	4	(2.9)	0	(0.0)	undefined	undefined	0.059
Chronic illness made worse	3	(2.2)	0	(0.0)	undefined	undefined	0.134
Undefined generalized illness	1	(0.7)	1	(0.4)	undefined	undefined	0.149
Sleep disturbance/Nightmare	12	(8.8)	2	(7.1)	3.3	(0.5– 22.3)	0.240
Rash	2	(1.5)	2	(0.7)	6.0	(0.2–149.6)	0.286
Allergies	0	(0.0)	1	(0.4)	undefined	undefined	0.527
Injury	11	(8.0)	6	(2.1)	1.9	(0.4– 8.4)	0.463
Fall	2	(1.5)	0	(0.0)	undefined	undefined	0.153
Blunt injury	1	(0.7)	0	(0.0)	undefined	undefined	0.387
Insect bite	3	(2.2)	0	(0.0)	undefined	undefined	0.394
Abrasion/Cut/Puncture	2	(1.5)	3	(1.1)	0.4	(0.0– 8.1)	0.596
Auto accident	0	(0.0)	1	(0.4)	undefined	undefined	0.683
Other undefined injury	1	(0.7)	0	(0.0)	undefined	undefined	0.683
Animal bite	2	(1.5)	2	(0.7)	1.0	(0.1– 20.0)	1.000

* Odds ratio.
† Confidence interval.
§ Analysis of odds ratio, confidence interval, and p value stratified by census tract.

The information from Hurricanes Katrina and Allison illustrates a problem common to many of the other papers: they are not detailed enough for the reader to determine whether exposures came about by the ingestion of contaminated food or water, by direct contact with flood water (especially contacts involving wounds), or by exposure to flood water residue or secondary microbial growth. A number of the studies provide evidence that the illnesses were related to flood conditions or contact with flood waters (CDC 2005 Sep 23, Katteruttanakul 2005, Karande 2003, Waring 2002, Miettinen 2001). Waring found that persons living in flooded houses after Tropical Storm Allison had a four-fold greater illness rate than those living in nonflooded houses (Waring 2002). A study of gastrointestinal illness that was underway when flooding occurred provides some evidence of flood-related illness that was unlikely to have been caused by contaminated drinking water (Wade 2004). It found that increased gastrointestinal symptoms were observed during the flood (incidence ratio 1.29) and that there was an association between increased symptoms and contact with flood water, but not with the use of tap water. An outbreak of norovirus was reported from an evacuation center (CDC 2005 Oct 14a) and an increase in acute respiratory illness was attributed to the close quarters experienced by a National Guard battalion (CDC 2005 Octb).

A few studies provide evidence that illnesses resulted from the post-event cleanup (CDC 2005 Oct 14b, Lee 1992), and some studies contain evidence for post-occupancy exposures:

- Two weeks after Hurricane Andrew the rate of injury complaints went down, the rate of respiratory complaints went up, and the rate of gastrointestinal complaints remained steady (Lee 1992).

- Post-Katrina data indicate that relief workers experienced significantly more skin rashes than non-workers (CDC 2005 Oct 14b), providing evidence that relief workers were experiencing exposures that others were not.

- A professor at the University of Hawaii contracted leptospirosis while cleaning up after heavy rains caused a stream to overflow and flood his lab. This is a single case and has none of the distracters inherent in statistics that follow major flooding events.

Respiratory Problems and Moisture/Dampness

Our review found numerous articles that report associations between health endpoints and buildings that are damp, contain resultant microbial growth, or both. The most comprehensive is the National Academies of Science report *Damp Indoor Spaces and Health* (IOM 2004), which concludes that there is an association between the presence of mold or other agents in damp indoor environments and (1) upper respiratory tract symptoms, (2) asthma symptoms in sensitized persons, (3) hypersensitivity pneumonitis in susceptible persons, (4) wheezing, and (5) coughing.

There is also limited or suggestive evidence of an association with lower respiratory illness in otherwise healthy children. (IOM 2004: pp.9-11). There is some evidence in the literature that living in flooded buildings where there is secondary microbial contamination is associated with symptoms consistent with those listed in the IOM report.

Upper respiratory problems were the most frequently reported symptoms among police officers and firefighters in the aftermath of Hurricane Katrina (CDC 2006 Apr 28). An editorial note says that the respiratory and skin rash symptoms were similar to those reported by Hurricane Katrina relief workers (CDC 2005 Octb), which were very similar to those reported by relief workers after Hurricane Rita (CDC 2006 Jan 20c). However, the note states, “The relation between floodwater exposure and reported symptoms of illness is not clear.”

Indoor and outdoor spore counts after floods

There is evidence in the literature that airborne levels of fungal spores and bacterial endotoxins are higher in flooded buildings than in other buildings; in some instances, reported outdoor levels are higher than ordinarily reported.

- Airborne bacterial endotoxin levels measured indoors and outdoors in New Orleans between October 22 and October 28, 2005, were 23.3 endotoxin units per cubic meter (EU/m3) and 10.5 EU/m3 respectively. These levels, measured almost 2 months after Hurricane Katrina, were higher than in previously reported work (<1.0 EU/m3). The post-Katrina study consisted of indoor air samples from 20 non-randomly selected homes that had been flooded; outdoor air samples were drawn at 11 of them. Six of the homes had been remediated (CDC 2006 Jan 20b).

- Another study reporting mold levels in New Orleans at this time found that total and culturable mold spore concentrations were significantly higher indoors (100,000 – 100,000,000 spores/m3) and outdoors (22,000 – 515,000 cfu/m3) than are generally reported indoors even after floods (0 – 48,760 cfu/m3 [mean 2,190 cfu/m3]) (Ross 2000). Chew also reported bacterial endotoxin levels between 17 and 139 EU/m3 for the same study. Indoor and outdoor samples were collected at three houses in New Orleans, all of which experienced flooding, before and after remedial efforts (Chew 2006). By comparison, a study in Boston reported a mean indoor endotoxin level of 0.64 EU/m3 (IOM 2004).

- Within 2 months of the floods caused by Hurricane Katrina, measured levels of airborne mold ranged from 11,000 – 645,000 spores/m3 indoors and from 21,000 – 102,000 spores/m3 outdoors. Indoor air samples were taken at 8 houses that had experienced different levels of flooding and were in various states of remediation. Two indoor endotoxin samples from flooded homes yielded mold concentrations of 4.5 and 7.3 EU/m3. Twenty-three outdoor locations also were sampled. The mean outdoor concentration in flooded areas (66,197 spores/m3) was double that in non-flooded areas (33,179 spores /m3). There was no significant difference between outdoor airborne endotoxin levels in flooded areas (2.2 – 5.6 EU/m3) and non-flooded areas (1.5 – 6.9 EU/m3 [mean of 4.1 EU/m3]). The researchers concluded that indoor and outdoor mold levels following Hurricane Katrina posed a significant respiratory hazard (Solomon 2006).

- Sampling in 100 non-compliant office buildings by the U.S. EPA Building Assessment Survey and Evaluation (BASE) Study found indoor levels of fungal spores ranging from 0 – 230 cfu/m3 and outdoor levels between 0 and 6,184 cfu/m3 (Shendell; Macher 2001).

- In a review of documented indoor and outdoor levels of fungal spores, Gots et al. reported a mean indoor spore level of 233 cfu/m3 in 149 non-compliant commercial buildings and an average outdoor level of 983 cfu/m3. Total spore counts for the buildings were 610 – 1,040 spores/m3; outdoor levels ranged from 400 – 800,000 spores/m3. The indoor levels for non-compliant residential buildings averaged 1,252 cfu/m3; outdoor levels averaged 1,524 cfu/m3 (Gots 2003).

Baxter et al. reported indoor and outdoor mold spore levels from 625 commercial and residential buildings. Outdoor levels ranged from 70 – 90,000 spores/m3 (mean of 2,000 spores/m3). Indoor levels in clean residential buildings were between 150 and 9,000 spores/m3 (mean of 900 spores/m3). Indoor levels ranged from 200 – 3,000,000 spores/m3 (mean of 5,000 spores/m3) in moldy residential buildings; from 20 – 8,000 spores/m3 (mean of 700 spores/m3) in clean commercial buildings; and from, 200 – 20,000,000 spores/m3 (mean of 5,000 spore/m3) in moldy commercial buildings (Baxter 2005).

2. Cleaning After Floods

The literature search included cleanup after floods generally and the use of cleaning and sanitizing methods and materials specifically. Four source documents currently in use by EPA and CDC were compared for coverage of several topics. But before we discuss the results of the search, we define the terms commonly used when discussing the killing or inactivation of microorganisms.

Definitions

A number of words are used to describe materials and methods that reduce, inactivate, or kill microbes or that prevent their growth. While many groups often apply their own meanings to the terms, EPA, as a regulatory body, employs standard legal definitions based primarily on the laboratory test methods required for product registration.

Biocide: A simple definition accepted by many groups is "any substance that kills a living organism" (IICRC 2006, ACGIH 1999). EPA uses the term "antimicrobial pesticide" to refer to the spectrum of chemical germicides, biocides, and antimicrobials.

Antimicrobial: EPA defines an antimicrobial as a substance that kills or inactivates bacteria, fungi, or viruses in the inanimate environment (excluding those on or in living organisms, food, beverages, pharmaceuticals, or cosmetics) or is used to inhibit microbial growth on materials. Antimicrobials include sterilizers, disinfectants, virucides, tuberculicides, algicides, sanitizers, bacteriostats, and fungistats.

The IICRC S500 standard defines an antimicrobial as a substance that kills or controls microorganisms or inhibits their growth (IICRC 2006).

The American Conference of Governmental Industrial Hygienists (ACGIH) defines an antimicrobial agent as a chemical formulation applied to or incorporated into a material to suppress or retard the growth of vegetative bacteria or fungi (ACGIH 1999). Many other authorities refer to materials that prevent microbial growth on environmental surfaces as biostats. Materials that specifically inhibit bacterial growth are termed bacteriostats, and materials that specifically inhibit the growth of fungi are referred to as fungistats.

Sanitizer: According to EPA, a sanitizer is one of three groups of antimicrobials registered by the Agency for public health uses. EPA considers an antimicrobial to be a sanitizer if it reduces but does not necessarily eliminate all the microorganisms on a treated surface. For a product to be a registered sanitizer, its test results must show a reduction of at least 99.9 percent in the number of each test microorganism over the parallel control. The IICRC and ACGIH definitions of sanitizer are essentially the same as the EPA definition, but they do not include the percent reduction.

Disinfectant: According to EPA, a disinfectant is one of three groups of antimicrobials registered by the Agency for public health uses. EPA considers an antimicrobial to be a disinfectant when it destroys or irreversibly inactivates infectious or other undesirable organisms, but not necessarily their spores. EPA registers three types of disinfectant products based on submitted efficacy data: limited, general or broad spectrum, and hospital disinfectant.

Sterilizer: According to EPA, a sterilizer is one of three groups of antimicrobials registered by the Agency for public health uses. EPA considers an antimicrobial to be a sterilizer if it destroys or eliminates all forms of bacteria, fungi and their spores, and viruses. Because spores are considered the most difficult form of microorganism to destroy, EPA considers the term “sporicide” to be synonymous with “sterilizer.”

Guidance Documents

Guidance documents make recommendations based where possible on thorough research or, where significant research is lacking, on the experience of those who have studied or responded to problems in flood-damaged buildings. Guidance documents are available from government agencies and from non-governmental organizations. The primary federal guidance comes from the U. S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), and the Federal Emergency Management Agency (FEMA). Governments and cooperative extension programs in states that historically experience floods have produced a significant number of guidance documents. Non-governmental organizations (NGOs) such as the American Red Cross, the American Lung Association, the National Center for Healthy Housing (NCHH) and the IICRC have produced guidance documents. This report focuses on documents from the three federal agencies—EPA, CDC, and FEMA—and examines one document from the NCHH and one from the IICRC. The two NGO documents were selected because they are current, comprehensive, and widely used by community housing groups (the NCHH document) and professional water restoration firms (the IICRC document).

The following documents have been selected for review:

1. “Fact Sheet: Flood Cleanup – Avoiding Indoor Air Quality Problems,” EPA Office of Radiation and Indoor Air, http://www.epa.gov/iaq/pubs/flood.html. This six-page Web-based fact sheet contains guidance on preparation, avoiding microbial growth, removing standing water, drying, removing wet materials, avoiding problems with cleaners and disinfectants, and avoiding carbon monoxide, asbestos, and lead hazards. It has numerous links to other sites. It recommends using household cleaners and disinfectants to clean materials and warns about safety when using disinfectants. (Note: The pdf version of this document does not display all the text found in the on-line document.)

2. *Repairing Your Flooded Home*, Federal Emergency Management Agency and the American Red Cross, http://www.bostonredcross.org/library/Repairing_Flooded_Home.pdf#search=%22Repairing%20Your%20Flooded%20Home%22. This 56-page document has been used by those responding to flooded buildings for many years and was last updated in 1992. The guidance is clear, practical, and prioritizes risks; it is the essential starting point for anyone returning to a flooded building. The guidance recommends cleaning with water and detergents. It does not seem to require the use of disinfectants, but notes that if disinfectants are used, quaternary compounds, phenolics, and pine oil disinfectants should be the first choice and bleach solutions second.

3. "Protect Yourself from Mold," CDC, http://www.bt.cdc.gov/disasters/mold/pdf/moldprotection.pdf. This two-page fact sheet briefly covers mold risks, recognizing mold, preventing mold growth, and cleaning mold from materials. It recommends using detergent and water or a water and bleach solution to clean mold from materials.

4. *S500 Standard and Reference Guide for Professional Water Damage Restoration – 2006*, Institute of Inspection, Cleaning and Restoration Certification (IICRC), http://www.iicrc.org/pdf/buydocs.pdf. The IICRC is the certification body for water restoration professionals. The S500 standard is a consensus document that forms the basis of certification by the Institute. It is the most comprehensive guidance document for cleaning up buildings after a flood. The S500 standard has 88 pages of standard and over 200 pages of reference. It covers water damage restoration, building physics, safety and health, administration of projects, evaluations, specialized experts, structural restoration, HVAC restoration, contents, catastrophic events, biocides, and equipment and tools. It is discussed in more detail later in this section.

5. *Creating a Healthy Home: A Field Guide for Cleanup of Flooded Homes*, National Center for Healthy Housing and Enterprise Community Partners, http://www.centerforhealthyhousing.org/FloodCleanupGuide_screen_.pdf. This 18-page booklet covers the cleanup of flooded homes, health risks and worker protection, and lead, asbestos, and carbon dioxide risks. The cleanup itself is covered in 8 steps: pre-work inspection, before work begins, site preparation, clean-out, gut tear-out, pre-construction cleaning and treatment, selective tear out and preparation before restoration; and restore possessions. Clear, informative illustrations set this document apart.

6. "Hurricane Katrina Advisory: Initial Restoration for Flooded Buildings," FEMA, http://www.fema.gov/pdf/rebuild/mat/initial_restoration.pdf . This four-page document provides five steps for restoring buildings: air out, move out, tear out, clean out, and dry out. It cautions against using bleach on porous or dirty materials, electrical outlets, metals, soil, and materials treated for termites. Advice on cleaning and removing materials is very practical.

7. "Dealing with Mold & Mildew in your Flood Damaged Home," FEMA, http://www.fema.gov/pdf/rebuild/recover/fema_mold_brochure_english.pdf. This seven-page document discusses mold growth, health effects, cleaning and disinfecting, and mold prevention. It recommends washing hard surface materials and then disinfecting with a bleach solution. For porous materials, it suggests cleaning and using phenolic or pine oil in an effort to sanitize.

8. "Clean Up Safely After a Natural Disaster," CDC, http://www.bt.cdc.gov/disasters/pdf/cleanup.pdf. This three-page document contains a list of recommendations for reentering buildings, general safety measures, carbon monoxide exposure, cleanup issues, electrical issues, hazardous materials, hygiene and infectious disease, and water issues. It suggests thorough cleaning of hard surfaces. It does not cover disinfectants (except to disinfect wash water).

9. “Get Rid of Mold,” CDC, http://www.bt.cdc.gov/disasters/pdf/flyer-get-rid-of-mold.pdf. This one-page flyer is very direct and hase good illustrations. It recommends cleaning mold off materials using a solution of water and bleach.

10. *NIOSH Interim Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers*, CDC, http://www.cdc.gov/niosh/topics/flood/pdfs/Cleaning-Flood-HVAC.pdf.

11. *Mold Prevention Strategies and Possible Health Effects in the Aftermath of Hurricanes and Major Floods*, CDC, http://www.cdc.gov/mmwr/PDF/rr/rr5508.pdf. This 27-page document appears to be written for a fairly knowledgeable audience (public health personal, emergency responders, and restoration professionals). There is extensive discussion of health effects, worker protection, sampling, cleaning, and restoration. The document recommends cleaning materials with soap and water, then disinfecting them using a solution of bleach and water.

12. *Guidelines for Environmental Infection Control in Health-Care Facilities*, CDC, http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/Enviro_guide_03.pdf. This 250-page document is not written specifically in regard to flood response, but does provide thoughtful, well-documented guidance for responding to sewage spills and floods in health-care facilities. It is very comprehensive and discussed further in this report.

13. *Guidelines for Environmental Infection Control in Health-Care Facilities*, CDC MMWR, http://www.cdc.gov/MMWR/preview/mmwrhtml/rr5210a1.htm. This is a 28-page synopsis of the longer document by the same name.

The first five documents in the list, three governmental documents and two non-governmental documents, were selected for comparison with each other. The comparisons are presented in table 3 (governmental documents) and table 4 (non-governmental documents).

