

Reference List: *Green Cleaning, Sanitizing, and Disinfecting: A Toolkit for Early Care and Education*

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Section 10: What is the most effective and safest way to clean body fluids and blood spills in ECE

1. Trasande, L. and Y. Liu, *Reducing the staggering costs of environmental disease in children, estimated at \$76.6 billion in 2008*. Health Aff (Millwood), 2011. **30**(5): p. 863-70.

A 2002 analysis documented \$54.9 billion in annual costs of environmentally mediated diseases in US children. However, few important changes in federal policy have been implemented to prevent exposures to toxic chemicals. We therefore updated and expanded the previous analysis and found that the costs of lead poisoning, prenatal methylmercury exposure, childhood cancer, asthma, intellectual disability, autism, and attention deficit hyperactivity disorder were \$76.6 billion in 2008. To prevent further increases in these costs, efforts are needed to institute premarket testing of new chemicals; conduct toxicity testing on chemicals already in use; reduce lead-based paint hazards; and curb mercury emissions from coal-fired power plants.

2. Landrigan, P.J. and L.R. Goldman, *Children's vulnerability to toxic chemicals: a challenge and opportunity to strengthen health and environmental policy*. Health Aff, 2011. **30**(5): p. 842-50.

A key policy breakthrough occurred nearly twenty years ago with the discovery that children are far more sensitive than adults to toxic chemicals in the environment. This finding led to the recognition that chemical exposures early in life are significant and preventable causes of disease in children and adults. We review this knowledge and recommend a new policy to regulate industrial and consumer chemicals that will protect the health of children and all Americans, prevent disease, and reduce health care costs. The linchpins of a new US chemical policy will be: first, a legally mandated requirement to test the toxicity of chemicals already in commerce, prioritizing chemicals in the widest use, and incorporating new assessment technologies; second, a tiered approach to premarket evaluation of new chemicals; and third, epidemiologic monitoring and focused health studies of exposed populations.

3. Barouki, R., et al., *Developmental origins of non-communicable disease: implications for research and public health*. Environ Health, 2012. **11**: p. 42.

This White Paper highlights the developmental period as a plastic phase, which allows the organism to adapt to changes in the environment to maintain or improve reproductive capability in part through sustained health. Plasticity is more prominent prenatally and during early postnatal life, i.e., during the time of cell differentiation and specific tissue formation. These developmental periods are highly sensitive to environmental factors, such as nutrients, environmental chemicals, drugs, infections and other stressors. Nutrient and toxicant effects share many of the same characteristics and reflect two sides of the same coin. In both cases, alterations in physiological functions can be induced and may lead to the development of non-communicable conditions. Many of the major diseases - and dysfunctions - that have increased

substantially in prevalence over the last 40 years seem to be related in part to developmental factors associated with either nutritional imbalance or exposures to environmental chemicals. The Developmental Origins of Health and Disease (DOHaD) concept provides significant insight into new strategies for research and disease prevention and is sufficiently robust and repeatable across species, including humans, to require a policy and public health response. This White Paper therefore concludes that, as early development (in utero and during the first years of postnatal life) is particularly sensitive to developmental disruption by nutritional factors or environmental chemical exposures, with potentially adverse consequences for health later in life, both research and disease prevention strategies should focus more on these vulnerable life stages.

4. Bartlett, E.S. and L. Trasande, *Economic impacts of environmentally attributable childhood health outcomes in the European Union*. Eur J Public Health, 2013.

BACKGROUND: There is increasing evidence of the role that exposure to industrial chemicals plays in the development of childhood disease. The USA and the European Union (EU) have taken divergent policy approaches to managing this issue, and economic estimates of disease costs attributable to environmental exposures in children are available in the USA but not the EU. We undertook the first economic evaluation of the impacts of childhood environmental chemical exposures in the EU. **METHODS:** We used a cost-of-illness approach to estimate health care system costs, and used environmentally attributable fraction modelling to estimate the proportion of childhood disease due to environmental exposures. We analysed data on exposures, disease prevalence and costs at a country level, and then aggregated costs across EU member states to estimate overall economic impacts within the EU. **RESULTS:** We found the combined environmentally attributable costs of lead exposure, methylmercury exposure, developmental disabilities, asthma and cancer to be \$70.9 billion in 2008 (range: \$58.9-\$90.6 billion). These costs amounted to approximately 0.480% of the gross domestic product of the EU in 2008. **CONCLUSIONS:** Childhood chemical exposures present a significant economic burden to the EU. Our study offers an important baseline of disease costs before the implementation of Registration, Evaluation and Authorization of Chemicals, which is important for studying the impacts of this policy regime.