The first obvious difference among the documents is their length and depth of coverage. The CDC and EPA documents are several pages long and provide simple, direct guidance with only brief discussion. The much longer FEMA/Red Cross document, NCHH document, and S500 standard provide far more detailed guidance and discussion. The IICRC standard is by far the most comprehensive and well-documented of the guidance materials.
Comparing the documents by topic:

- **Removing water and drying.** All the documents agree that the house should be dried quickly. They vary in level of detail on accomplishing the drying. The NCHH document briefly covers safety issues before entering a building and has guidance on airing it out. The FEMA/Red Cross document contains extensive guidance on removing water and drying out. The S500 standard contains extensive guidance on dewatering and drying.

- **Removing material.** The guidance documents agree that removing porous materials is warranted. Again, the level of detail on what and how to discard the materials varies. The FEMA/Red Cross, NCHH, and S500 standard contain extensive guidance on removing materials.

- **Cleaning hard surfaces.** All recommend water and detergent, but there are differences regarding the use of disinfectants. The EPA document recommends washing surfaces and provides cautions on the use of disinfectants. The CDC document refers to EPA's *A Brief Guide to Mold and Moisture in your Home* for guidance on disinfecting; it recommends using detergent and water or a solution of water and bleach to clean up mold and advises seeking professional help if the area of mold is more than 10 square feet. The FEMA/Red Cross document recommends disinfecting with quaternary ammonium compounds, phenolic, or pine-oil based products and specifies a solution of household bleach as a second choice. The NCHH guide recommends HEPA vacuuming, followed by water and detergent, followed by a solution of household bleach. The S500 standard discusses air- and water-based cleaning in detail; it cautions against the use of biocides, but provides guidance for using them if circumstances warrant.

- **HVAC systems.** Four of the five documents recommend cleaning or disinfecting HVAC equipment that has been flooded. The EPA fact sheet recommends disinfection and refers to the FEMA/Red Cross guide. The FEMA/Red Cross guide recommends hosing out ducts to clean them (if the ducts are accessible) and using a quaternary, phenolic, or pine oil-based disinfectant to sanitize them. The NCHH recommends throwing out all the flooded equipment, but in another place recommends fungicidal coating. The S500 standard recommends professional inspection and cleaning according to the National Air Ducts Cleaners Association standard ACR 2006. Any insulated ductwork saturated with water should be removed. When contaminated with Category 2 or Category 3 water, ductwork with an interior sound/insulation liner, plastic flex duct, and coated fiberboard ducting should be replaced. Use of an antimicrobial may be considered, but its use shall not be substituted for the removal of viable microbial bodies. The National Institute for Occupational Safety and Health's (NIOSH's) interim guidance for responding to flooded HVAC equipment is reviewed later in this report. The NCHH document recommends removing and replacing any HVAC equipment that was flooded. CDC has no recommendations for HVAC equipment.

- **Using bleach.** Here again the guidance differs between documents. The EPA fact sheet does not specifically mention bleach, but cautions against the use of biocides and refers to the FEMA/Red Cross guide. CDC recommends cleaning mold with detergent and water or a solution of 1 cup bleach per gallon of water. The FEMA/Red Cross guide shows a preference for disinfectants other than bleach, but allows diluted household bleach as a second choice for surfaces and recommends it for suspect drinking water; the FEMA Hurricane Katrina Recovery Advisories (reviewed later with other federal documents) recommend against using bleach. The NCHH guide recommends the use of diluted household bleach on non-porous hard surfaces after thoroughly cleaning them. The S500 standard extensively discusses biocide selection and use, and it adopts the American Conference of Governmental Industrial Hygienists' policy of avoiding the routine use of biocides.

- **Do not mix bleach with ammonia.** All the documents contain this warning. Chlorine bleach reacts with a number of other compounds to produce toxic compounds. (See the figure in the section on biocides.)

- **Clearance.** Only the S500 standard discusses clearance, and then only briefly. It recommends using a third party for testing after remediation has taken place.

- **Worker protection.** The EPA document does not discuss worker protection. The FEMA/Red Cross guidance recommends sturdy shoes and gloves. The CDC document recommends gloves and ventilation. The NCHH contains fairly extensive discussion and illustrations. The S500 standard has substantial discussion and refers to 29 CFR 1901 – Occupational Safety and Health Standards and 29 CFR 1926 – Safety and Health Regulations for Construction.

Table 3: Comparison of Governmental Guidance Documents

	"Fact Sheet: Flood Cleanup - Avoiding Indoor Air Quality Problems" (EPA)	***Repairing Your Flooded House*** **(FEMA/Red Cross)**	**"Protect Yourself From Mold" (CDC)**
Remove Standing Water	X	X Basement advice.	
Drying Out	X Refers to FEMA/Red Cross guidance	X No timeframe. Lower humidity. Advice on drying building.	Dry within 48 hours, open windows, use fans
Material Removal	Replace wet fiberboard, insulation, HVAC filters. Refers to FEMA/Red Cross guidance. Guidance on discarding items. Link to EPA Mold in Commercial Buildings.	Throw away flood soaked mattress, carpets, upholstered furniture, books, paper, fiberglass or cellulous insulation, wallboard, and food.	Remove porous materials wet >48 hrs. that cannot be dried and thoroughly cleaned (carpeting, upholstery, wallpaper, gypsum board); store salvageable items outside house
Cleaning Hard surfaces	Household cleaners & disinfectants; cautions of safety when using disinfectants	Detergent & water. Disinfect with: Quaternary, phenolic, or pine oil-based products. 2nd choice bleach (with care).	Clean with detergent and water or bleach solution; refers to EPA Brief Guide to Mold, Moisture and Your Home for disinfection; > 10ft^2 professional help
Cleaning HVAC Systems & Duct	Ducts: Disinfectant or sanitizer. Refers to FEMA/Red Cross guidance	Ducts: Hose out, wash with disinfectant or sanitizer (quaternary, phenolic, pine oil).	
Use of bleach	Not mentioned specifically, but reference to FEMA/Red Cross guidance implies agreement	2nd choice as disinfectant; use for suspect drinking water	Use detergents, soap and water or bleach solution: 1 cup bleach per gallon water
Do not mix bleach and ammonia	X – general caution on mixing cleaners and disinfectants	X	X
Other	Use fans during and after cleaning	Washing machine: disinfect with quaternary, phenolic or pine oil based cleaners or bleach.	
"Clearance"			
Worker Protection		Sturdy shoes, gloves	Gloves, ventilation

Table 3: Comparison of Governmental Guidance Documents

	"Fact Sheet: Flood Cleanup - Avoiding Indoor Air Quality Problems" (EPA)	***Repairing Your Flooded House* (FEMA/Red Cross)**	**"Protect Yourself From Mold" (CDC)**
Carbon Monoxide	No unvented combustion devices inside.	Under health effects.	
Asbestos	X contact EPA.		
Lead	Do not disturb lead paint or dust.		
Health Effects			Brief discussion
Comments	6 pages	Extensive general advice; Defines disinfectants. 56 pages	2 pages

Table 4: Comparison of Non-Governmental Guidance Documents

	***S500 Standard and Reference Guide for Professional Water Damage Restoration – 2006* (IICRC)**	***Creating a Healthy Home: A Field Guide for Cleanup of Flooded Homes* (NCHH)**
Remove Water	X	X
Drying Out	Begin as soon as safely practical following the initial moisture intrusion. Promote evaporation of remaining water in materials. Remove vapor from air by supplying less humid air and/or dehumidification. Specific advice on drying different materials (carpets, dry wall, etc.) and building components (floor systems, walls, etc.).	X No timeframe. Air out building. Advice on drying building.
Material Removal	X	X
	Throw away or clean depending on water category, object's value, and porosity of material.	Throw away moldy carpet, furniture, electronics, paper; books, food in contact with flood waters. Advice on removal of walls, floor tiles, wood, gut tear out. Remove or machine wash clothes with detergent & bleach.
Cleaning	X	X
Hard surfaces	Contains information on air-based cleaning such as HEPA Vacuuming and air washing, and liquid-based cleaning with detergent/water, ultrasonic cleaning, steam cleaning, etc.	HEPA vacuum. Wash & disinfect (bleach & non phosphate detergent). Wood: Clean with non phosphate detergent. Treat with borates. Avoid bleach. Optional fungicidal coating. > $10ft^2$ professional.
HVAC Systems & Duct	Inspect for cleanliness and clean using NADCA Standard ACR 2006. Any insulated ductwork saturated with water, regardless of Category should be removed. When contaminated with Category 2 or 3 water, ductwork with an interior sound/insulation liner, plastic flex duct and coated fiberboard ducting should be replaced. Use of antimicrobial may be considered but use shall not be substituted for removal of viable microbial bodies.	Discard flooded ductwork & air handlers. Fungicidal coatings.

Table 4: Comparison of Non-Governmental Guidance Documents

	***S500 Standard and Reference Guide for Professional Water Damage Restoration – 2006* (IICRC)**	***Creating a Healthy Home: A Field Guide for Cleanup of Flooded Homes* (NCHH)**
Use of bleach	Extensive biocide discussion; refers to ACGIH guidance to avoid biocides except in unusual circumstances	Use dilute bleach only on non-porous, hard surfaces
Do not mix bleach and ammonia		X
Other		Guidance mold on wood; fungicidal coatings.
"Clearance"	Recommends independent post-remediation verification	
Worker Protection	Refers to OSHA CFR 1901 - General Industry Standards OSHA CFR 1926 - Construction Industry Standards	Respirator, coveralls, boots, gloves, eye & head protection.
Carbon Monoxide		
Asbestos	Refers to OSHA Construction Industry Standard CFR 1926.1101 and General Industry Standard 1901.1001	X warnings on tile.
Lead	Refers to OSHA Standards 29 CFR 1926.62 and 1910.1025.	X
Health Effects		
Comments		Great graphics. Fungicidal coating.

Discussion of the S500 standard and the CDC Guidelines for Environmental Infection Control in Health-Care Facilities

Two of the guidance documents contain material that applies specifically to the report topic. They are both comprehensive, developed by practitioners and researchers in the respective fields, passed through well-established review processes, and extensively documented. Elements of these two documents that relate to the use of biocides in responding to sewage spills and floods are reviewed here.

The S500 Standard and Reference Guide for Professional Water Damage Restoration – 2006 warrants further discussion. The IICRC has published the S500 standard for restoration after water damage since 1994. The third edition was published in 2006.

This is the only American National Standards Institute (ANSI) standard that specifically addresses cleanup after floods. It is an industry consensus standard with an extensive reference guide explaining and referencing the science behind the standard. The S500 standard categorizes water by levels of contamination:

- Category 1 is water that originates from a sanitary source and poses no significant risk from contact, ingestion, or inhalation.

- Category 2 water has significant contamination and may pose a health hazard if contacted or consumed by humans. (Dishwasher or washing machine overflow, toilet backup without feces, and water from aquariums are in this category.)

- Category 3 water is heavily contaminated and can contain pathogens or toxins. Anyone who comes in contact with or consumes Category 3 water risks health impacts. (Examples of Category 3 water are sewage; floods from sea, river or lake; and wind-driven rain from hurricanes.)

The category of water plays a conditional role in remediation. For example, gypsum board may be restorable if the water it contacts is Category 1 or 2, but must be removed if that water is Category 3. By contrast, concrete is generally recoverable when flooded even by Category 3 water.

Chapter 8 of the S500 standard discusses biocides. It discourages the routine use of biocides, but since they may be appropriate in some circumstances, chapter 8 leaves their use to the professional judgment of the restorer. The chapter also refers to guidance from the American Conference of Governmental Industrial Hygienists (ACGIH), *Bioaerosols: Assessment and Control*, which recommends that microbial growth be removed by cleaning or removing contaminated materials:

> 15.4 Biocide Use. Remediators must carefully consider the necessity and advisability of applying biocides when cleaning microbially contaminated surfaces (see 16.2.3). The goal of remediation programs should be the removal of all microbial growth. This generally can be accomplished by physical removal of materials supporting active growth and through cleaning of non-porous materials. Therefore, application of a biocide would serve no purpose that could not be accomplished with a detergent or cleaning agent. Prevention of future microbial contamination should be accomplished by a) avoiding the conditions that lead to past contamination, b) using materials that are not readily susceptible to biodeterioration, and c) where necessary, applying compounds designed to suppress vegetative bacterial and fungal growth or using materials treated with such compounds.
>
> 16.2 Biocide Use and Application. Biocide use should not be considered if careful and controlled removal of contaminated material is sufficient to address a problem . . . b) biocide use may play an important role in the remediation of certain conditions (e.g. microbial contamination from sewage backflow into buildings).

According to the S500 standard, biocide use (in combination with cleaning and removal) should be considered when:

- Drying will be too slow to prevent microbial growth.

- Pathogenic organisms are present.

The standard also notes that the use of biocides might be precluded if:

- The sanitizers to be used (e.g., chlorine-based formulations, alcohol, peroxide, or quaternary ammonium compounds) require that soiled surfaces be cleaned first.

- The risk from exposure to the biocide is comparable or greater than the risk from exposure to the organism.

To aid in selection of an appropriate biocide, the S500 standard includes the table presented here as table 5.

Table 5: Types of Biocides (Disinfectants)

Disinfectant/Class	**Use Dilution Concentration**	**Action**	**Advantages**	**Disadvantages**
Alcohols (ethanol, isopropanol)	60% – 90%	B, V, F	Nonstaining, nonirritating	Inactivated by organic matter, highly flammable
Quaternary ammonium compounds	0.4% – 1.6%	B*, V*, F	Inexpensive	Inactivated by organic matter, limited efficacy
Phenolics	0.4% – 5%	B,V, F, (T)	Inexpensive, residual action	toxic, irritant, corrosive
Iodophors	75 ppm	B, V, F, S** T**	Stable, residual action	Inactivated by organic matter, expensive
Gluteraldehyde	2.00%	B, V, F, S** T	Unaffected by organics, non-corrosive	Irritating vapors, expensive
Hypochlorites	≥5,000 ppm free chlorine (mix 1:10)	B, V, F, S** T	Inexpensive	Bleaching agent, toxic, corrosive, inactivated by organic matter, 1, 2
Hydrogen peroxide	3%	B, V, F, S** T	Relatively stable	Corrosive, expensive, 3

Abbreviations:
B = Bactericidal
V = Viricidal
F = Fungicidal
* = Limited effectiveness
** = Requires prolonged contact
( ) = Not all formulations
T = Tuberculocidal
1 = Removes color from many interior décor fabrics
2 = Dissolves protein (wool, silk)
3 = Degrades in heat or UV light
S = Sporicidal

Discussion of the CDC Guidelines for Environmental Infection Control in Health-Care Facilities

CDC has published two documents titled *Guidelines for Environmental Infection Control in Health-Care Facilities.* One is a comprehensive 235-page book, the other is a shortened version consisting of Part II of the full version and published in the June 6, 2003, Morbidity and Mortality Weekly Report. The CDC guidance is extensively documented.

Section D of Part I provides guidance for responding to sewage intrusion and flooding. CDC's guidance for responding to flooding is the same as for responding to sewage spills plus the use of moisture meters to guide drying activities after a flood (page 51). The guidance for responding to sewage spills (page 52) is as follows.

- Overall strategy:
  - Move patients and clean sterile supplies out of the area.
  - Redirect traffic away from area.
  - Close doors and use plastic sheeting to isolate the area prior to clean-up.
  - Restore sewage system function first, then potable water system (if both are malfunctioning).
  - Remove sewage solids, drain the area, and let dry.

- Remediation of the structure:
  - Hard surfaces: clean with detergent/disinfectant after the area has been drained.
  - Carpeting, loose tiles, buckled flooring: remove and allow the support surface to dry; replace items; wet down carpeting with low-level disinfectant or sanitizer prior to removal to minimize dust dispersion to the air.
  - Wall board and other porous structural materials: remove and replace if they cannot be cleaned and dried within 72 hours.

- Furniture:
  - Hard surface furniture (e.g. metal or plastic): clean and allow to dry.
  - Wood furniture: let dry, sand the wood surface and reapply varnish.
  - Cloth furniture: replace.

- Electrical equipment:
  - Replace if the item cannot be easily dismantled, cleaned, and reassembled.

Part II of the CDC document provides recommendations for environmental infection control in health-care facilities. Section D lists recommendations pertaining to water problems. In that section (page 127), the CDC recommends cleaning walls and floors with detergent according to standard cleaning procedures. The section on cleaning environmental surfaces in patient-care areas (page 133) recommends:

- Not using high-level disinfectants on environmental surfaces.

- Cleaning environmental surfaces with an EPA-registered detergent/disinfectant in patient care areas where the soil may contain blood or body fluid or where drug-resistant organisms may be present on surfaces.

- Cleaning surfaces in non-patient care areas with detergent and water.

Part II categorizes evidence supporting each recommendation. Recommendations are rated according to the following categories:

- **Category IA.** Strongly recommended for implementation and strongly supported by welldesigned experimental, clinical, or epidemiologic studies.

- **Category IB.** Strongly recommended for implementation and supported by certain experimental, clinical, or epidemiologic studies and a strong theoretical rationale.
- **Category IC.** Required by state or federal regulation, or representing an established association standard. (Note: Abbreviations for governing agencies and regulatory citations are listed, where appropriate. Recommendations from regulations adopted at state levels are also noted. Recommendations from AIA guidelines cite the appropriate sections of the standard).
- **Category II.** Suggested for implementation and supported by suggestive clinical or epidemiologic studies, or a theoretical rationale.
- **Unresolved Issue.** No recommendation is offered. No consensus or insufficient evidence exists regarding efficacy.

The following excerpt from sub-section L of section D II details the recommendations for responding to sewage intrusion, floods, or other water-related emergencies (Page 127).

L **"Remediate the facility after sewage intrusion, flooding, or other water-related emergencies**.