5. Council on Environmental Health, *Chemical-management policy: prioritizing children's health*. Pediatrics, 2011. **127**(5): p. 983-90.

The American Academy of Pediatrics recommends that chemical-management policy in the United States be revised to protect children and pregnant women and to better protect other populations. The Toxic Substance Control Act (TSCA) was passed in 1976. It is widely recognized to have been ineffective in protecting children, pregnant women, and the general population from hazardous chemicals in the marketplace. It does not take into account the special vulnerabilities of children in attempting to protect the population from chemical hazards. Its processes are so cumbersome that in its more than 30 years of existence, the TSCA has been used to regulate only 5 chemicals or chemical classes of the tens of thousands of chemicals that are in commerce. Under the TSCA, chemical companies have no responsibility to perform premarket testing or postmarket follow-up of the products that they produce; in fact, the TSCA contains disincentives for the companies to produce such data. Voluntary programs have been inadequate in resolving problems. Therefore, chemical-management policy needs to be rewritten in the United States. Manufacturers must be responsible for developing information about chemicals before marketing. The US Environmental Protection Agency must have the authority to demand additional safety data about a chemical and to limit or stop the marketing

of a chemical when there is a high degree of suspicion that the chemical might be harmful to children, pregnant women, or other populations.

6. Landrigan, P.J., et al., *Environmental pollutants and disease in American children: estimates of morbidity, mortality, and costs for lead poisoning, asthma, cancer, and developmental disabilities*. Environ Health Perspect, 2002. **110**(7): p. 721-8.

In this study, we aimed to estimate the contribution of environmental pollutants to the incidence, prevalence, mortality, and costs of pediatric disease in American children. We examined four categories of illness: lead poisoning, asthma, cancer, and neurobehavioral disorders. To estimate the proportion of each attributable to toxins in the environment, we used an environmentally attributable fraction (EAF) model. EAFs for lead poisoning, asthma, and cancer were developed by panels of experts through a Delphi process, whereas that for neurobehavioral disorders was based on data from the National Academy of Sciences. We define environmental pollutants as toxic chemicals of human origin in air, food, water, and communities. To develop estimates of costs, we relied on data from the U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, National Center for Health Statistics, the Bureau of Labor Statistics, the Health Care Financing Agency, and the Practice Management Information Corporation. EAFs were judged to be 100% for lead poisoning, 30% for asthma (range, 10-35%), 5% for cancer (range, 2-10%), and 10% for neurobehavioral disorders (range, 5-20%). Total annual costs are estimated to be \$54.9 billion (range \$48.8-64.8 billion): \$43.4 billion for lead poisoning, \$2.0 billion for asthma, \$0.3 billion for childhood cancer, and \$9.2 billion for neurobehavioral disorders. This sum amounts to 2.8 percent of total U.S. health care costs. This estimate is likely low because it considers only four categories of illness, incorporates conservative assumptions, ignores costs of pain and suffering, and does not include late complications for which etiologic associations are poorly quantified. The costs of pediatric environmental disease are high, in contrast with the limited resources directed to research, tracking, and prevention.

7. Kramer, A., et al., *Maintaining health by balancing microbial exposure and prevention of infection: the hygiene hypothesis versus the hypothesis of early immune challenge*. J Hosp Infect, 2013. **83 Suppl 1**: p. S29-34.

The human immune system is inseparably bonded to an individual's personal micro-biome from birth to death. Since the beginning of life, commensal relationships have ensured the survival of micro- and macro-organisms within complex relationships. However, technological advances and altered lifestyle imposed new rules for this interaction during recent decades. It has been observed that reduced exposure to micro-organisms and parasites results in decreased morbidity and mortality, but is also associated with a rising prevalence of atopic disorders and autoimmune diseases, mostly in industrialized countries. This inverse relationship is described by the 'hygiene hypothesis', put forward in 1989, yet this term only imperfectly describes these observations, as excessive hygiene or hygienic measures may not directly be the central cause. The lack of appropriate immune stimulation during early childhood with the consequence of disturbed alignment in the sequence of encountering self- or non-self-antigens might account in the rise of atopy and autoimmune disease. For this reason we propose the term 'early immune challenge hypothesis'. This concept highlights the importance of immune priming in early life in the context of genetic, social, geographic, cultural, and economic background. Moreover, it emphasizes the central role of 'training' of regulatory T-cells through sufficient microbial exposure, leading to a robust, healthy balance between inflammation and anti-inflammation or immune tolerance. Insufficient exposure might result in abnormal immune regulatory

development. Finally, it incorporates the idea of encountering 'old friends' - organisms that shaped our immune system during human phylogeny. This article gives a comprehensive overview of the relationship between microbial exposure, and the incidence of asthma and hay fever is outlined. Although the outcomes of these studies originally were interpreted in the framework of the hygiene hypothesis, they may suit the concept of the hypothesis of early immune challenge even better. Moreover, recent studies have revealed that T or T imbalances in disease may be partially corrected by the administration of helminthic or bacterial extracts.

8. Gruber, C., et al., *History of respiratory infections in the first 12 yr among children from a birth cohort*. *Pediatr Allergy Immunol*, 2008. **19**(6): p. 505-12.

Respiratory infections are the most frequent health problem in childhood. There is little precise information on how many respiratory illness episodes can be expected in a normal child. This study was designed to create reference values for the frequency of respiratory infections as recordable by history. Respiratory illnesses were recorded in a prospective birth cohort of 1314 German children born in 1990 and tracked until age 12 yr (760 children). Parents recorded the child's illnesses in a diary and answered structured questions yearly up to age 12. Age of study subjects was categorized into infancy (0-2 yr), pre-school age (3-5 yr), and school age (6-12 yr). The mean cumulative number of respiratory infection episodes up to age 12 yr was 21.9 (s.d. 9.0) episodes. In infancy, the mean annual number was 3.4 (3.7) episodes; at pre-school age, 2.3 (2.6) episodes; and at school, age 1.1 (1.2) episodes. The mean cumulative time of episodes up to age 7 yr was 20.1 (15.2) wk. Forty-five percent of the infants in the upper episode incidence tertile continued to be in the upper tertile at school age. Based on a twofold standard deviation of the mean number, up to 11 respiratory infection episodes per year in infancy, 8 episodes per year at pre-school age, and 4 episodes per year at school age could be regarded as normal. Episodes within these reference values per se should not cause unwarranted concern or intervention because of suspected immunodeficiency.

9. Urayama, K.Y., et al., *Early life exposure to infections and risk of childhood acute lymphoblastic leukemia*. *Int J Cancer*, 2011. **128**(7): p. 1632-43.

Evidence from a growing number of studies indicates that exposure to common infections early in life may be protective against childhood acute lymphoblastic leukemia (ALL). We examined the relationship between three measures of early life exposure to infections-daycare attendance, birth order and common childhood infections in infancy-with the risk of ALL in non-Hispanic white and Hispanic children, two ethnicities that show sociodemographic differences. The analysis included 669 ALL cases (284 non-Hispanic whites and 385 Hispanics) and 977 controls (458 non-Hispanic whites and 519 Hispanics) ages 1-14 years enrolled in the Northern California Childhood Leukemia Study (NCCLS). When the three measures were evaluated separately, daycare attendance by the age of 6 months (odds ratio [OR] for each thousand child-hours of exposure = 0.90, 95% confidence interval [CI]: 0.82-1.00) and birth order (OR for having an older sibling = 0.68, 95% CI: 0.50-0.92) were associated with a reduced risk of ALL among non-Hispanic white children but not Hispanic children, whereas ear infection before age 6 months was protective in both ethnic groups. When the three measures were assessed simultaneously, the influence of daycare attendance (OR = 0.83, 95% CI: 0.73-0.94) and having an older sibling (OR = 0.59, 95% CI: 0.43-0.83) became stronger for non-Hispanic white children. In Hispanic children, a strong reduction in risk associated with ear infections persisted (OR = 0.45, 95% CI: 0.25-0.79). Evidence of a protective role for infection-related exposures early in life is supported by findings in both the non-Hispanic white and Hispanic populations within the NCCLS.