1. Close off affected areas during cleanup procedures. Category II
2. Ensure that the sewage system is fully functional before beginning remediation so contaminated solids and standing water can be removed. Category II
3. If hard-surfaced equipment, floors, and walls remain in good repair, ensure that these are dry within 72 hours; clean with detergent according to standard cleaning procedures. Category II
4. Clean wood furniture and materials (if still in good repair); allow them to dry thoroughly before restoring varnish or other surface coatings. Category II
5. Contain dust and debris during remediation and repair as outlined in air recommendations (Air: IIG 4, 5). Category II"

The following excerpt from Part II, Section E. Recommendations – Environmental Services, sub-section I details recommendations for cleaning and disinfecting patient care areas under ordinary circumstances (page 133).

I. **"Cleaning and Disinfecting Strategies for Environmental Surfaces in Patient-Care Areas**

A. Select EPA-registered disinfectants, if available, and use them in accordance with the manufacturer's instructions (*270–272*). Category IC (EPA: 7 United States Code [USC] § 136 et seq.)
B. Do not use high-level disinfectants/liquid chemical sterilants for disinfection of either non-critical instruments and devices or any environmental surfaces; such use is counter to label instructions for these toxic chemicals (*273–278*). Category IC (Food and Drug Administration [FDA]: 21 CFR 801.5, 807.87.e)
C. Follow manufacturers' instructions for cleaning and maintaining non-critical medical equipment. Category II
D. In the absence of a manufacturer's cleaning instructions, follow certain procedures.
   1. Clean non-critical medical equipment surfaces with a detergent/disinfectant. This may be followed by an application of an EPA-registered hospital disinfectant with or

without a tuberculocidal claim (depending on the nature of the surface and the degree of contamination), in accordance with germicide label instructions (*274*). Category II

2. Do not use alcohol to disinfect large environmental surfaces (*273*). Category II
3. Use barrier protective coverings as appropriate for non-critical surfaces that are 1) touched frequently with gloved hands during the delivery of patient care; 2) likely to become contaminated with blood or body substances; or 3) difficult to clean (e.g., computer keyboards) (*265*). Category II

E. Keep housekeeping surfaces (e.g., floors, walls, tabletops) visibly clean on a regular basis and clean up spills promptly (*279*). Category II

1. Use a one-step process and an EPA-registered hospital detergent/disinfectant designed for general housekeeping purposes in patient-care areas where 1) uncertainty exists as to the nature of the soil on the surfaces (e.g., blood or body fluid contamination versus routine dust or dirt); or 2) uncertainty exists regarding the presence of multi-drug resistant organisms on such surfaces (*272*,*274*,*280*,*281*). Category II
2. Detergent and water are adequate for cleaning surfaces in non-patient-care areas (e.g., administrative offices). Category II
3. Clean and disinfect high-touch surfaces (e.g., doorknobs, bed rails, light switches, and surfaces in and around toilets in patients' rooms) on a more frequent schedule than minimal-touch housekeeping surfaces. Category II
4. Clean walls, blinds, and window curtains in patient-care areas when they are visibly dusty or soiled (*270,282–284*). Category II"

The rationale for environmental services cleaning recommendations is provided earlier in the book, in Part I Section E. Environmental Services (page 71), and is summarized below.

- **E.1 Principles of Cleaning and Disinfecting Environmental Surfaces**
  - Based on Spaulding's classification (Favero 2001), the CDC divides surfaces into:
    - Critical.
    - Semi-critical.
    - Non-critical.
  - In 1991 CDC proposed adding environmental surfaces, which it sub-divides into:
    - Medical surfaces (knobs or handles on e.g. dialysis machines, x-ray machines, instrument carts).
    - Housekeeping surfaces (floors, walls and tabletops).
  - Cleaning is the necessary first step of any sterilization process (page 72).

- **E.2 General Cleaning Strategies for Patient Care Areas**
  - b. most if not all housekeeping surfaces need to be cleaned with only soap and water or detergent/disinfectant, depending on the nature of the surface and the type and degree of contamination; physical removal of microorganisms and soil by wiping or scrubbing is probably as important, if not more so than any antimicrobial effect of the cleaning agent used (Gable 1966).
  - CDC divides patient care area environmental surfaces into:
    - High-touch (knobs, bedrails, light switches, walls around toilets); clean or disinfect more frequently
    - Low-contact (floors and ceilings)

- Extraordinary cleaning and decontamination of floors is not warranted; studies have demonstrated that disinfection over regular detergent/water cleaning has no impact on the occurrence of health care associated infections (Maki 1982, Danforth 1987, Ayliffe 1966, Vesley 1970, Daschner 1980, Dharan 1999).
- Newly cleaned floors become rapidly re-contaminated (Ayliffe 1967, Petersen 1973, Palmer 1972).
- Minimize contamination of cleaning solutions and tools.
- Use of contaminated water spreads number of microorganisms (Ayliffe 1967, Palmer 1972).
- A variety of bucket methods have been developed to avoid problem (Chou 2000, Rutala 2000).
- Mop heads left soaking become contaminated (Ayliffe 1967, Walter 1960, Scott 1990, Scott 1900b).
- Dilute solutions of detergents and disinfectants have become contaminated when stored for extended periods ((Ehrenkranz 1980, Givan 1971).

Selected References from the Literature Search

Our search of the scientific literature regarding cleaning and sanitizing in buildings showed a small number of documents related directly to this issue. Highlights from several are listed below:

"Household cleaning and surface disinfection: new insights and strategies"
Exner M, Vacata V, Hornei B, Dietlein E, Gebel J
Journal of Hospital Infection 2004; 56:S70-S75

- This article demonstrates that *Staphylococcus aureus* can be transferred from one portion of a flooring surface to another by mops.

- This article found experimentally that:
  - Water and surfactants reduced concentrations by over a factor of 100 and spread one in 10,000 cfu to neighboring floor sections.
  - Glycol derivatives, quaternary ammonium salts, and alkylamines reduced concentrations by over 1,000 and spread 1 in 100,000 cfu to neighboring floor sections.
  - Aldehydes and peroxides reduced concentrations by over 10,000 (essentially eliminating test organism) and spread no measurable levels to neighboring floor sections.
  - Study limitation - mopping was one pass from contaminated site over three other sites and back; no scrubbing, no multiple passes, no rinse.

"Surface disinfection: should we do it?"
Rutala WA, Weber DJ
Journal of Hospital Infection 2001; 48 (Supplement A):S64-S68

- This article reports the following:
  - Cleaning floors with soap and water resulted in 80-percent reduction in bacteria; 99-percent reduction using phenolic disinfectant; in either case levels were back to pre-treatment levels within a few hours (Ayliffe 1966).
  - Detergents become contaminated as floors are mopped, spreading dilute contamination (Ayliffe 1967).
  - Nosocomial infection rates are the same whether floors are cleaned with detergent or disinfectant (Daschner 1980, Danforth 1987, Dharan 1999).
  - Contamination of non-critical surfaces does not seem to correlate to nosocomial infection rates or profiles (Maki 1982).
  - Disinfectants with silver iodide provided residual benefit.
  - Use of biocides might lead to organisms resistant to biocides or antibiotics (Moken 1997, McMurry 1998, Levy 1998).

A combination cleaner/sanitizer was reported to be effective at removing and deactivating microorganisms from environmental surfaces (Wilson et al. 2004).

Our search of the literature for studies addressing cleaning or sanitization/disinfection of specific building materials revealed a dearth of citations, strongly emphasizing the need for more applied research in this area.

While two studies present data relative to the cleaning of gypsum wallboard, it must be re-emphasized that heavily contaminated porous materials such as wallboard should be removed and replaced because fungal growth typically penetrates the material and results in re-growth at a later time. However, non-saturated, intact wallboard may have mold growth in a surface condensate layer, which then may be removed using a suitable cleaning/sanitizing/disinfecting product.

In one study (Price and Ahearn 1999), sections of unused, nonsterile gypsum board were inoculated with varying concentrations of *Stachybotrys chartarum* and incubated at high relative humidity (86 percent to 92 percent) for up to 12 weeks. Sections were then cleaned with a quaternary ammonium product, a quaternary plus chlorine dioxide, a concentrated oxygen-saline solution, or a quaternary/acrylic treatment and then re-incubated. Re-growth of S. chartarum occurred within 5 weeks only on those sections cleaned only with the quaternary. Other fungi, mostly species of *Aspergillus, Chaetomium, and Penicillium*, slowly colonized (between 9 and 12 weeks) at least some areas of most cleaned/treated surfaces and most control surfaces. Surfaces cleaned/treated with the quaternary/acrylic remained visually free of colonized fungi for over 90 days, although microscopic examination revealed fungal penetration of the coating after 3 weeks.

Another study used large sections of wallboard wet from immersion of their bottom inch in water for 8 weeks. After drying for 2 weeks, some sections were cleaned by dry brushing, some by spraying with a high-concentration hypochlorite solution and wiping, and some by spraying with a high-concentration hypochlorite solution with detergent surfactants and wiping (Krause et al. 2006). Upon continued incubation for 2 more weeks, the appearance of mold, as determined microscopically by tape-lift and by culturable swab samples, was delayed by at least 1 week on the biocide-treated sections. Other sections treated with commercially available fungicidal/fungistatic coatings remained mold free.

In a third study, samples of wet oriented strand board, gypsum drywall, and plywood were inoculated with *Aspergillus fumigatus* spores and further incubated for 14 days, after which some were treated separately with one or the other of a high-concentration bleach solution or a commercial sodium hypochlorite/cleaner product (Martyny et al. 2005). Subsequent sampling and testing showed kill of the *Aspergillus*, although no long-term re-growth studies were conducted. The investigators also tried to assess the capability of the tested solutions to neutralize the antigenic effects of the mold spores, but their sample was too small for meaningful interpretation and calls for further research.

While studies such as these indicate that the use of commercial biocide cleaner/treatments or fungicidal/fungistatic coatings can kill or retard the growth of water-damage molds on porous building materials for varying time periods, growth ultimately can re-occur, and hence the most cost-effective rational approach to remediation is the recommendation to replace such moisture-damaged and mold-contaminated materials, ensure adequate and complete drying of the indoor environment, and implement and maintain sustainable moisture control practices.

Krause, M, Geer, W, Swenson, L, Fallah, P, and Robbins, C (2006). Controlled study of mold growth and cleaning procedure on treated and untreated wet gypsum wallboard in an indoor environment, Journal of Occupational and Environmental Hygiene 3:435-441.

Price, Dl, Ahearn, DG (1999). Sanitation of wallboard colonized with Stachybotrys chartarum, Current Microbiology 39(1):21-26.

Martyny, JW, Harbeck, RJ, Pacheco, K, Barker, EA, Sills, M, Silveira, L, Arbuckle, S, and Newman, L (2005). Aerosolized sodium hypochlorite inhibits viability and allergenicity of mold on building materials Journal of Allergy and Clinical Immunology 116(3):630-635.

Cleaning and Sanitizing Medical and Food Industry Surfaces

The literature search uncovered a number of papers regarding cleaning and sanitizing critical medical and food preparation surfaces but not specifically related to buildings. We summarize the major points below:

- Cases of nosocomial antibiotic resistant bacteria infection correlate to hospital stays longer than a week before admission to an intensive care unit (ICU), treatment with vanomycin, use of quinolones before admission to ICU, and placement in contaminated treatment rooms (which received regular ICU cleaning) (Martinez 2003).

- The concentration of active ingredient in a sanitizer affects efficacy (Bremer 2002).

- The specific organism's tolerance to the sanitizing agent affects efficacy (Knowles, Weber 1999, Bremer 2002).

- The state of bacteria, planktonic, free cell, or biofilm affects efficacy (biofilm hardest to inactivate) (Peng 2002, Mafu 1990, Bremer 2002).

- Chlorine is more effective at sanitizing surfaces contaminated by a biofilm of *Campylobacter jejuni* than quaternary ammonium compounds or peracetic acid sanitizers in 45-second exposures (Trachoo 2002).

- Smoother, non-porous materials (e.g., stainless steel, glass, granite) are easier to sanitize, while porous, rough ones (e.g., wood, mineral resin, some plastics, scratched or scored smooth surfaces) are more difficult by orders of magnitude; concrete and tile surfaces fall in between (Frank 1997, Snyder 1997, Snyder 1999, Mafu 1990, Bremer 2002).

- The presence of contaminants on a surface or in a liquid reduces the effectiveness of the sanitizer (which may be compensated for by increased concentration, contact time or both) (Peng 2002, Barker 2003, Barker 2004, Mafu 1990, Kusumaningrum 2003, Weber 1999).

- Washing with water and detergent is sometimes very effective (Peng 2002, Snyder 1999), while other times it is not (Barker 2003, Cogan 1999, Scott 1993).

- Combination cleaners/sanitizers are effective (Olson 1994, Peng 2002, Barker 2003).

- Inactivating some viruses, even under good conditions, requires high concentrations and long contact time (Weber 1999, Jean 2003, Barker 2004, Allwood 2004).

- Electrolyzed water performs as an effective sanitizer (Park 2002).

- Chlorine bleach must be stored at room temperature in dark bottles (Frais 2001).

- Solution of sodium hypochlorite can be stored in open, clear containers for 30 days, retaining 40 percent – 50 percent; 83 percent – 85 percent stored in sealed containers, and 97 percent – 100 percent stored in dark, sealed containers (Rutala 1998).

- Hypochlorite activity is reduced by the presence of heavy metal ions, biofilm, organic material, low temperature, low pH or UV; long history of use, low toxicity at recommended use concentrations, effective against most microbes, including viruses, less effective against endo-spore-forming bacteria (Rutala 1997).

Effects of disinfectants on allergens

Four papers report cleaning or disinfecting compounds as agents that can reduce allergenicity.

- A study of mouse urinary allergen found that sodium hypochlorite reduced the allergenicity of Mus m 1 at molar concentrations of 100:1 and fragmented the protein at higher concentrations. Dust mite (Der p 1) and cockroach (Bla g 1) allergen were tested in a mixture with Mus m 1. Much higher concentrations of sodium hypochlorite were needed to reduce the allergenicity (molar rations of 50,000 to 500,000). It was hypothesized that the higher levels were needed with the mixture than the purified Mus m 1 because of intereference by much higher protein levels (Chen 2001).

- A similar study of cat allergen (Fel d 1) found that while Fel d 1 could be fragmented it required a molar ratio of 7,000. However, cat specific IgG recognition was found at a lower molar ratio of 560 (Matsui 2003).

- In a study of *Aspergillus fumigatus* growth on plywood, oriented strand board, and paper covered gypsum board, sodium hypochlorite was reported to reduce recognition of *A. fumigatus* by ELISA and results in a loss of skin test reactivity to the treated mold for people who are allergic to *A. fumigatus* (Martyny 2005).

- Allergic proteins in floor dust tested for denaturing by household cleaners. Soft soap, guanidine hydrochloride and sodium lauryl sulphate reduced antigenic and allergenic activities, but none destroyed them. None of the products used to clean carpets had any effect (Dybendal 1990).

3. Heating, Ventilating, and Air Conditioning Systems

Heating, ventilating, and air conditioning (HVAC) equipment provides comfortable conditions inside buildings regardless of how uncomfortable conditions are outdoors. To achieve this end, HVAC equipment may add or remove heat, add or remove humidity, and remove or prevent the entry of airborne contaminants. HVAC equipment must distribute effectively throughout the building the heat, humidity, or fresh air it adds. In the opposite modes, it must effectively collect unwanted heat, unwanted humidity, and airborne contaminants. There are two distinctly different approaches to providing effective distribution and collection. The first is central heating, cooling, humidification, and ventilation in which pipes and ducts provide distribution and collection. The second is individual heating, cooling, humidification, dehumidification, and ventilation units spread throughout a building. When it comes to flood damage remediation, HVAC equipment shares a number of important characteristics:

- Nearly all the controls they use contain electrical and electronic components that can be damaged by flood waters.
- They contain cavities (e.g., ducts, air handlers, furnaces, boilers, fans) that are difficult to inspect, clean, and disinfect.
- Many of their components (e.g., ducts, pipes, air handling cabinets) are insulated inside or outside with fibrous material that gets wet easily and is difficult to clean.
- Contamination in systems that distribute air that is heated, cooled, or brought in from outdoors can be distributed throughout the building served by that system.
- In many parts of the United States, HVAC systems must be in operation for a building to be occupied normally.
- Servicing, maintaining, and assessing the problems of HVAC systems are beyond the experience and training of most people.

These characteristics make it likely that flood waters will render HVAC equipment inoperable, deposited contamination will be difficult to find and clean, and contamination may be distributed through a building. Inspection and remediation are best done by professionals who are knowledgeable about the systems involved.

Our literature search found a small number of guidance documents that address HVAC systems. Of the previously discussed guidance documents, the FEMA/Red Cross guide and the S500 standard provide more than a brief mention of HVAC systems. The FEMA/Red Cross guide contains a few paragraphs that recommend removing diffusers, hosing out ducts, and disinfecting ducts with quaternary, phenolic, or pine oil compounds. The S500 standard contains two pages of requirements and a chapter of reference material. Generally, the S500 standard requires that HVAC components wetted by Category 2 or 3 waters must be inspected and restored to operable condition using methods and criteria presented in the NADCA Standard ACR 2006 Assessment and Cleaning and Restoration of HVAC Systems. S500 further recommends removing and disposing of any porous material that cannot be easily cleaned and decontaminated (e.g., flex-duct, fibrous insulation).

We found two guidance documents that specifically address flooded HVAC equipment. They are the *NIOSH Interim Recommendations for the Cleaning and Remediation of Flood Contaminated HVAC Systems: A Guide for Building Owners and Managers* and *NADCA Standard ACR 2006 Assessment and Cleaning and Restoration of HVAC Systems*.

- *NIOSH Interim Recommendations for the Cleaning and Remediation of Flood Contaminated HVAC Systems: A Guide for Building Owners and Managers* covers worker protection, containment, discarding materials, cleaning remaining materials, disinfecting HVAC surfaces, and resuming operations. Regarding removal, cleaning, and disinfecting, the guide suggests:

    - Relying on a professional for inspection, removal, cleaning, and disinfection.
    - Removing and discarding flood-damaged insulation and filters.
    - HEPA vacuuming surfaces to remove dirt and debris; cleaning with pressure washer or steam if vacuuming, depending on the level of debris.
    - Disinfecting using a solution of 1 cup bleach to 1 gallon of water.
    - Applying a clean water rinse.

- *NADCA Standard ACR 2006 Assessment and Cleaning and Restoration of HVAC Systems* (http://www.nadca.com/) is a consensus standard practice document for professionals in the field of assessing, cleaning, and remediating HVAC systems. The standard covers mold contamination in HVAC systems, but not flooded systems specifically. The S500 standard and the NIOSH Interim HVAC guide refer to this standard.

- *Bioaerosols: Assessment and Control* (ACGIH 1999) contains a section on remediating microbial growth in HVAC systems. The ACGIH takes a clear position on biocide use in contaminated HVAC equipment: "Application of biocides as a substitute for removing microbial growth is not acceptable." The ACGIH reports two instances of biocide use in operating HVAC systems that resulted in the evacuation of buildings.

- Use of Disinfectants and Sanitizers in Heating, Ventilating, Air Conditioning, and Refrigeration Systems (http://www.epa.gov/oppad001/hvac.htm). This letter is an open advisory that EPA registers disinfectants and sanitizers for specific uses, and that it had come to the Agency's attention that products not registered for use as disinfectants or sanitizers in HVAC systems were in fact being used in them.

- Effect of Heating-Ventilation-Air Conditioning System Sanitation on Airborne Fungal Populations in Residential Environments (Garrison 1993). This study compared baseline and post-remedial fungal spore levels in the supply air of experimental and control houses. The components of HVAC systems in six (winter) and five (summer) experimental houses were cleaned and sanitized and no interventions were performed in two control houses. Eight weeks after the interventions, the experimental houses showed a 92-percent reduction (winter) and an 84-percent reduction (summer), while the control houses showed no reductions.

4. Injuries Related to the Use of Sanitizers

Last, we searched for injuries related to the use of sanitizers. A number of individual cases were found, but the most interesting finding is from the 2004 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System (Watson 2004). Table 22A of that report provides statistics for exposures and outcomes by agent. Two categories are relevant to biocides: Bleaches and Disinfectants. Statistics include the number of exposures, age demographics, intentional/unintentional, whether treated at a health-care center, and outcome ranking from none to death. The relevant sections from table 22A are excerpted in table 6.

Table 6: Excerpt of Statistics for Exposures and Outcomes by Agent

Household cleaning substances	No. Exposures	Age			Unint	Int	Treated In Health-care Facility	Outcome				
		<6	6-19	>19				None	Minor	Moderate	Major	Death
Bleach - Hypochlorite	57,137	21,259	5,819	29,430	53,263	2,637	10,751	8,511	17,469	2,529	64	0
Disinfectants												
Hypochlorite	3,018	1,479	274	1,236	2,889	67	700	491	733	204	3	1
Phenol	1,636	1,082	183	360	1,525	76	201	293	365	33	3	1
Pine oil	4,496	2,451	371	1,629	4,026	345	968	1,194	1,197	99	14	2
Other	5,275	3,411	502	1,318	4,976	157	627	1,197	1,147	152	4	0
Industrial Cleaners												
Disinfectant	3,942	572	444	2,894	3,666	205	1,159	375	1,306	405	12	0
Fumes/ Vapors/ Gases												
Chlorine: acid mixed with hypochlorite	1,208	55	120	1,030	1,171	34	326	88	578	250	0	0
Chlorine: other	6,031	481	1,227	4,206	5,803	124	1,794	260	2,508	914	17	2

The first number that draws attention is the large number of hypochlorite exposures, 57,137 listed under household cleaning. Of these 53,263 were unintentional exposures. These exposures resulted in 10,751 people receiving treatment at a health care facility. Disinfectants are listed separately under household cleaners and grouped under industrial cleaners. These would be exposures to more highly concentrated products than household products.

In a survey of cases after Hurricane Andrew, Quinn reports among the expected wounds, gastroenteritis, and skin infections a small increase (not statistically significant) in hydrocarbon and bleach ingestion (Quinn 1994).

Additional Ingestion Reports

A number of cases were found in which injury or death was caused by ingestion of disinfectants; some of these cases were identified as suicides. Sodium hypochlorite was ingested more often than other disinfectants. Most of the remaining cases were the result of ingesting disinfectants that are not commonly found in household products (e.g., formaldehyde, formalin, or compounds of mercury). A number of poisonings from Dettol (British proprietary disinfectants) are reported in the British literature.

- Children are frequently treated for ingesting cleaners and sanitizers (McGuigan 1999, Lamireau 1997).

- A review of 743 case histories involving children in Galicia who ingested caustic substances found that bleach was ingested in 73 percent of the cases and 11 percent of those cases of bleach ingestion resulted in esophageal burns. Although only 3 percent of the 743 cases involved the ingestion of dishwasher detergent, 59 percent of those cases resulted in esophageal burns (Bautista Casasnovas 1997).

- The results of ingesting bleach vary from none to major injuries (Landau 1964, Ward 1988, Weeks 1969, Weeks 1971, Tanyel 1988).

- The ingestion of water-diluted bleach is reported to be a frequent cause for visits to healthcare facilities, but often results in minor effects (Lambert 2000).

- A survey of 11 poison control centers in France found that none of them recommended hospitalization for children who ingest less than 100 ml of bleach diluted with water, but 9 of them recommended hospitalization for ingesting any amount of concentrate bleach (Cardona 1993).

- A number of studies reporting children ingesting bleach found no serious injury after ingestion (Racioppi 1994, Paredes Osado 1993, Harley 1997). (Whether the bleach was diluted or ingested directly from the bottle is often not reported.)

- Children who ingest substances often are performing a "lick and taste" behavior and swallow small amounts (Wason 1985).

- Several papers reported more serious injuries from ingesting bleach; some of these instances are known to be suicide attempts (Ross 1999, Babl 1998, de Ferron 1987, Van Rhee 1990).

Respiratory Exposure Reports

A number of studies reported respiratory exposures. They divide into two categories: exposures to cleaning and disinfecting products that were linked to asthma risk and exposures resulting from mixing sodium hypochlorite based cleaners or bleach solutions with ammonia or phosphoric acid based cleaning products.

Asthma Studies

- Sixteen studies were found that linked cleaning activities with increased asthma, wheezing, or reactive airways dysfunction syndrome (RADS). Of these, five studies (Medina-Ramon 2005, Medina-Ramon 2006, Rosenman 2003, Sherriff 2005) and Zock 2007 found evidence of a link between sodium hypochlorite-based bleach exposures and increased risk of illness. Three linked asthma or atopy consistent with asthma to exposures to quaternary ammonium compounds (QAC). Two of these were clinical study reports that attributed exposure to QAC (benzakonium chloride, dimethylbenzyl ammonium) to the development of four cases of asthma (Richardson 1994, Purohit 2000). One was an epidemiological study of Dutch pig farmers that linked use of QAC to the development of atopic sensitization (Preller 1996). Note: One additional study (Gorguner 2004) linked RADS with exposure to a mixture of chlorine bleach and hydrochloric acid.
    - An epidemiological study identified cleaners, construction workers, laborers, equipment cleaners, and motor vehicle operators as having a high risk of work-related wheezing (odds ratios > 4.5). Persons employed in protective services occupations and as equipment cleaners were reported as having a high risk of work-related asthma (odds ratios >9.0) (Arif 2003).
    - Henneberger identified the seven most frequently reported agents for reactive airways dysfunction syndrome as cleaning materials (15 percent), unspecified chemicals (8 percent), chlorine (7 percent), solvents (7 percent), acids-bases (6 percent), smoke (6 percent), and diesel exhaust (6 percent) (Henneberger 2003).
    - A case-control study of 521 cases and 932 controls found relationships between asthma and occupations. The link was strongest for men and women in the chemical, rubber, and plastic industries (OR 5.69, 2.61 and 1.72 respectively); for men only as bakers and food processors (OR 8.62), textile workers (OR 4.70), electrical and electronic workers (OR 2.83), lab technicians (OR 1.66), and storage workers (OR 1.57); and for women only as dental workers (4.74), wait staff (OR 3.03), and cleaners (OR 1.42) (Jaakkola 2003).
    - A large epidemiological study of 2,414 cleaners and 5,235 administrative workers found the cleaners had a greater risk of adult-onset asthma compared to the administrative workers (risk ratio 1.5) (Karjalainen 2002).
    - In a cross-sectional study of 4,521 women, asthma was more prevalent in group of 593 women then employed in domestic cleaning (OR 1.46). Asthma strongly correlated to group of 1,170 former cleaning women (OR 2.09) (Medina-Ramon 2003).
    - The cases of 160 domestic cleaning women who had contracted asthma, chronic bronchitis, or both were nested in large population-based survey that included 386 non-symptomatic women. Women who had asthma, chronic bronchitis, or both used bleach more frequently than did controls (OR 3.3 for intermediate exposures and 4.9 for high exposures). Airborne chlorine levels were measured. Asthma symptoms in domestic cleaning women were associated with exposure to bleach and possibly other irritant agents in a case-control study (Medina-Ramon 2005). This study was a follow-up to an earlier study that found a link between asthma risk and cleaning professions (Medina-Ramon 2003). The earlier study did not collect data that would allow insights into the agents related to asthma risk; however, the follow-up study collected data by suspected agent.

- An epidemiological study of 394 occupational asthma cases found an association between the occupation of cleaner and occupational asthma (Mendonca 2003).
- A pharmacist developed occupational asthma. The reported cause was exposure to a floor cleaner containing dimethylbenzyl ammonium chloride (a QAC). Substituting a different floor cleaner resulted in significant improvement in serial peak flow measurements (Richardson 1994).
- A longitudinal study of parents and children determined the frequency with which pregnant women used 11 domestic products. A total chemical burden score was derived based on the sum of the frequency of use for the products; high TCB scores correlated with persistent wheezing during early childhood (OR 2.3). The chemicals and the percentage of women using them included disinfectants (87 percent), bleach (85 percent), aerosols (72 percent), air fresheners (spray, stick or aerosol) (68 percent), window cleaner (61 percent), carpet cleaner (36 percent), paint or varnish (33 percent), turpentine (23 percent), pesticides (21 percent), stripper (5.5 percent), and dry cleaning fluid (5 percent) (Sherriff 2005).
- A case-control study to investigate the agents in cleaning activities that lead to reported asthma found the prevalence of asthma was 1.7 times higher among cleaners than referents. The increase in asthma was associated with kitchen cleaning, furniture polishing, and the use of oven sprays and polishes (Zock 2001).
- Rosenman reported on 1,915 cases of adult-onset or work-related asthma. Exposure to cleaning products across a wide range of occupational settings was linked to 236 cases; the most commonly reported occupations were janitors and cleaners and housekeepers (52) and nurses and nurses aids (37). The two most commonly reported agents were unspecified cleaning products (107 cases) and bleach (43 cases) (Rosenman 2003).
- Three cases of asthma symptoms were reportedly triggered by the handling of QAC (benzakonium chloride) used as disinfectants in hospital settings. Reference was made to a Swiss study linking QAC to contact dermatitis and to four asthma case studies associated with QAC (Purohit 2000).
- Reactive airways dysfunction associated with the use of a mixture of household bleach and hydrochloric acid was reported in a retrospective case study in Turkey (Gorguner 2004).
- A robust longitudinal study found a dose response relationship between the use of household spray cleaners and asthma and wheeze events. Relative risk ratios for furniture polish, glass-cleaning and air-freshening sprays ranged from 1.54 to 2.0 for these products. Solvent, ammonia and bleach cleaning products had relative risk ratios ranging from 1.12 to 2.0. (Zock 2007)
- In a follow-up study to Medina-Ramon 2005 43 domestic cleaners with recent history of asthma or chronic bronchitis kept diaries recording respiratory symptoms, PEF and respiratory exposures (cleaning products and tasks, smoking status). Regression models found that lower respiratory symptoms were associated with diluted bleach (OR 4.4), degreasing sprays (OR 6.9) and air fresheners (OR7.8). (Medina-Ramon 2006).
- An epidemiological study of atopic sensitization in 194 Dutch pig farmers found an association between the use of quaternary ammonium compounds and atopy (OR 6.5). (Preller 1996)

Cases Reporting Exposure to Chlorine Gas or Chloramines after Mixing Two Products

Five studies and four cases were found that reported injuries occurring because bleach containing sodium hypochlorite was mixed with other compounds, releasing materials more hazardous than the hypochlorite itself. In residential and commercial buildings the most common occurrences appear to be mixing with ammonia based cleaners or drain opener. The figure on the next page, from the Chlorine Institute, summarizes problem mixtures. Reported symptoms range from minor acute effects to serious health hazards.

The Chlorine Institute, Inc.
1300 Wilson Boulevard
Arlington, VA 22209
Ph: 703-741-5760 // www.CL2.com

Sodium Hypochlorite Incompatibility Chart

Do NOT mix Sodium Hypochlorite (bleach) with ANY other chemical unless adequate engineering controls and personal protective equipment (PPE) are in place. Accidental mixing may cause dangerous conditions that could result in injury to personnel and/or damage to property or the environment.

Incompatible Material	Mixing May Result In
Acids, Acidic Compounds and Acid Based Cleaning Compounds such as: - Alum (Aluminum Sulfate) - Aluminum Chloride - Ferrous or Ferric Chloride - Ferrous or Ferric Sulfate - Chlorinated Solutions of Ferrous Sulfate - Hydrochloric Acid (HCl) - Sulfuric Acid - Hydrofluoric Acid - Fluorosilicic Acid - Phosphoric Acid - Brick and Concrete Cleaners	- Release of chlorine gas, may occur violently.
Chemicals and Cleaning Compounds containing ammonia such as: - Ammonium Hydroxide - Ammonium Chloride - Ammonium Silicofluoride - Ammonium Sulfate - Quaternary Ammonium Salts (Quats)	- Formation of explosive compounds. - Release of chlorine or other noxious gases.
Organic Chemicals and Chemical Compounds such as: - Solvents and Solvent Based Cleaning Compounds - Fuels and Fuel Oils - Amines - Propane - Organic Polymers - Ethylene Glycol - Insecticides - Methanol	- Formation of chlorinated organic compounds. - Formation of explosive compounds. - Release of chlorine gas, may occur violently.
Metals such as: - Copper - Nickel - Cobalt - Iron Avoid piping and material handling equipment containing stainless steel, aluminum, carbon steel or other common metals.	- Release of oxygen gas, generally does not occur violently. Could cause overpressure/rupture of a closed system.
Hydrogen Peroxide	- Release of oxygen gas, may occur violently.
Reducing agents such as: - Sodium Sulfite - Sodium Bisulfite - Sodium Hydrosulfite - Sodium Thiosulfate	- Evolution of heat, may cause splashing or boiling.

- Five episodes of temporary illness were reported among patients doing cleaning chores in a psychiatric hospital who mixed bleach with phosphoric acid cleaner. The symptoms included tightness of the chest, difficulty breathing, irritation of the eyes and throat, nausea, cough, and headache (CDC 1991 Sep).

- An elderly woman who had a brain tumor was reported to have died while using a mixture of chlorine bleach and ammonia to clean a bathroom (Cohle 2001).

- A study of construction workers exposed to an accidental release of chlorine gas in a paper mill bleach plant found that 60 percent of 281 workers experienced flu-like symptoms: eye, nose and throat irritation; cough; and headache. Shortness of breath not associated with age, smoking, or a history of asthma or chronic bronchitis was reported by 54 percent of the workers (Courteau 1994).

- Over the course of a year 216 cases of exposure to chlorine or chloramine gas after mixing cleaning products at home were reported to a regional poison control center. The most frequently reported symptom was cough (180 cases); other reported symptoms were shortness of breath, throat irritation, chest pain, wheezing, dizziness, vomiting, eye irritation, and nasal irritation. Symptoms did not persist after 6 hours for 200 cases (Mrvos 1993).

- Two episodes involving 72 soldiers who were exposed to chlorine gas from mixing bleach and ammonia during a “cleaning party” were reported to have resulted in acute respiratory symptoms (Pascuzzi 1998).

- Three case studies of toxic pneumonitis caused by exposure to a mixture of bleach and ammonia and resulting in serious long-term injury were reported (Reisz 1986).

- Correspondence in the New England Journal of Medicine reported a case of exposure to chloramine gas released by mixing household bleach with an ammonia-based cleaner; chest x-rays showed pneumonitis developed over the course of 4 hours (Tanen 1999).

Irritancy Effects of Cleaners and Disinfectants

Three sources describe irritancy effects associated with cleaners and disinfectants:

- A text book on irritant dermatitis reports the irritant properties of cleaners and disinfectants: soaps and detergents, antiseptics and disinfectants, and acids and alkalis. Chapping, redness, scaling, and fissuring may result from exposure to soaps and detergents. (The removal of intracellular lipids is described as the mechanism.) Benzalkonium chloride (QAC) is reported as a known cause of acute contact dermatitis. Acids are reported to denature proteins and alkalis are reported to denature lipids (Chew 2005).

- An overview of risk while cleaning and identifies disinfectants as the most hazardous group of agents covered. Sodium hypochlorite is reported to cause allergic contact dermatitis (Wolkoff 1998).

- A study of acute occupational disinfectant-related illness in adolescent workers found that hypochlorites were responsible for 45 percent of the 307 cases. Seventy eight percent of the illnesses were mild, and there were no fatalities. There were 206 cases that involved disinfectants whose EPA toxicity category was known; 80 percent were rated Category 1, the highest toxicity level (Brevard 2003).