10. Cowling, B.J., et al., *Aerosol transmission is an important mode of influenza A virus spread*. Nat Commun, 2013. **4**.

11. Yezli, S. and J.A. Otter, *Does the discovery of biofilms on dry hospital environmental surfaces change the way we think about hospital disinfection?* Journal of Hospital Infection, 2012. **81**(4): p. 293-294.

12. Heijne, J.C., et al., *Enhanced hygiene measures and norovirus transmission during an outbreak*. Emerg Infect Dis, 2009. **15**(1): p. 24-30.

Control of norovirus outbreaks relies on enhanced hygiene measures, such as handwashing, surface cleaning, using disposable paper towels, and using separate toilets for sick and well persons. However, little is known about their effectiveness in limiting further spread of norovirus infections. We analyzed norovirus outbreaks in 7 camps at an international scouting jamboree in the Netherlands during 2004. Implementation of hygiene measures coincided with an 84.8% (95% predictive interval 81.2%-86.6%) reduction in reproduction number. This reduction was unexpectedly large but still below the reduction needed to contain a norovirus outbreak. Even more stringent control measures are required to break the chain of transmission of norovirus.

13. Roberts, J.W., et al., *Monitoring and reducing exposure of infants to pollutants in house dust*. Rev Environ Contam Toxicol, 2009. **201**: p. 1-39.

The health risks to babies from pollutants in house dust may be 100 times greater than for adults. The young ingest more dust and are up to ten times more vulnerable to such exposures. House dust is the main exposure source for infants to allergens, lead, and PBDEs, as well as a major source of exposure to pesticides, PAHs, Gram-negative bacteria, arsenic, cadmium, chromium, phthalates, phenols, and other EDCs, mutagens, and carcinogens. Median or upper percentile concentrations in house dust of lead and several pesticides and PAHs may exceed health-based standards in North America. Early contact with pollutants among the very young is associated with higher rates of chronic illness such as asthma, loss of intelligence, ADHD, and cancer in children and adults. The potential of infants, who live in areas with soil contaminated by automotive and industrial emissions, can be given more protection by improved home cleaning and hand washing. Babies who live in houses built before 1978 have a prospective need for protection against lead exposures; homes built before 1940 have even higher lead exposure risks. The concentration of pollutants in house dust may be 2-32 times higher than that found in the soil near a house. Reducing infant exposures, at this critical time in their development, may reduce lifetime health costs, improve early learning, and increase adult productivity. Some interventions show a very rapid payback. Two large studies provide evidence that home visits to reduce the exposure of children with poorly controlled asthma triggers may return more than 100% on investment in 1 yr in reduced health costs. The tools provided to families during home visits, designed to reduce dust exposures, included vacuum cleaners with dirt finders and HEPA filtration, allergy control bedding covers, high-quality door mats, and HEPA air filters. Infants receive their highest exposure to pollutants in dust at home, where they spend the most time, and where the family has the most mitigation control. Normal vacuum cleaning allows deep dust to build up in carpets where it can be brought to the surface and become airborne as a result of activity on the carpet. Vacuums with dirt finders allow families to use the three-spot test to monitor deep dust, which can reinforce good cleaning habits. Motivated families that receive

home visits from trained outreach workers can monitor and reduce dust exposures by 90% or more in 1 wk. The cost of such visits is low considering the reduction of risks achieved. Improved home cleaning is one of the first results observed among families who receive home visits from MHEs and CHWs. We believe that proven intervention methods can reduce the exposure of infants to pollutants in house dust, while recognizing that much remains to be learned about improving the effectiveness of such methods.

14. Sheffield, P., et al., *Fine particulate matter pollution linked to respiratory illness in infants and increased hospital costs*. Health Aff (Millwood), 2011. **30**(5): p. 871-8.