Behavior That Leads to Exposure to Cleaners and Disinfectants

Six references were found that provide insight into behaviors that lead to exposures. Two references link increased exposures or health endpoints to the use of sprayers.

- Exposure potential was assessed by watching subjects during cleaning activities; the strength of the warning labels was intended to be used to study frequency and amount of use by suggested hazard, but only a tiny fraction of subjects read the labels. Thirty-nine percent of women and 15 percent of men reported using protective gloves (Kovacs 1997).

- In a study of consumer behavior to provide a basis for estimating exposures to dishwashing detergents, cleaning products, and hair-styling products, bleach was included as a toilet-cleaning product. Four of 29 subjects wore gloves during toilet cleaning; diaries, observation, and videos were used to assess behaviors. Exposures occurred during mixing, checking suds, rinsing the cap, spills on the package, rinsing the cleaning cloth, wiping with the cloth, and clearing away suds. Subjects were seen to have hand-to-mouth contact during cleaning (Weegels 2001).

- A study of dermal exposures during mixing, spraying, and wiping found that exposures for hands during the large-scale disinfection of countertops and fume hoods by wiping for an hour a day were more than 100 times greater than the exposures from wiping a small section of countertop for 10 – 15 minutes a day. While there were essentially no exposures to head, arms, legs, or chest during the small-scale disinfection, there were significant exposures to these areas during the large-scale disinfection (Hughson 2004).

- A longitudinal study of the incidence of eye symptoms, nose or throat symptoms, nose and throat symptoms, asthma, and bronchitis among 1,011 cleaners and former cleaners found that those who began using sprayers to apply cleaning products part way through the study increased the risk of eye (OR 1.3), nose/throat (OR 2.0), asthma (OR 2.4), and bronchitis (OR 1.9) (Nielsen 1999).

- A study of dermal and inhalation exposures to diisocyanate and oligomers found that increased inhalation and dermal exposures correlate with spraying paint. The use of gloves during spraying reduces dermal exposures (Pronk 2006).

- A longitudinal study examining a hypothesized link between the use of cleaning sprays and adult asthma found was conducted as a follow-up to the first phase of the European Community Respiratory Health Survey. A consistent dose-response relationship was found between the frequency of use of cleaning sprays and the relative risk of having asthma events or wheeze within the past year. The relationship held for a wide variety of sprays as well as for individual sprays (e.g. furniture, glass-cleaning and air-freshening sprays). Liquid cleaners not used as sprays had significantly lower relative risk ratios than spray applied products. The authors hypothesize that sprays facilitate respiratory exposures. (Zock 2007)

The most comprehensive review of cleaning materials and health-effects literature was found in a research report to the California Air Resources Board (Nazaroff 2006). Exposure mechanisms were grouped into seven categories. The following table, based on table 2.2 of the final report, lists the seven exposure mechanisms and provides examples of each one.

Table 7: How Cleaning Product Use Can Influence Inhalation Exposure to Air Pollutants

Mechanism	Examples
Volatilization	Formaldehyde from wood floor cleaning spray (Akland and Whitaker, 2000; Figure 4-11); glycol ethers from hard-surface cleaners (Zhu et al. 2001; Gibson et al. 1991)
Production of airborne droplets	Aerosol or pump-spray delivery of surface cleaning products; some spray droplets remain airborne instead of depositing (Fortmann et al. 1999; Roache et al. 2000)
Suspension of powders	Fine particulate matter from carpet freshener (Steiber 1995); sodium tripolyphosphate from carpet cleaner (Lynch 2000)
Suspension of wear products	Surfactants, film formers, complexing agents, acids and bases, and disinfectants (Wolkoff et al. 1998; Vejrup and Wolkoff 2002)
Inappropriate mixing	Chloramines from mixing household bleach and ammonia-based cleaners; chlorine gas from mixing bleach with acid-containing cleaner (see table 8, below)
Chemical transformations	Chloroform release from chlorine bleach chemistry in laundry applications (Shepherd et al. 1996); terpene hydrocarbons plus ozone form OH radical (Weschler and Shields 1997a), hydrogen peroxide (Li et al. 2002) and secondary particulate matter (Weschler and Shields 1999; Wainman et al. 2000)
Altered surfaces	Nicotine release from walls following ammonia cleaner use in smoking environment (Webb et al. 2002); enhanced volatile organic emissions from wet linoleum (Wolkoff et al. 1995)

Summaries of studies and case reports documenting toxic exposures from the mixing of cleaning products are also provided. table 8, below, is based on table 2.3 of the final report. Table 9, which follows, is based on table 2.4.

Table 8: Documented Inhalation Toxicity Related to Mixing of Cleaning Products

Nature of Study	Products Mixed	Toxic Gas(es)	Outcomes	Ref a
Case reports (2)	NaOCl, vinegar, bleach, and detergent; ammonia and NaOCl	Chlorine, ammonia	Acute illness with recovery in days.	a
Case report	Ammonia type and hypochlorite cleaners	Ammonia	Acute illness with recovery in days.	b
Case report	Bleach (5.25% NaOCl) and powder containing 80% $NaHSO_4$	Chlorine gas	Acute illness with recovery after several days	c
Case report	Several products applied to clear a clogged drain b	Uncertain	Severe obstructive airway disease	d
Case reports (2)	NaOCl (5%) and HCl (10%)	Chlorine gas	Acute illness with recovery in several days	e
Case report	Ammonia with household bleach containing hypochlorite	Chloramines	Acute illness with recovery in days.	f
Case reports (3)	Aqueous ammonia (5% – 10%) with bleach (5.25% NaOCl), plus laundry detergent in 2 cases	Chloramines	Life-threatening toxic pneumonitis requiring prolonged hospitalization and resulting in residual symptoms	g

Table 8: Documented Inhalation Toxicity Related to Mixing of Cleaning Products

Nature of Study	Products Mixed	Toxic Gas(es)	Outcomes	Ref a
Case reports (5 episodes at 2 state hospitals)	Bleach (NaOCl) and phosphoric acid cleaner	Chlorine	Acute poisoning symptoms that abated within hours to days; a few cases required medical treatment	h
Analysis of 216 cases reported to Regional Poison Information Center	Hypochlorite-containing product with (a) ammonia (50%), (b) acid (29%), and (c) alkali (21%)	Chlorine/ chloramines	Symptom resolution for 93% of patients within 6 hours; 33% received medical care; 1 patient w/ a preexisting condition required hospital admission for continued respiratory distress	i
Case report	Sequential application of numerous cleaning products to remove a bathtub stain c	Hydrofluoric acid	Hemorrhagic alveolitis and adult respiratory distress syndrome; month-long hospital care; residual pulmonary deficit	j
Case reports (2 cases each w/ 36 soldiers)	Liquid bleach and ammonia mixed in bowls and buckets	Chloramine gas	Acute symptoms; two patients admitted to hospital, one required several days of intensive care observation	k
Case report	Liquid ammonia (3% – 10% NH3(aq)) and bleach (5% NaOCl)	Chloramine gas	Upper air compromise and pneumonitis requiring emergency tracheostomy and7 days of hospital care	l
Case report	Bleach and ammonia	Cloramine gas	Death	m

a References: a — Faigel, 1964; b — Dunn and Ozere, 1966; c — Jones, 1972; d — Murphy et al., 1976; e — Gapany-Gapanavicius et al., 1982a; f — Gapany-Gapanavicius et al., 1982b; g — Reisz and Gammon, 1986; h — Hattis et al., 1991; i — Mrvos et al., 1993; j — Bennion and Franzblau, 1997; k — Pascuzzi and Storrow, 1998; l — Tanen et al., 1999; m — Cohle et al., 2001. b Products used (selected active ingredients): Liquid Plum-R (NaOCl, 5%; KOH, 2%); Drano (NaOH, 54%; NaNO3, 30%); Clorox (NaOCl, 5%); Sani Flush (NaHSO4, 75%). c Cleaning products used (active ingredient, if reported): cleanser, mildew stain remover (NaOCl, 25-45%), tub and tile cleaner (H3PO4, 18%), ammonia cleaner (NaOH, 2-2.5%), bleach (NaOCl, 5.25%), toilet cleaner (HCl, 14.5%), vinegar (CH3COOH, 5%), rust remover (H6F6, 8%). Application of each product was followed by a coldwater rinse.

Table 9: Documented Associations of Asthma, Allergy, and Sick-Building Syndrome Symptoms In Relation to Cleaning Product Use

Key Finding	Ref a
Dried detergent residue from carpet shampoo "caused respiratory irritation among most employees in an office building and among all staff members and most children in a day-care center."	a
Excessive application of carpet shampoo was associated with widespread, transient, mild respiratory illness among conference attendees	b
Case report of a cleaning worker's occupational asthma caused by inhalation exposure to ethanolamine from a floor-cleaning detergent.	c
Case report of occupational asthma in a pharmacist attributed to indirect exposure to lauryl dimethyl benzyl ammonium chloride from a floor-cleaning product regularly used in his workplace	d
With data from 22 offices in 12 buildings in California, researchers found a principal component vector associated with the use of cleaning products and air fresheners was useful in predicting stuffy nose (OR=1.6) and composite irritated mucous membrane symptoms (OR=1.4).	e

Population-based study of occupational asthma revealed that "cleaners" had the fourth highest odds ratio (1.97) for "bronchial hyper-responsiveness and asthma symptoms or medication."	f
Prospective study design indicated increased risk of eye, nose, and throat symptoms; asthma and bronchitis associated with "use of sprayers" among current cleaners compared to former cleaners.	g
Case report of anaphylactic shock with respiratory failure secondary to carpet cleaning in 42-year-old female who was hospitalized for 18 days	h
Case reports of female nurses who exhibited occupational asthma following exposure to surfaces cleaned with solutions containing benzalkonium chloride. Cases were also occupationally exposed to this chemical as a disinfectant	i
Asthma prevalence among indoor cleaners in Spain was 1.7 times the rate for office workers. Risk was associated mainly with the cleaning of private homes and "may be explained by the use of sprays and other products in kitchen cleaning and furniture polishing."	j
Population study of women in Finland revealed a relative risk of asthma of 1.5 for cleaners compared to administrative workers.	k
Twelve percent of confirmed cases of work-related asthma in California, Michigan, Massachusetts, and New Jersey were associated with exposure to cleaning products	l
"Janitors, housekeepers, and cleaners" was the occupational group with the highest number of reported cases of occupational asthma in Sao Paulo, Brazil; "cleaning products" were the most commonly reported exposure agent.	m
"Cleaning materials" are the most frequently reported agents for work-related reactive airways dysfunction syndrome cases in Michigan, New Jersey, Massachusetts, and California	n
In NHANES III survey of U.S. workers, the occupation of "cleaning" was associated with an elevated odds ratio of work-related wheezing (OR = 5.4, 95% CI = 2.4-12.2) and work-related asthma, although not statistically significant for latter (OR = 2.4, 95% CI = 0.5-10.6).	o
Population-based incident case-control study of relation between occupation and risk of developing asthma showed an association, but not a statistically significant one, for women cleaners (OR = 1.42, 95% CI= 0.81-2.48)	p
Current or former employment as domestic cleaner was associated with a statistically significant increase in the prevalence of asthma in Barcelona, Spain. Symptoms were associated with exposure to bleach and possibly other irritant agents.	q
The frequency with which chemical-based household products were used during the prenatal period was associated with persistent wheeze in young children. Among the 11 products in analysis were disinfectant, bleach, carpet cleaner, window cleaner, and air fresheners.	r

[a] References: a — Kreiss et al., 1982; b — Robinson et al., 1983; c — Savonius et al., 1994; d — Burge and Richardson, 1994; e — Ten Brinke et al., 1998; f — Kogevinas et al., 1999; g — Nielsen and Bach, 1999; h — Lynch, 2000; i — Purohit et al., 2000; j — Zock et al., 2001; k — Karjalainen et al., 2002; l — Rosenman et al.,2003; m — Mendonça et al., 2003; n — Henneberger et al., 2003; o — Arif et al., 2003; p — Jaakkola et al., 2003; q — Medina-Ramón et al., 2003, 2005; r — Sherriff et al., 2005.

5. Summary of Key Findings

The literature review supports a number of findings:

- The literature documents a number of hazards in flood water residue including pathogens, parasites, and chemicals.

- Illnesses that might have been contracted during cleanup of indoor spaces after floods are reported in the literature, but very few cases can be conclusively attributed to exposures to flood residue on environmental surfaces in buildings.

- The literature documents that exposures to endotoxins and fungal spores in flooded buildings is significantly elevated compared to exposures in non-flooded buildings after floods.

- CDC *Guidelines for Environmental Infection Control in Health-Care Facilities* recommends using ordinary environmental cleaning protocols after sewage spills. Although this procedure may include the use of a combination cleaner/disinfectant, high-level disinfectants are ruled out, and a solution of detergent and water is recommended for cleaning surfaces outside of patient-care areas.

- "Extraordinary cleaning and decontamination of floors in health-care settings is unwarranted. Studies have demonstrated that disinfection of floors offers no advantage over regular detergent/water cleaning and has minimal effect on the occurrence of health-care-associated infections."—CDC *Guidelines for Environmental Infection Control in Health-Care Facilities*

- Sodium hypochlorite is implicated in numerous health endpoints, including tens of thousands of visits to poison control centers each year.

- Exposure studies support these conclusions:
  - The use of gloves when mixing, preparing, wiping, or spraying wet products greatly reduces dermal exposures.
  - The use of respirators reduces exposures to airborne particles.
  - Wash and rinse water should be changed frequently to avoid cross-contamination when mopping or wiping.

6. Key Resources

1. "Fact Sheet: Flood Cleanup – Avoiding Indoor Air Quality Problems," EPA Office of Radiation and Indoor Air, http://www.epa.gov/iaq/pubs/flood.html.

2. *Repairing Your Flooded Home*, Federal Emergency Management Agency and the American Red Cross, http://www.bostonredcross.org/library/Repairing_Flooded_Home.pdf#search=%22Repairing%20Your%20Flooded%20Home%22.

3. "Protect Yourself from Mold," CDC, http://www.bt.cdc.gov/disasters/mold/pdf/moldprotection.pdf.

4. *S500 Standard and Reference Guide for Professional Water Damage Restoration – 2006*, Institute of Inspection, Cleaning and Restoration Certification (IICRC), http://www.iicrc.org/pdf/buydocs.pdf.

5. *Creating a Healthy Home: A Field Guide for Cleanup of Flooded Homes*, National Center for Healthy Housing and Enterprise Community Partners, http://www.centerforhealthyhousing.org/FloodCleanupGuide_screen_.pdf.

6. *Guidelines for Environmental Infection Control in Health-Care Facilities*, CDC, http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/Enviro_guide_03.pdf.

7. *NIOSH Interim Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers*, CDC, http://www.cdc.gov/niosh/topics/flood/pdfs/Cleaning-Flood-HVAC.pdf.

8. *NADCA Standard ACR 2006 Assessment and Cleaning and Restoration of HVAC Systems* (http://www.nadca.com/)

9. *Indoor Air Chemistry: Cleaning Agents, Ozone and Toxic Air Contaminants;* California Air Resources Board, April 2006. http://www.arb.ca.gov/research/abstracts/01-336.htm#Disclaimer

10. *2004 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System;* http://www.poison.org/prevent/documents/TESS%20Annual%20Report%202004.pdf

7. References

Reference	Title	Author	Citation
ACGIH 1999	Bioaerosols: Assessment and Control	American Conference of Governmental Industrial Hygienists	ACGIH; Cincinnati, OH 1999
Boss 2003	Biological risk engineering handbook : infection control and decontamination	edited by Martha J. Boss, Dennis W. Day	Lewis Pub.; Boca Raton, FL 2003
CDC 2003 June	Guidelines for environmental infection control in health care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)	Centers for Disease Control and Prevention (CDC)	CDC 2003; Atlanta, GA
Chew 2005	Handbook of Irritant Dermatitis	Chew, Ai-Lean, Howard I. Maibach	Springer 2005
FEMA 1992	Repairing Your Flooded Home	Federal Emergency Management Agency/American Red Cross	FEMA; 1992
IICRC 2006	CRC S500 Standard and Reference Guide for Professional Water Damage Restoration	Insitute of Inspection Cleaning and Restoration	IICRC; Vancouver, WA 2006
IOM 2004	Damp indoor spaces and health	Institute of Medicine, National Academies of Science	National Academies of Science; Washington DC 2004
Akbar-Khanzadeh 1999	Incident trends for a hazardous waste cleanup company.	Akbar-Khanzadeh F, Rejent GM.	Am Ind Hyg Assoc J. 1999 Sep-Oct;60(5):666-72.
Allwood 2002	Effect of temperature and sanitizers on the survival of feline calicivirus, Escherichia coli, and F-specific coliphage MS2 on leafy salad vegetables	Allwood PB, Malik YS, Hedberg CW, Goyal SM. Division of Environmental and Occupational Health, School of Public Health, University of Minnesota, 420 Delaware Street S.E., Minneapolis, Minnesota 55455, USA	J Food Prot. 2004 Jul;67(7):1451-6
Arif 2003	Occupational exposures associated with work-related asthma and work-related wheezing among U.S. workers	Arif AA., Delclos GL, Whitehead LW, TortoleroSR, Lee ES	American Journal of Industrial Medicine 44:368-376 (2003)
Ayliffe 1966	Cleaning and disinfection of hospital floors	Ayliffe GAJ, Collins BJ, Lowbury EJL	Brit Med J 1966; 2: 442-445
Ayliffe 1967	Ward floors and other surfaces as reservoirs of hospital infection	Ayliffe GAJ, Collins BJ, Lowbury EJL, Babb JR, Lilly HA	J Hyg Camb 1967; 65: 515-536
Babl	Airway edema following household bleach ingestion	Babl FE, Kharsch S, Woolf A	Am J Emerg Med 1998 Sep; 16(5): 514-516
Barker 2003	The effects of cleaning and disinfection in reducing Salmonella contamination in a laboratory model kitchen.	Barker, J., Naeeni, M. & Bloomfield, S.F.	J Appl Microbiol. 2003;95(6):1351-1360

Reference	Title	Author	Citation
Barker 2004	Effects of cleaning and disinfection in reducing the spread of Norovirus contamination via environmental surfaces	Barker J, Vipond IB, Bloomfield SF. Department of Pharmaceutical and Biological Sciences, School of Life and Health Sciences, Aston University, Aston Triangle, Birmingham B4 7ET, UK. j.e.barker@aston.ac.uk	J Hosp Infect. 2004 Sep;58(1):42-9
Bautusta Casasnovas	A retrospective analysis of ingestion of caustic substances by children. Ten year statistics in Galicia	Bautista Casasnovas A, Estevez Martinez E, Varela Cives R, Villanueva Jeremias A, Tojo Sierra R, Cadranel S	Eur J Pediatrc 1997 May; 156(5): 410-414
Baxter, Daniel M.	A Regional Comparison of Mold Spore Concentrations Outdoors and Inside "Clean" and "Mold Contaminated" Southern California Buildings	Baxter, Daniel M., Jimmy L Perkins, Charles R. McGhee, James M Seltzer	Journal of Occupational and Environmental Hygiene, 2:8-18
Bennion, JR 1997	Chemical pneumonitis following household exposure to hydrofluoric acid	Bennion, JR., A. Franzblau	Am J Ind Med, 1997 Apr;31(4):474-8
Berry 1994	Suggested guidelines for remediation of damage from sewage backflow into buildings	Berry NM, Bishop J, Blackburn C, Cole E, Ewald W, Smith T, Suazo N, Swan S	J. Environ Health 1994 57;9-15
Bremer 2002	Inactivation of Listeria monocytogenes/Flavobacterium sp. biofilms using chlorine: impact of substrate, pH, time and concentration.	Bremer PJ, Monk I, Butler R. Food Science, University of Otago, Dunedin, New Zealand phil.bremer@stonebow.otago.ac.nz	Lett Appl Microbiol. 2002;35(4):321-5
Brevard 2003	Acute occupational disinfectant-related illness among youth, 1993-1998	Brevard TA, Calvert GM, Blondell JM, Mehler LN	Environ Health Perspect 2003 Oct; 111(13): 1654-1659
Brewer 1994	Hurricane-related emergency department visits in an inland area: an analysis of the public health impact of Hurricane Hugo in North Carolina	Brewer RD, Morris PD, Cole TB. Epidemic Intelligence Service, Centers for Disease Control and Prevention, Atlanta, Georgia.	Ann Emerg Med. 1994 Apr;23(4):731-6
Butcher 2005	Contact inactivation of orthopoxviruses by household disinfectants	Butcher W, Ulaeto D. Department of Biomedical Sciences , Dstl Porton Down, Porton Down, Salisbury, UK	J Appl Microbiol. 2005;99(2):279-84
Cancellotti 1995	Aircraft and ship disinfection.	Cancellotti FM.	Rev Sci Tech. 1995 Mar;14(1):177-89.
Cardona 1993	[Accidental bleach ingestion in children: results of a survey in 11 anti-poison centres. Proposals for management]	Cardona J, Boussemart T, Berthier M, Oriot D.	Pediatrie. 1993;48(10):705-9
Casasnovas 1997	A retrospective analysis of ingestion of caustic substances by children. Ten year statistics in Galicia	Casasnovas AB, Martinez EE, Cives RV, Jeremias AV, Sierra RT, Cadranel S	Eur J Pediatr 1997; 156: 410-414
CDC 1983 Apr	Current Trends Flood Disasters and Immunization -- California	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1983 Apr 8;32(13):171-2 178.
CDC 1983 Dec	Outbreak of Diarrheal Illness Associated with a Natural Disaster -- Utah	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1983 Dec 23;32(50):662-4.

Reference	Title	Author	Citation
CDC 1991 Sep	Chlorine gas toxicity from mixture of bleach with other cleaning products--California	Centers for Disease Control (CDC)	MMWR Morb Mortal Wkly Rep. 1991 Sep 13;40(36):619-21, 627-9
CDC 1992 Sep	Preliminary Report: Medical Examiner Reports of Deaths Associated with Hurricane Andrew -- Florida, August 1992	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1992 Sep 4;41(35):641-644.
CDC 1993 Apr	Injuries and Illnesses Related to Hurricane Andrew -- Louisiana, 1992	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1993 Apr 9;42(13):242-243,250-251.
CDC 1993 Dec	Flood-Related Mortality -- Missouri, 1993	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1993 Dec 10;42(48):941-943.
CDC 1993 Oct	Morbidity Surveillance Following the Midwest Flood -- Missouri, 1993	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1993 Oct 22;42(41):797-798.
CDC 1993 Sep	Public Health Consequences of a Flood Disaster -- Iowa, 1993	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1993 Sep 3;42(34):653-656.
CDC 1994 Jul 29	Flood-Related Mortality -- Georgia, July 4-14, 1994	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1994 Jul 29; 43(29):526-530.
CDC 1994 Jul 6	Rapid Assessment of Vectorborne Diseases During the Midwest Flood -- United States, 1993	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1994 Jul 6;43(26):481-3.
CDC 1996 Feb	Surveillance for Injuries and Illnesses and Rapid Health-Needs Assessment Following Hurricanes Marilyn and Opal, September-October 1995	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1996 Feb 2;45(4):81-5.
CDC 1996 Jan	Deaths Associated with Hurricanes Marilyn and Opal -- United States, September-October 1995	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 1996 Jan 19;45(2):32-8.
CDC 2000 May	Morbidity and Mortality Associated With Hurricane Floyd --- North Carolina, September--October 1999	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2000 May 5;49(17):369-372.
CDC 2002 May	Tropical Storm Allison Rapid Needs Assessment -- Houston, Texas, June 2001	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2002 May 3;51(17):365.
CDC 2003 June	Guidelines for environmental infection control in health care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2003 June 6;52(No. RR-10):1-44
CDC 2004 Dec	Brief Report: Acute Illness from Dry Ice Exposure During Hurricane Ivan --- Alabama, 2004	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2004 Dec 24;53(50):1182-1183.
CDC 2005 Oct 14a	Norovirus outbreak among evacuees from hurricane Katrina - Houston, Texas, September 2005	Centers for Disease Control and Prevention (CDC).	MMWR Morb Mortal Wkly Rep. 2005 Oct 14;54(40):1016-18.

Reference	Title	Author	Citation
CDC 2005 Oct 14b	Surveillance for Illness and Injury After Hurricane Katrina --- New Orleans, Louisiana, September 8-25, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2005 Oct 14;54(40):1018-1021.
CDC 2005 Oct 21	Surveillance for illness and injury after hurricane Katrina--New Orleans, Louisiana, September 8-25, 2005.	Centers for Disease Control and Prevention (CDC).	MMWR Morb Mortal Wkly Rep. 2005 Oct 14;54(40):1018-21. Erratum in: MMWR Morb Mortal Wkly Rep. 2005 Oct 21;54(41):1057.
CDC 2005 Sep 23	Vibrio Illnesses After Hurricane Katrina --- Multiple States, August--September 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2005 Sep 23;54(37):928-931.
CDC 2006 Apr 21	Monitoring Poison Control Center Data to Detect Health Hazards During Hurricane Season --- Florida, 2003--2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Apr 21;55(15):426-428.
CDC 2006 Apr 28	Health Hazard Evaluation of Police Officers and Firefighters After Hurricane Katrina --- New Orleans, Louisiana, October 17--28 and November 30--December 5, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Apr 28;55(16):456-458.
CDC 2006 Feb	Brief report: Leptospirosis after flooding of a university campus--Hawaii, 2004.	Centers for Disease Control and Prevention (CDC).	MMWR Morb Mortal Wkly Rep. 2006 Feb 10;55(5):125-7.
CDC 2006 Jan 20a	Assessment of Health-Related Needs After Hurricanes Katrina and Rita --- Orleans and Jefferson Parishes, New Orleans Area, Louisiana, October 17-22, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Jan 20;55(2):38-41.
CDC 2006 Jan 20b	Health concerns associated with mold in water-damaged homes after Hurricanes Katrina and Rita--New Orleans area, Louisiana, October 2005.	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Jan 20;55(2):41-4
CDC 2006 Jan 20c	Injury and Illness Surveillance in Hospitals and Acute-Care Facilities After Hurricanes Katrina and Rita --- New Orleans Area, Louisiana, September 25--October 15, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Jan 20;55(2):35-38.
CDC 2006 Jan 20d	Surveillance in Hurricane Evacuation Centers --- Louisiana, September--October 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Jan 20;55(2):32-35.
CDC 2006 Jan 20e	Two Cases of Toxigenic Vibrio cholera O1 Infection After Hurricanes Katrina and Rita --- Louisiana, October 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Jan 20;55(2):31-32.
CDC 2006 Jun	Mold prevention strategies and possible health effects in the aftermath of hurricanes and major floods	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 June 9;55(No. RR-8):1-27
CDC 2006 Mar 10a	Carbon Monoxide Poisonings After Two Major Hurricanes --- Alabama and Texas, August--October 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Mar 10;55(9):236-239.
CDC 2006 Mar 10b	Illness Surveillance and Rapid Needs Assessment Among Hurricane Katrina Evacuees --- Colorado, September 1--23, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Mar 10;55(9):244-247.

Reference	Title	Author	Citation
CDC 2006 Mar 10c	Surveillance for Illness and Injury After Hurricane Katrina --- Three Counties, Mississippi, September 5--October 11, 2005	Centers for Disease Control and Prevention (CDC)	MMWR Morb Mortal Wkly Rep. 2006 Mar 10;55(9):231-234.
Chen 2001	Allergenic proteins are fragmented in low concentrations of sodium hypochlorite	Chen P, Egleston P	Clin Exper Allergy 2001; 31:1086-1093
Chew 2006	Mold and endotoxin levels in the aftermath of Hurricane Katrin: a pilot project of homes in New Orleans undergoing renovation	Chew GL, Wilson J, Rabito FA, Grimsley F, Iqbal S, Reponen T, Muilenberg M, Thorne P, Dearborn DG, Morley RL	accepted for publication Environmental Health Perspectives
Cogan 1999	The effectiveness of hygiene procedures for prevention of cross-contamination from chicken carcasses in the domestic kitchen	T. A. Cogan, S. F. Bloomfield1 and T. J. Humphrey	Lett Appl Microbiol. 1999;29:354
Cogan 2002	Achieving hygiene in the domestic kitchen: the effectiveness of commonly used cleaning procedures	Cogan, T.A. , Slader, J. , Bloomfield, S.F. & Humphrey, T.J	J Appl Microbiol. 2002;92(5):885-892
Cohle, SD	Unexpected death due to chloramine toxicity in a woman with a brain tumor	Cohle, CD, W. Thompson, BH Eisenga, SL Cottingham	Forensic Sci Int, 2001 Dec 27;124(2-3):137-9
Cole 1987	Ineffectiveness of hospital disinfectants against bacteria: A collaborative study	E. C. Cole and W. A. Rutala	American Journal of Infection Control, Volume 15, Issue 2, April 1987, Page 90
Cole 2001	Suggested Practice for Remediation of Highly Infectious Biological Agent Contamination in Indoor Environments	Cole EC, Lantrip BM	Applied Biosafety; 2001; 6(3): 136-138
Cools 2005	Persistence of Campylobacter jejuni on surfaces in a processing environment and on cutting boards.	Cools I, Uyttendaele M, Cerpentier J, D'Haese E, Nelis HJ, Debevere J.	Lett Appl Microbiol. 2005;40(6):418-23
Courteau 1994	Survey of construction workers repeatedly exposed to chlorine over a three to six month period in a pulpmill: I. Exposure and symptomatology	Courteau JP, Cushman R, Bouchard F, Quevillon M, Chartrand A, Bherer L.	Occup Environ Med. 1994 Apr;51(4):219-24.
Danforth 1987	Nosocomial infections on nursing units with floors cleaned with a disinfectant compared with detergent	Danforth D, Nicolle LE, Hume K, Alfieri N, Sims H	J Hosp Infect 1987; 10:229-235
Daschner 1980	Surface decontamination in the control of hospital infections: comparison of different methods	Daschner F, Rabbenstein G, Langmaack GRH	Dtsch Med Wochenschr 1980; 105: 325-329
de Ferron 1987	Esogastric lesions caused by ingestion of liquid chlorine bleach in adults] French	de Ferron P, Gossot D, Sarfati E, Celerier M	Presse Med. 1987 Dec 12;16(42):2110-2.
Deza 2005	Inactivation of Escherichia coli, Listeria monocytogenes, Pseudomonas aeruginosa and staphylococcus aureus on stainless steel and glass surfaces by neutral electrolyzed water	Deza MA, Araujo M, Garrido MJ	Lett Appl Microbiol. 2005;40(5):351-6
Dharan 1999	Routine disinfection of patients' environmental surfaces: myth or reality?	Dharan S, Mourouga P, Copin P, Bessmer G, Tschanz B, Pittet D	J Hosp Infect 1999; 42:113-117

Reference	Title	Author	Citation
Dybendal 1990	Dust from carpeted and smooth floors--III. Trials on denaturation of allergenic proteins by household cleaning solutions and chemical detergents	Dybendal T, Vik H, Elsayed S. Allergy Research Group, Laboratory of Clinical Biochemistry, University Hospital, Bergen, Norway.	Ann Occup Hyg. 1990 Apr;34(2):215-29
Eskenazi 1982	Evaluation of glutaraldehyde and hydrogen peroxide for sanitizing packaging materials of medical devices in sterility testing.	Eskenazi S, Bychkowski OE, Smith M, MacMillan JD.	J Assoc Off Anal Chem. 1982 Sep;65(5):1155-61.
Exner 2004	Household cleaning and surface disinfection: new insights and strategies	Exner M, Vacata V, Hornei B, Dietlin E, Gebel J	Journal of Hospital Infection; 2004; 56:S70-S75
Fatemi 1999	Inactivation of Listeria monocytogenes/Pseudomonas biofilms by peracid sanitizers.	Fatemi P, Frank JF.	J Food Prot. 1999 Jul;62(7):761-5.
Foarde 2002	Evaluating the potential efficacy of three antifungal sealants of duct liner and galvanized steel as used in HVAC systems	Foarde KK, Menetrez MY. Center for Environmental Tec hnology, RTI, 3040 Cornwallis Road, Research Triangle Park, NC 27709, USA	J Ind Microbiol Biotechnol. 2002 Jul;29(1):38-43
Frais 2001	Some factors affecting the concentration of available chlorine in commercial sources of sodium hypochlorite.	Frais S, Ng YL, Gulabivala K. Department of Conservative Dentistry, Eastman Dental Institute for Oral Health Care Sciences, University College London, London, England, UK	Int Endod J. 2001 Apr;34(3):206-15.
Frank 1997	Effectiveness of sanitation with quaternary ammonium compound or chlorine on stainless steel and other domestic food-preparation surfaces.	Frank JF, Chmielewski RA. Center for Food Safety and Quality Enhancement, Department of Food Science and Technology, University of Georgia, Athens 30602, USA. frank@flavor.fst.uga.edu	J Food Prot. 1997 Jan;60(1):43-7.
Garrison 1993	Effect of heating-ventilation-air conditioning system sanitation on airborne fungal populations in residential environments.	Garrison RA, Robertson LD, Koehn RD, W ynn SR. Mycotech Biological, Inc., Jewett, Texas	Ann Allergy. 1993 Dec;71(6):548-56
Gibson 1999	Use of quantitative microbial risk assessment for evaluation of the benefits of laundry sanitation	Gibson LL, Rose JB, Haas CN.	Am J Infect Control. 1999 Dec;27(6):S34-9.
Gorguner 2004	Reactive airways dysfunction syndrome in housewives due to a bleach-hydrochloric acid mixture	Gorguner M, Aslan S, Inandi T, Cakir Z. Department of Chest Diseases, Faculty of Medicine, Ataturk University, Erzurum, Turkey. gorguner@atauni.edu.tr	Inhal Toxicol. 2004 Feb;16(2):87-91
Gots 2003	Indoor Health: Background Levels of Fungi	Gots, Ronald E., Nancy J. Layton, Suellen W. Pirages	AIHA Journal (64) July/August 2003: 427-438
Greene 1993	A comparison of ozonation and chlorination for the disinfection of stainless steel surfaces	Greene AK, Few BK, Serafini JC	J Dairy Sci. 1993 Nov;76(11):3417-20.