There has been little research to date on the linkages between air pollution and infectious respiratory illness in children, and the resulting health care costs. In this study we used data on air pollutants and national hospitalizations to study the relationship between fine particulate air pollution and health care charges and costs for the treatment of bronchiolitis, an acute viral infection of the lungs. We found that as the average exposure to fine particulate matter over the lifetime of an infant increased, so did costs for the child's health care. If the United States were to reduce levels of fine particulate matter to 7 percent below the current annual standard, the nation could save \$15 million annually in reduced health care costs from hospitalizations of children with bronchiolitis living in urban areas. These findings reinforce the need for ongoing efforts to reduce levels of air pollutants. They should trigger additional investigation to determine if the current standards for fine-particulate matter are sufficiently protective of children's health.

15. Jurewicz, J. and W. Hanke, *Exposure to phthalates: Reproductive outcome and children health. A review of epidemiological studies*. International Journal of Occupational Medicine and Environmental Health, 2011. **24**(2): p. 115-141.

Phthalates are a family of industrial chemicals that have been used for a variety of purposes. As the potential consequences of human exposure to phthalates have raised concerns in the general population, they have been studied in susceptible subjects such as pregnant women, infants and children. This article aims at evaluating the impact of exposure to phthalates on reproductive outcomes and children health by reviewing most recent published literature. Epidemiological studies focusing on exposure to phthalates and pregnancy outcome, genital development, semen quality, precocious puberty, thyroid function, respiratory symptoms and neurodevelopment in children for the last ten years were identified by a search of the PubMed, Medline, Ebsco, Agricola and Toxnet literature bases. The results from the presented studies suggest that there are strong and rather consistent indications that phthalates increase the risk of allergy and asthma and have an adverse impact on children's neurodevelopment reflected by quality of alertness among girls, decreased (less masculine) composite score in boys and attention deficit hyperactivity disorder. Results of few studies demonstrate negative associations between phthalate levels commonly experienced by the public and impaired sperm quality (concentration, morphology, motility). Phthalates negatively impact also on gestational age and head circumference; however, the results of the studies were not consistent. In all the reviewed studies, exposure to phthalates adversely affected the level of reproductive hormones (luteinizing hormone, free testosterone, sex hormone-binding globulin), anogenital distance and thyroid function. The urinary levels of phthalates were significantly higher in the pubertal gynecomastia group, in serum in girls with premature thelarche and in girls with precocious puberty. Epidemiological studies, in spite of their limitations, suggest that phthalates may affect reproductive outcome and children health. Considering the suggested health effects, more

epidemiologic data is urgently needed and, in the meantime, precautionary policies must be implemented.

16. Steinemann, A.C., et al., *Fragranced consumer products: Chemicals emitted, ingredients unlisted*. Environmental Impact Assessment Review, 2011. **31**(3): p. 328-333.

Fragranced consumer products are pervasive in society. Relatively little is known about the composition of these products, due to lack of prior study, complexity of formulations, and limitations and protections on ingredient disclosure in the U.S. We investigated volatile organic compounds (VOCs) emitted from 25 common fragranced consumer products—laundry products, personal care products, cleaning supplies, and air fresheners—using headspace analysis with gas chromatography/mass spectrometry (GC/MS). Our analysis found 133 different VOCs emitted from the 25 products, with an average of 17 VOCs per product. Of these 133 VOCs, 24 are classified as toxic or hazardous under U.S. federal laws, and each product emitted at least one of these compounds. For “green” products, emissions of these compounds were not significantly different from the other products. Of all VOCs identified across the products, only 1 was listed on any product label, and only 2 were listed on any material safety data sheet (MSDS). While virtually none of the chemicals identified were listed, this nonetheless accords with U.S. regulations, which do not require disclosure of all ingredients in a consumer product, or of any ingredients in a mixture called “fragrance.” Because the analysis focused on compounds emitted and listed, rather than exposures and effects, it makes no claims regarding possible risks from product use. Results of this study contribute to understanding emissions from common products, and their links with labeling and legislation.

17. Woodruff, T.J., A.R. Zota, and J.M. Schwartz, *Environmental chemicals in pregnant women in the United States: NHANES 2003-2004*. Environ Health Perspect, 2011. **119**(6): p. 878-85.