Reference	Title	Author	Citation
Guidry 2004	Unequal respiratory health risk: using GIS to explore hurricane-related flooding of schools in Eastern North Carolina	Guidry VT, Margolis LH. Department of Maternal and Child Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA. ginger_guidry@unc.edu	Environ Res. 2005 Jul;98(3):383-9. Epub 2004 Dec 15
Guinan 2002	The effect of a comprehensive handwashing program on absenteeism in elementary schools.	Guinan M, McGuckin M, Ali Y. Agnes Irwin School, Rosemont, PA, USA.	Am J Infect Control. 2002 Jun;30(4):217-20.
Hansen 2003	Curvularia haloperoxidase: antimicrobial activity and potential application as a surface disinfectant.	Hansen EH, Albertsen L, Schafer T, Johansen C, Frisvad JC, Molin S, Gram L.	Appl Environ Microbiol. 2003 Aug;69(8):4611-7.
Harley 1997	Liquid household bleach ingestion in children: a retrospective review	Harley EH, Collins MD	Laryngoscope 1997 Jan; 107(1): 122-125
Henderson 1994	Disaster medical assistance teams: providing health care to a community struck by Hurricane Iniki	Henderson AK, Lillibridge SR, Salinas C, Graves RW, Roth PB, Noji EK. Disaster Assessment and Epidemiology Section, Centers for Disease Control and Prevention, Atlanta, Georgia.	Ann Emerg Med. 1994 Apr;23(4):726-30
Henneberger 2003	Work-related reactive airways dysfunction syndrome cases from surveillance in selected U.S. states	Henneberger PK, Derk SJ, Davis L, Tumpowsky C, Reilly MJ, Rosenman KD, Schill DP, Valiante D, Flattery J, Harrison R, Reinisch F, Filios, MS, Tift B	JOEM Vol 45, Number 4, April 2003
Heuschle 1995	Use of disinfectants in zoos and game parks	Heuschele WP. Center for Reproduction of Endangered Species, Zoological Society of San Diego, CA 92112-0551, USA.	Rev Sci Tech. 1995 Jun;14(2):447-54
Hubalek 1999	Surveillance of mosquito-borne viruses in Breclav after the flood of 1997	Hubalek Z, Halouzka J, Juricova Z, Prikazsky Z, Zakova J, Sebesta O. Oddeleni medicinske zoologie, Ustav biologie obratlovcu AV CR, Brno. zhubalek@brno.cas.cz	Epidemiol Mikrobiol Imunol. 1999 Aug;48(3):91-6.
Hughson, G. W. 2004	Determination of Dermal Exposures During Mixing, Spraying and Wiping Activities	Hughson, G. W., R.J. Aitken	Ann. Occup. Hyg.,Vol 48,No 3:245-255 (2004)
Jaakkola 2003	Occupation and Asthma: A Population-based Incident Case-Control Study	Jaakkola, Jouni J., Ritva Piipari, Maritta S. Jaakkola	Am J Epidemiol 2003;158:981-987
Jean 2003	Effectiveness of commercial disinfectants for inactivating hepatitis A virus on agri-food surfaces	Jean J, Vachon JF, Moroni O, Darveau A, Kukavica-Ibrulj I, Fliss I	J Food Prot. 2003 Jan; 66(1):115-119
Jordan 1969	Antiviral effectiveness of chlorine bleach in household laundry use.	Jordan WE, Jones DV, Klein M.	Am J Dis Child. 1969 Mar;117(3):313-6
Karande 2003	Comment in: Arch Dis Child. 2003 Dec;88(12):1033. An observational study to detect leptospirosis in Mumbai, India, 2000.	Karande S, Bhatt M, Kelkar A, Kulkarni M, De A, Varaiya A. Department of Paediatrics, Lokmanya Tilak Municipal Medical College and General Hospital, Sion, Mumbai, Bombay, 400 022, India.	Arch Dis Child. 2003 Dec;88(12):1070-5.

Reference	Title	Author	Citation
Karjalainen 2002	Excess incidence of asthma among Finnish cleaners employed in different industries	Karjalainen A, Martikainen R, Karjalainen J, Klaukka T, Kurppa K	Eur Resp J 2002; 19: 90-95
Kateruttanakul 2005	Respiratory complication of tsunami victims in Phuket and Phang-Nga.	Kateruttanakul P, Paovilai W, Kongsaengdao S, Bunnag S, Atipornwanich K, Siriwatanakul N.Department of Medicine, Rajavithi Hospital, Bangkok 10400, Thailand.	J Med Assoc Thai. 2005 Jun;88(6):754-8.
Knape 2001	Response of food borne Salmonella spp. marker strains inoculated on egg shell surfaces to disinfectants in a commercial egg washer.	Knape KD, Carey JB, Ricke SC.	J Environ Sci Health B. 2001 Mar;36(2):219-27.
Knowles 2001	Efficacy of chitosan, carvacrol, and a hydrogen peroxide-based biocide against food borne microorganisms in suspension and adhered to stainless steel	Knowles J, Roller S	J Food Prot. 2001 Oct; 64(10): 1542-1548
Kovacs 1997	Behavioral factors affecting exposure potential for household cleaning products	Kovacs DC, Small MJ, Davidson CI, Fischoff B	Journal of Exposure Analysis and Environmental Epidemiology 1997; vol 7, No 4: 505-520
Krause 2006	Control Study of Mold Growth and Cleaning Procedure on Treated and Untreated Wet Gypsum Wallboard in an Indoor Environment	Krause, Michael, William Geer, Lonie Swenson, Payam Fallah, Coreen Robbins	Journal of Occupational and Environmental Hygiene,3: 435-441
Kusumaningrum 2003a	Survival of food borne pathogens on stainless steel surfaces and cross-contamination to foods	Kusumaningrum HD, Riboldi G, Hazeleger WC, Beumer RR	In J Food Microbiol. 2003 Aug 25; 85(3): 227-236
Kusumaningrum 2003b	Tolerance of Salmonella Enteritidis and Staphylococcus aureus to surface cleaning and household bleach.	Kusumaningrum HD, Paltinaite R, Koomen AJ, Hazeleger WC, Rombouts FM, Beumer RR.	J Food Prot. 2003 Dec;66(12):2289-95.
Lalla 2004	The efficacy of cleaning products on food industry surfaces	Lalla F, Dingle P.	J Environ Health. 2004 Sep;67(2):17-22.
Lambert 2000	Poisoning by household products	Lambert H, Manuel J, Gabrion I	Rev Prat 2000 Feb 15; 50(4): 365-371
Lambert 2001	The effect of interfering substances on the disinfection process: a mathematical model.	Lambert, R.J.W. & Johnston, M.D.	J Appl Microbiol. 2001;91(3):548-555
Lamireau 1997	Severity of ingestion of caustic substances in children	Lamireau T, Llanas B, Deprez C, el Hammar F, Vergnes P, Demarquez JL, Favarel-Garrigues JC	Arch Pediatr
Landau 1964	The effect of chlorine bleach on the esophagus	Landau GD, Saunders WH.	Arch Otolaryngology. 1964 Aug;80:174-6.
Larkin 2005	In hurricanes' aftermath, keeping infection under control	Larkin M.	Lancet Infect Dis. 2005 Nov;5(11):673.

Reference	Title	Author	Citation
Lee 1993	Active morbidity surveillance after Hurricane Andrew--Florida, 1992	Lee LE, Fonseca V, Brett KM, Sanchez J, Mullen RC, Quenemoen LE, Groseclose SL, Hopkins RS. Division of Field Epidemiology, Centers for Disease Control and Prevention, Atlanta, GA 30333.	JAMA. 1993 Aug 4;270(5):591-4
Levy 1998	The challenge of antibiotic resistance	Levy SB	Scientific American 1998 (March); 46-53)
Lomander 2004	Evaluation of chlorines' impact on biofilms on scratched stainless steel surfaces.	Lomander A, Schreuders P, Russek-Cohen E, Ali L.	Bioresour Technol. 2004 Sep;94(3):275-83.
Loret 2005	Comparison of disinfectants for biofilm, protozoa and Legionella control	Loret JF, Robert S, Thomas V, Cooper AJ, McCoy WF, Levi Y. Suez Environnement, Cirsee, 38 rue du President Wilson, 78230 Le pecq, France. jean-francois.loret@suez-env.com	J Water Health. 2005 Dec;3(4):423-33
Macher, Janet M. 2001	Prevalence of Culturable Airborne Fungi in 100 U.S. Office Buildings in the Building Assessment Survey and Evaluation (BASE) Study	Macher, Janet M. ScD., Feng C. Tsai, PhD., Laureen E. Burton, Kai-Shen Liu, PhD., Jed M. Waldman, PhD.	ASHRAE Indoor Air Quality, November 4-7, 2001
Mafu 1990	Efficiency of sanitizing agents for destroying Listeria monocytogenes on contaminated surfaces	Mafu AA, Roy D, Goulet J, Savoie L, Roy R.	J Dairy Sci. 1990 Dec;73(12):3428-32.
Maki 1982	Relation of the inanimate hospital environment to endemic nosocomial infection	Maki DG, Alverado CJ, Hassemer CA, Zilz MA	N Engl J Med 1982; 307:1562-1566
Mallin 2002	Impacts and Recovery from Multiple Hurricanes in a Piedmont-Coastal River System	Mallin MA, Posey, Mh, McIver MR, Parsons DC, Ensign SH, Alphin TD	Bioscience 2002; 52(11): 999-1010
Martinez 2003	Role of environmental contamination as a risk factor for acquisition of vancomycin-resistant enterococci in patients treated in a medical intensive care unit	Martinez JA, Ruthazer R, Hansjosten K, Barefoot L, Snydman DR. Division of Geographic Medicine and Infectious Disease and Clinical Care Research, Department of Medicine, Tufts New England Medical Center and Tufts University School of Medicine, Boston, MA 02111, USA.	Arch Intern Med. 2003 Sep 8;163(16):1905-12
Martyny, John W. PhD 2005	Aerosolized sodium hypochlorite inhibits viability and allergenicity of mold on building materials	Martyny, JW, R. J. Jarbeck, K. Pacheco, E.A. Barker, M. Sills, L. Silveira, S. Arbuckle, L. Newman	J Allergy Clin Immunol; vol 116, no 3
Matsui 2003	Allergic potency of recombinant Fel d 1 is reduced by low concentrations of chlorine bleach	Matsui E, Kagey-Sobotka A, Chichester K, Eggleston PA. Departments of Pediatrics and Medicine, Johns Hopkins School of Medicine, Johns Hopkins Hospital, 600 N. Wolfe Street, Baltimore, MD 21287, USA	J Allergy Clin Immunol. 2003 Feb;111(2):396-401
Maule 2000	Survival of verocytotoxigenic Escherichia coli O157 in soil, water and on surfaces.	Maule A.	Symp Ser Soc Appl Microbiol. 2000;(29):71S-78S.

Reference	Title	Author	Citation
McGuigan 1999	Common culprits in childhood poisoning: epidemiology, treatment and parental advice	McGuigan MA	Paediatr Drugs 1999; Oct-Dec; 1(4):313-324
McMurry 1998	Over-expression of marA, soxS, or acrAB produces resistance to triclosan in laboratory and clinical strains of Escherichia coli	McMurry LM, Oethinger M, Levy SB	FEMS Microbial Lett 1998; 166:305-309
McNabb 1995	Hurricane Andrew-related injuries and illnesses, Louisiana, 1992	McNabb SJ, Kelso KY, Wilson SA, McFarland L, Farley TA. Louisiana Office of Public Health, New Orleans, USA.	South Med J. 1995 Jun;88(6):615-8
Meadows 2004	A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children.	Meadows E, Le Saux N. Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario, Canada. emead024@uottawa.ca	BMC Public Health. 2004 Nov 1;4:50.
Medina-Ramon 2003	Asthma symptoms in women employed in domestic cleaning: a community based study	Medina-Ramon M, Zock JP, Kogevinas, M, Sunyer J, Anto JM	Thorax 2003; 58:950-954
Medina-Ramon 2005	Asthma, chronic bronchitis, and exposure to irritant agents in occupational domestic cleaning: a nested case-control study	Medina-Ramon M, Zock JP, Kogevinas, M, Sunyer J, Torralba Y, Borrell A, Burgos F, Anto JM	Occup Environ Med. 2005 Sep;62(9):598-606
Meklin 2005	Effects of moisture-damage repairs on microbial exposure and symptoms in schoolchildren	Meklin T, Potus T, Pekkanen J, Hyvarinen A, Hirvonen MR, Nevalainen A. Department of Environmental Health, National Public Health Institute, Kuopio, Finland. teija.meklin@ktl.fi	Indoor Air. 2005;15 Suppl 10:40-7.
Mendonca, E M 2003	Occupation asthma in the city of Sao Paulo, 1995-2000, with special reference to gender analysis	Mendonca, EM, E Algranti, JB de Freitas, EA Rosa, dos Santos, JA Frire, Ud U de Paula Santos, J Pinto, MA Bussacos	Am J Ind Med: 2003 Jun; 43 (6): 611-7
Meng 2003	Study on hospitalization expenses of flood disaster areas' residents of Dongting Lake in Hunan province in 1998 [Article in Chinese]	Meng W, Yang TB, Tan HZ, Li SQ, Liu AZ, Zhou J, Xie MZ, Tang XM, Tang SL, Zhang XM, Xiang BL, He HX, Li LL. Department of Epidemiology, School of Public Health, Central South University, Changsha 410078, China.	Zhonghua Liu Xing Bing Xue Za Zhi. 2003 Aug;24(8):689-93.
Miettinen 2001	Waterborne epidemics in Finland in 1998-1999	Miettinen IT, Zacheus O, von Bonsdorff CH, Vartiainen T. National Public Health Institute, Division of Environmental Health, P.O.Box 95, FIN-70701 Kuopio, Finland. Ilkka.Miettinen@ktl.fi	Water Sci Technol. 2001;43(12):67-71
Moken 1997	Selection of multiple antibiotic resistant (Mar) mutants of Escherichia coli by using disinfectant pine oil; roles of the mar and acrAB loci	Moken MC, McMurry LM, Levy SB	Antimicrob Agents Chemother 1997; 41:2770-2772
Mrvos 1993	Home exposures to chlorine/chloramine gas: review of 216 cases	Mrvos R, Dean BS, Krenzelok EP	Southern Medical Journal ;June 1993 Vol 86, No 6

Reference	Title	Author	Citation
Nazaroff 2006	Indoor air chemistry: cleaning agents, ozone and toxic air contaminants	Nazaroff WW, Coleman BK, Destaillats H, Hodgson AT, Liu D, Lunden MM, Singer BC, Weschler CJ	Final Report Contract 01-336, California Air Resources Board, Sacromento 2006
Nethercott 1988	Health status of a group of sewage treatment workers in Toronto, Canada.	Nethercott JR, Holness DL.	Am Ind Hyg Assoc J. 1988 Jul;49(7):346-50.
Nielsen, J. 1999	Work-related eye symptoms and respiratory symptoms in female cleaners	Nielsen, J., E. Bach	Occup. Med. Vol 49, No. 5:291-297 (1999
NIOSH 2006	NIOSH Interim Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers	NIOSH	CDC
NTP 2005	NTP Toxicology and Carcinogenesis Studies of Sodium Chlorate (CAS No. 7775-09-9) in F344/N Rats and B6C3F(1) Mice (Drinking Water Studies)	National Toxicology Program	Natl Toxicol Program Tech Rep Ser. 2005 Dec;(517):1-256
Ogden 2001	Emergency health surveillance after severe flooding in Louisiana, 1995	Ogden CL, Gibbs-Scharf LI, Kohn MA, Malilay J.	Prehospital Disaster Med. 2001 Jul-Sep;16(3):138-44.
O'Leary 2002	Assessment of dengue risk in relief workers in Puerto Rico after Hurricane Georges, 1998.	O'Leary DR, Rigau-Perez JG, Hayes EB, Vorndam AV, Clark GG, Gubler DJ. Division of Vector-Borne Infectious Diseases, National Centers for Infectious Diseases, Centers for Disease Control and Prevention, Fort Collins, Colorado 80521, USA. rld4@cdc.gov	Am J Trop Med Hyg. 2002 Jan;66(1):35-9.
Olson 1994	Hard Surface Cleaning Performance of Six Alternative Household Cleaners under Laboratory Conditions	Olson W, Vesley D, Bode M, Dubbel P, Bauer T	J Environ Health. 1994; 56(6):27-31
Pao 2000	Efficacy of alkaline washing for the decontamination of orange fruit surfaces inoculated with Escherichia coli.	Pao S, Davis CL, Kelsey DF.	J Food Prot. 2000 Jul;63(7):961-4
Pardue 2005	Chemical and Microbiological Parameters in New Orleans Floodwater Following Hurricane Katrina	Pardue JH, Moe WM, McInnis D, Thibodeaux LJ, Valsaraj KT, MacIasz E, Van Heerden, I, Korevec N, Yuan QZ LSU, CK Associates, EHS Technical Solutions	Environ Sci Technol. 2005 Nov 15;39(22):8591-9
Paredes 1993	[Our experience with caustic substance ingestion in children]	Paredes Osado JR, Gras Albert JR, Crespo Marco C, Mira Navarro J.	Acta Otorrinolaringol Esp. 1993 Mar-Apr;44(2):101-5.
Park 2000	Longitudinal study of dust and airborne endotoxin in the home	Park JH, Speigelman DL, Burge HA, Gold DR, Chew GL, Milton DK	Environ Health Perspect 2000; 108:1023-1028)
Park 2002	Effectiveness of electrolyzed water as a sanitizer for treating different surfaces.	Park H, Hung YC, Kim C. Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.	J Food Prot. 2002 Aug;65(8):1276-80.