BACKGROUND: Exposure to chemicals during fetal development can increase the risk of adverse health effects, and while biomonitoring studies suggest pregnant women are exposed to chemicals, little is known about the extent of multiple chemical exposures among pregnant women in the United States. OBJECTIVE: We analyzed biomonitoring data from the National Health and Nutritional Examination Survey (NHANES) to characterize both individual and multiple chemical exposures in U.S. pregnant women. METHODS: We analyzed data for 163 chemical analytes in 12 chemical classes for subsamples of 268 pregnant women from NHANES 2003-2004, a nationally representative sample of the U.S. population. For each chemical analyte, we calculated descriptive statistics. We calculated the number of chemicals detected within the following chemical classes: polybrominated diphenyl ethers (PBDEs), perfluorinated compounds (PFCs), organochlorine pesticides, and phthalates and across multiple chemical classes. We compared chemical analyte concentrations for pregnant and nonpregnant women using least-squares geometric means, adjusting for demographic and physiological covariates. RESULTS: The percentage of pregnant women with detectable levels of an individual chemical ranged from 0 to 100%. Certain polychlorinated biphenyls, organochlorine pesticides, PFCs, phenols, PBDEs, phthalates, polycyclic aromatic hydrocarbons, and perchlorate were detected in 99-100% of pregnant women. The median number of detected chemicals by chemical class ranged from 4 of 12 PFCs to 9 of 13 phthalates. Across chemical classes, median number ranged from 8 of 17 chemical analytes to 50 of 71 chemical analytes. We found, generally, that levels in pregnant women were similar to or lower than levels in nonpregnant women; adjustment for covariates tended to increase levels in pregnant women compared with nonpregnant women. CONCLUSIONS: Pregnant women in the U.S. are exposed to multiple chemicals. Further efforts are warranted to understand sources of exposure and implications for policy making.

18. Baur, X., P. Bakehe, and H. Vellguth, *Bronchial asthma and COPD due to irritants in the workplace - an evidence-based approach*. *J Occup Med Toxicol*, 2012. **7**(1): p. 19.

ABSTRACT: BACKGROUND: Respiratory irritants represent a major cause of occupational obstructive airway diseases. We provide an overview of the evidence related to irritative agents causing occupational asthma or occupational COPD. METHODS: We searched MEDLINE via PubMed. Reference lists of relevant reviews were also screened. The SIGN grading system was used to rate the quality of each study. The modified RCGP three-star system was used to grade the body of evidence for each irritant agent regarding its causative role in either occupational asthma or occupational COPD. RESULTS: A total of 474 relevant papers were identified, covering 188 individual agents, professions or work-sites. The focus of most of the studies and the predominant diagnosis was occupational asthma, whereas occupational COPD arose only incidentally. The highest level assigned using the SIGN grading was 2+ (well-conducted systematic review, cohort or case-control study with a low risk of confounding or bias). According to the modified RCGP three-star grading, the strongest evidence of association with an individual agent, profession or work-site ("**") was found for 17 agents or work-sites, including benzene-1,2,4-tricarboxylic acid-1,2-anhydride, chlorine, platinum salt, isocyanates, cement dust, grain dust, animal farming, environmental tobacco smoke, welding fumes or construction work. Phthalic anhydride, glutaraldehyde, sulphur dioxide, cotton dust, cleaning agents, potrooms, farming (various), foundries were found to be moderately associated with occupational asthma or occupational COPD ("*+"). CONCLUSION: This study let us assume that irritant-induced occupational asthma and especially occupational COPD are considerably underreported. Defining the evidence of the many additional occupational irritants for causing airway disorders will be the subject of continued studies with implications for diagnostics and preventive measures.

19. Dodson, R.E., et al., *Endocrine Disruptors and Asthma-Associated Chemicals in Consumer Products*. *Environ Health Perspect*, 2012.