Reference	Title	Author	Citation
Park 2004	Building-related respiratory symptoms can be predicted with semi-quantitative indices of exposure to dampness and mold	Park JH, Schleiff PL, Attfield MD, Cox-Ganser JM, Kreiss K NIOSH	Indoor Air 2004; 14; 425-433
Pascuzzi 1998	Mass casualties from acute inhalation of chloramine gas	Pascuzzi TA, Storrow AB	Mil Med 1998 Feb; 163(2): 102-103
Peng 2002	Inactivation and removal of Bacillus cereus by sanitizer and detergent	Peng J, Tsai W, Chou C	In J Food Microbial 2002; 77:11-18
Perez 2005	Activity of selected oxidizing microbiocides against the spores of Clostridium difficile: relevance to environmental control	Perez J, Springthorpe VS, Sattar SA. Centre for Research on Environmental Microbiology, Faculty of Medicine, University of Ottawa, Ottawa, Ontario, Canada	Am J Infect Control. 2005 Aug;33(6):320-5
Portnoy 2005	Health effects of indoor fungi	Portnoy JM, Kwak K, Dowling P, VanOsdol T, Barnes C. The Children's Mercy Hospital, Kansas City, Missouri 64108, USA. jportnoy@cmh.edu	Ann Allergy Asthma Immunol. 2005 Mar;94(3):313-9; quiz 319-22, 390.
Pronk, A 2006	Dermal, inhalation, and internal exposure to 1,6-HDI and its oliomers in car body repair shop workers and industrial spray painters	Pronk, A., F Yu, J Vlaanderen, E Tielemans, L Preller, I Bobeldijk, J A Deddens, U Latza, X Baur, D Heederik	Occup Environ Med 2006; 63: 624-631
Purohit 2000	Quaternary ammonium compounds and occupational asthma	Purohit A, Kopferschmitt-Kubler MC, Moreau C, Popin E, BlaumeiserM, Pauli G	Int Arch Occup Environ Health 2000; 73: 423-427
Quinn 1994	Hurricane Andrew and a pediatric emergency department	Quinn B, Baker R, Pratt J	Ann Emerg Med 1994 Apr; 23(4): 737-741
Racioppi 1994	Household bleaches based on sodium hypochlorite: review of acute toxicology and poison control center experience	Racioppi F, Daskaleros PA, Besbelli N, Borges A, Deraemaeker C, Magalini SI, Martinez Arrieta R, Pulce C, Ruggerone ML, Vlachos P	Food Chem Toxicol. 1994 Sep;32(9):845-61
Rao 2005	Use of surrogate markers of biological agents in air and settled dust samples to evaluate a water-damaged hospital	Rao CY, Cox-Ganser JM, Chew GL, Doekes G, White S. Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Morgantown, WV 26505, USA. cnr3@cdc.gov	Indoor Air. 2005;15 Suppl 9:89-97
Reacher 2004	Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households.	Reacher M, McKenzie K, Lane C, Nichols T, Kedge I, Iversen A, Hepple P, Walter T, Laxton C, Simpson J; Lewes Flood Action Recovery Team.	Commun Dis Public Health. 2004 Mar;7(1):39-46.
Reisz 1986	Toxic pneumonitis from mixing household cleaners	Reisz GR, Gammon RS	Chest 1986; vol 88, no 1, January
Richardson, M.N.	Occupation asthma due to indirect exposure to lauryl dimethylbenzyl ammonium chloride, used in a floor cleaner	Richardson, M. N., P. Sherwood Burge	
Rosenman 2003	Cleaning products and work-related asthma	Rosenman KD, Reilly MJ, Schill DP, Flattery J, Harrison R, Reinisch F, Pechter E, Davis L, Tumpowsky C, Filios M	JOEM Vol 45, Number 5, May 2003

Reference	Title	Author	Citation
Ross 1999	Fatal ingestion of sodium hypochlorite bleach with associated hypernatriemia and hyperchloremic metabolic acidosis	Ross MP, Spiller HA	Vet Hum Toxicol 1999 Apr; 41(2): 82-86
Ross 2000	Association of asthma symptoms and severity with indoor bioaerosols	M. A. Ross1, L. Curtis2, P. A. Scheff2, D. O. Hryhorczuk2, V. Ramakrishnan2, R. A. Wadden2, V. W. Persky2	Allergy Volume 55 Page 705 - August 2000 Volume 55 Issue 8
Rossoni 2000	Comparison of sodium hypochlorite and peracetic acid as sanitizing agents for stainless steel food processing surfaces using epifluorescent microscopy	Rossoni EMM, Gaylarde CC	In J Food Microbiol 2000; 61:81-85
Rutala 1982	Oyster-associated outbreak of diarrhoel disease possibly caused by plesiomonas shigelloides	WilliamA. Rutala, FelixA. Sarubbi, JR , CharlesS. Finch, J. N. Maccormack and GregoryE. Steinkraus	The Lancet, Volume 319, Issue 8274, 27 March 1982, Page 739
Rutala 1985	Cost-effective application of the centers for disease control guideline for handwashing and hospital environmental control	Rutala WA	American Journal of Infection Control, Volume 13, Issue 5, October 1985, Pages 218-224
Rutala 1996	APIC guideline for selection and use of disinfectants	Rutala WA	American Journal of Infection Control, Volume 24, Issue 4, August 1996, Pages 313-342
Rutala 1997a	Epidemiology: A critical tool for infection control professionals	Rutala WA, Weber DJ	American Journal of Infection Control, Volume 25, Issue 3, June 1997, Pages 193-194
Rutala 1997b	Uses of inorganic hypochlorite (bleach) in health-care facilities	Rutala WA, Weber DJ. Division of Infectious Diseases, University of North Carolina School of Medicine, USA	Clin Microbiol Rev. 1997 Oct;10(4):597-610
Rutala 1998	Stability and bactericidal activity of chlorine solutions.	Rutala WA, Cole EC, Thomann CA, Weber DJ. Division of Infectious Diseases, University of Nort h Carolina School of Medicine, Chapel Hill 27599-7030, USA.	Infect Control Hosp Epidemiol. 1998 May;19(5):323-7
Rutala 1999	Infection control: the role of disinfection and sterilization	Rutala WA and Weber DJ	Journal of Hospital Infection, Volume 43, Supplement 1, December 1999, Pages S43-S55
Rutala 2001	Surface disinfection: should we do it?	Rutala WA, Weber DJ	Journal of Hospital Infection; 2001; 48 (supplement A):S64-S68
Rutala 2002	Should we routinely disinfect floors? Reply to Professor F. Daschner	Rutala WA, Weber DJ	Journal of Hospital Infection, Volume 51, Issue 4, August 2002, Pages 309-311

Reference	Title	Author	Citation
Rutala 2004	The benefits of surface disinfection	Rutala WA, Weber DJ	American Journal of Infection Control, Volume 32, Issue 4, June 2004, Pages 226-231
Rutala 2005	The benefits of surface disinfection	Rutala WA, Weber DJ	American Journal of Infection Control, Volume 33, Issue 7, September 2005, Pages 434-435
Schuler	Cleaning, sanitizing and pest control in food processing, storage and service areas	Schuler, G, Nolan M, Reynolds A, Hurst W	University of Georgia College of Agricultural and Environmental Sciences Bulletin 927
Scott 1993	An in-use study of the relationship between bacterial contamination of food preparation surfaces and cleaning cloths	Scott, E.A. and Bloomfield, S.F	Lett Appl Microbiol 1993 16, 173-177
Sehgal 2002	Outbreak of leptospirosis after the cyclone in Orissa.	Sehgal SC, Sugunan AP, Vijayachari P. National Leptospirosis Reference Centre, Regional Medical Research Centre, Port Blair, Andaman and Nicobar Islands, India. icmr@cal3.vsnl.net.in	Natl Med J India. 2002 Jan-Feb;15(1):22-3
Setzer 2004	Medicaid outpatient utilization for waterborne pathogenic illness following Hurricane Floyd.	Setzer C, Domino ME.	Public Health Rep. 2004 Sep-Oct;119(5):472-8.
Shendell,D.G.	Airborne Bacteria and Fungi in 100 Large U.S. Office Buildings	Shendell, D.G., J. M. Macher, F. C. Tsai, L. Burton	
Sherriff 2005	Frequent use of chemical household products is associated with persistent wheezing in pre-school age children	Sherriff A, Farrow A, Golding J, ALSPAC Study team, Henderson J	Thorax 2005; 60: 45-49
Sickbert-Bennett 2004	The effects of test variables on the efficacy of hand hygiene agents	Emily E. Sickbert-Bennett , David J. Weber , Maria F. Gergen-Teague and William A. Rutala	American Journal of Infection Control, Volume 32, Issue 2, April 2004, Pages 69-83
Sickbert-Bennett 2005a	Comparative efficacy of hand hygiene agents in the reduction of bacteria and viruses	Emily E. Sickbert-Bennett, David J. Weber, Maria F. Gergen-Teague, Mark D. Sobsey, Gregory P. Samsa and William A. Rutala	American Journal of Infection Control, Volume 33, Issue 2, March 2005, Pages 67-77
Sickbert-Bennett 2005b	The benefits of surface disinfection Reply	Emily E. Sickbert-Bennett, David J. Weber, Gregory P. Samsa and William A.Rutala	American Journal of Infection Control, Volume 33, Issue 7, September 2005, Pages 436-438
Siddique 1991	1988 floods in Bangladesh: pattern of illness and causes of death	Siddique AK, Baqui AH, Eusof A, Zaman K. International Centre for Diarrhoeal Disease Research, Bangladesh.	J Diarrhoeal Dis Res. 1991 Dec;9(4):310-4
Snyder 1997	The microbiology of cleaning and sanitizing a cutting board	Snyder, OP	Hospitality Institute of Technology and Management 1997

Reference	Title	Author	Citation
Snyder 1999	The reduction of E Coli on various countertop surfaces	Snyder, OP	Hospitality Institute of Technology and Management Mar 22, 1999
Soljour 2004	Efficacy of egg cleaning compounds on eggshells contaminated with Salmonella enterica serovar Enteritidis	Soljour G, Assanta MA, Messier S, Boulianne M.	J Food Prot. 2004 Apr;67(4):706-12.
Solomon 2006	Airborne Mold and Endotoxin Concentrations in New Orleans, Louisiana, after Flooding, October through November 2005	Solomon, Gina M., Mervi Hjelmroos-Koski, Miriam Rotkin-Ellman, S. katharine Hammond	Environmental Health Perspectives: vol 114, number9, September 2006
Somers 2004	Efficacy of two cleaning and sanitizing combinations on Listeria monocytogenes biofilms formed at low temperature on a variety of materials in the presence of ready-to-eat meat residue	Somers EB, Wong AC.	J Food Prot. 2004 Oct;67(10):2218-29
Stier 2004	Clean Operations: Cleanliness is next to godliness	Stier R	Food Safety Magazine April 2004
Straub 1993	Hazards from pathogenic microorganisms in land disposed sewage sludge	Straub T, Pepper I, Gerba C	Curr Opin in Pediatrics 1993; 213-218
Suarez 2003	The effect of various disinfectants on detection of avian influenza virus by real time RT-PCR	Suarez DL, Spackman E, Senne DA, Bulaga L, Welsch AC, Froberg K. Southeast Poultry Research Laboratory, Agriculture Research Service, U.S. Department of Agriculture, 934 College Station Road, Athens, GA 30605, USA.	Avian Dis. 2003;47(3 Suppl):1091-5
Sullivent 2006	Nonfatal injuries following Hurricane Katrina--New Orleans, Louisiana, 2005.	Sullivent EE 3rd, West CA, Noe RS, Thomas KE, Wallace LJ, Leeb RT.	J Safety Res. 2006;37(2):213-7. Epub 2006 May 12.
Takatori 2001	The effect of house design and environment on fungal movement in homes of bronchial asthma patients	Takatori K, Saito A, Yasueda H, Akiyama K. Laboratory of Mycology, National Institute of Health Sciences, Tokyo, Japan. takatori@nihs.go.jp	Mycopathologia. 2001;152(1):41-9
Tanen 1999	Severe lung injury after exposure to chloramine gas from household cleaners	Tanen DA	New England Journal of Medicine
Tanyel 1988	Chlorine bleach ingestion in children: a review of 80 cases.	Tanyel FC, Buyukpamukcu N, Hicsonmez A.	Turk J Pediatr. 1988 Apr-Jun;30(2):105-8
Todd 2006	Infection Control and Hurricane Katrina	Todd B	Am J Nurs. 2006 Mar;106(3):29-31
Trachoo 2002	Effectiveness of chemical sanitizers against Campylobacter jejuni-containing biofilms.	Trachoo N, Frank JF. Center for Food Safety, Department of Food Science and Technology, University of Georgia, Athens 30602-2106, USA.	J Food Prot. 2002 Jul;65(7):1117-21.

Reference	Title	Author	Citation
Trevejo 1998	Epidemic leptospirosis associated with pulmonary hemorrhage-Nicaragua, 1995	Trevejo RT, Rigau-Perez JG, Ashford DA, McClure EM, Jarquin-Gonzalez C, Amador JJ, de los Reyes JO, Gonzalez A, Zaki SR, Shieh WJ, McLean RG, Nasci RS, Weyant RS, Bolin CA, Bragg SL, Perkins BA, Spiegel RA. Centers for Disease Control, Epidemiology Program Office, Managua, Nicaragua. rtrevejo@sonoma-county.org	J Infect Dis. 1998 Nov;178(5):1457-63
Twum-Danso 2002	Disaster epidemiology: prudent public health practice in the Pacific Islands.	Twum-Danso NY.	Pac Health Dialog. 2002 Mar;9(1):58-63.
Ukuku 2002	Behavior of Listeria monocytogenes inoculated on cantaloupe surfaces and efficacy of washing treatments to reduce transfer from rind to fresh-cut pieces.	Ukuku DO, Fett W.	J Food Prot. 2002 Jun;65(6):924-30.
Ukuku 2004a	Effect of hydrogen peroxide treatment on microbial quality and appearance of whole and fresh-cut melons contaminated with Salmonella spp.	Ukuku DO	Int J Food Microbiol. 2004 Sep 1;95(2):137-46.
Ukuku 2004b	Method of applying sanitizers and sample preparation affects recovery of native microflora and Salmonella on whole cantaloupe surfaces.	Ukuku DO, Fett WF.	J Food Prot. 2004 May;67(5):999-1004.
Van Rhee 1990	Gastric stricture complicating oral ingestion of bleach	Van Rhee F, Beuamont DM	Br J Clin Pract 1990 Dec; 44(12): 681-682
Verran 2005	Factors affecting microbial adhesion to stainless steel and other materials used in medical devices	Verran J, Whitehead K.	Int J Artif Organs. 2005 Nov;28(11):1138-45.
Vesley 1970	A cooperative microbiological evaluation of floor-cleaning procedures in hospital patient rooms	Vesley D, Pryor AK, Walter WG, Shaffer JG	Health Lab Sci. 1970 Oct;7(4):256-64
Vesley 1987	Microbiological evaluation of wet and dry floor sanitization systems in hospital patient rooms.	Vesley D, Klapes NA, Benzow K, Le CT.	Appl Environ Microbiol. 1987 May;53(5):1042-5.
Wade 2004	Did a severe flood in the Midwest cause an increase in the incidence of gastrointestinal symptoms?	Wade TJ, Sandhu SK, Levy D, Lee S, LeChevallier MW, Katz L, Colford JM Jr.	Am J Epidemiol. 2004 Feb 15;159(4):398-405.
Ward 1988	Hypernatraemia and hyperchloraemic acidosis after bleach ingestion	Ward MJ, Routledge PA. Department of Pharmacology and Therapeutics, University of Wales College of Medicine, Llandough Hospital, South Glamorgan, UK	Hum Toxicol. 1988 Jan;7(1):37-8
Waring 2002	Rapid assessment of household needs in the Houston area after Tropical Storm Allison	Waring SC, Reynolds KM, D'Souza G, Arafat RR. University of Texas Health Sciences Center at Houston, School of Public Health, Houston, Texas 77225, USA	Disaster Manag Response. 2002 Sep;:3-9
Wason 1985	The emergency management of caustic ingestions	Wason S	J Emerg Med. 1985;2(3):175-82

Reference	Title	Author	Citation
Watson 2005	2004 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System	Watson WA, Litovitz TL, Rodgers GC, Klein-Schwartz W, Reid N, Youniss J, Flanagan A, Wruk KM	Am J Emerg Med. 2005 Sep;23(5):589-666
Weber 1999	The effect of blood on the antiviral activity of sodium hypochlorite, a phenolic, and a quaternary ammonium compound	Weber J, Barbee SL, Sobsey MD, Rutala WA	Infect Control Hosp Epidemiol. 1999 Dec;20(12):821-7
Weegels 2001	Variation in consumer contact with household products: a preliminary investigation	Weegels MF, van Veen MP	Risk Analysis 2001; vol 21, No 3
Weeks 1969	Esophageal injury by liquid chlorine bleach: experimental study	Weeks RS, Ravitch MM	J Pediatr. 1969 Jun;74(6):911-6
Weeks 1971	The pathology of experimental injury to the cat esophagus by liquid chlorine bleach	Weeks RS, Ravitch MM	Laryngoscope. 1971 Sep;81(9):1532-41.
White 2003	The effect of hand hygiene on illness rate among students in university residence halls.	White C, Kolble R, Carlson R, Lipson N, Dolan M, Ali Y, Cline M. University of Colorado, Boulder, Colorado, USA.	Am J Infect Control. 2003 Oct;31(6):364-70.
Wilson 2004	An investigation into techniques for cleaning mold-contaminated home contents	Wilson SC, Brasel TL, Carriker CG, Fortenberry GD, Fogle MR, Martin JM, Wu C, Andriychuk LA, Karunasena E, Straus DC. Center for Indoor Air Research, Department of Microbiology and Immunology, Texas Tech University Health Sciences Center, Lubbock, Texas 79430, USA. Stephen.Wilson@tthusc.edu	J Occup Environ Hyg. 2004 Jul;1(7):442-7
Wolkoff 1998	Risk in cleaning: chemical and physical exposure	Wolkoff P, Schneider T, Kildeso J, Degerth R, Jaroszewski M, Schunk H	the science of the total environment 1998; 215: 135-156
Yang 1997	Damp housing conditions and respiratory symptoms in primary school children	Yang CY, Chiu JF, Chiu HF, Kao WY. School of Public Health, Kaohsiung Medical College, Taiwan, R.O.C.	Pediatr Pulmonol. 1997 Aug;24(2):73-7
Zock 2001	Asthma risk. Cleaning activities and use of specific cleaning products among Spanish indoor cleaners	Zock J, Kogevinas M, Sunyer J, Almar E, Muniozguren N, Payo F, Sanchez JL, Anto JM,	Scan J Work Environ Health 2001, vol 27, no 1
Zottola 1994	Microbial biofilms in the food processing industry--should they be a concern?	Zottola EA, Sasahara KC.	Int J Food Microbiol. 1994 Oct;23(2):125-48