BACKGROUND: Laboratory and human studies raise concerns about endocrine disruption and asthma from exposure to chemicals in consumer products. Limited labeling or testing information is available to evaluate products as exposure sources. OBJECTIVES: We analytically quantified endocrine disruptors and asthma-related chemicals in a range of cosmetics, personal care products, cleaners, sunscreens, and vinyl products. We evaluated whether labels can be used to select products without these chemicals. METHODS: We selected 213 commercial products representing 50 product types. We tested 42 composited samples of high market-share products. We also tested 43 alternative products identified using criteria expected to minimize target compounds. Analytes included parabens, phthalates, bisphenol A, triclosan, ethanolamines, alkylphenols, fragrances, glycol ethers, cyclosiloxanes and UV filters. RESULTS: We detected 55 compounds, indicating a wide range of exposures from common products. Vinyl products contained >10% DEHP and could be an important source of DEHP in homes. In other products, the highest concentrations and numbers of detects were in the fragranced products perfume, air fresheners, and dryer sheets, and in sunscreens. Some products that did not contain the well-known EDC phthalates contained other less-studied phthalates (also EDCs), suggesting a substitution. Many detected chemicals were not listed on labels. CONCLUSIONS: Common products contain complex mixtures of EDCs and asthma-related compounds. Toxicological studies of these mixtures are needed to understand their biological activity. For epidemiology, findings raise cautions about potential confounding from co-occurring chemicals and misclassification due to variability in product composition. It

appears that consumers can avoid some target chemicals—synthetic fragrances, BPA, and regulated active ingredients—using purchasing criteria. More complete labeling would enable consumers to avoid the rest.

20. Ghosh, R.E., et al., *Asthma and occupation in the 1958 birth cohort*. Thorax, 2013. **68**(4): p. 365-71.

OBJECTIVE: To examine the association of adult onset asthma with lifetime exposure to occupations and occupational exposures. **METHODS:** We generated lifetime occupational histories for 9488 members of the British 1958 birth cohort up to age 42 years. Blind to asthma status, jobs were coded to the International Standard Classification of Occupations 1988 and an Asthma Specific Job Exposure Matrix (ASJEM) with an expert re-evaluation step. Associations of jobs and ASJEM exposures with adult onset asthma were assessed in logistic regression models adjusting for sex, smoking, social class at birth and childhood hay fever. **RESULTS:** Of the 7406 cohort members with no asthma or wheezy bronchitis in childhood, 639 (9%) reported asthma by age 42 years. Adult onset asthma was associated with 18 occupations, many previously identified as risks for asthma (eg, farmers: OR 4.26, 95% CI 2.06 to 8.80; hairdressers: OR 1.88, 95% CI 1.24 to 2.85; printing workers: OR 3.04, 95% CI 1.49 to 6.18). Four were cleaning occupations and a further three occupations were likely to use cleaning agents. Adult onset asthma was associated with five of the 18 high-risk specific ASJEM exposures (flour exposure: OR 2.12, 95% CI 1.17 to 3.85; enzyme exposure: OR 2.32, 95% CI 1.22 to 4.42; cleaning/disinfecting products: OR 1.67, 95% CI 1.26 to 2.22; metal and metal fumes: OR 1.45, 95% CI 1.02 to 2.07; textile production: OR 1.71, 95% CI 1.12 to 2.61). Approximately 16% (95% CI 3.8% to 27.1%) of adult onset asthma was associated with known asthmagenic occupational exposures. **CONCLUSIONS:** This study suggests that about 16% of adult onset asthma in British adults born in the late 1950s could be due to occupational exposures, mainly recognised high-risk exposures.

21. Gonzalez, M., et al., *Asthma among workers in healthcare settings: role of disinfection with quaternary ammonium compounds*. Clin Exp Allergy, 2013.

INTRODUCTION: An increased incidence of asthma has been reported among healthcare workers. The role of quaternary ammonium compounds (QACs), commonly used in cleaning/disinfection products, has not been clearly defined. The aim of this study was to analyze associations between asthma and occupational exposure to disinfectants, especially QACs. **METHODS:** The study was performed on a stratified random sample of the various healthcare departments of 7 healthcare settings. The study included: questionnaire, physical examination and specific IgE assays. Occupational exposure assessment was performed by means of a work questionnaire, workplace studies and a review of products ingredients. Data were analyzed by logistic regression. **RESULTS:** response rate was 77%; 543 workers (89% female) participated; 37.1% were registered nurses (RNs), 16.4% auxiliary nurses (ANs), 17.3% cleaners; 32.8% were atopic. 335 participants were exposed to QACs. Nursing professionals reported a significantly higher risk of reported physician-diagnosed asthma and, for RNs, of nasal symptoms at work than administrative staff working in healthcare sector. This risk was particularly marked during disinfection tasks and when exposure to QACs. Exposure to QACs increased significantly the risk of reported physician diagnosed asthma and nasal symptoms at work (adjusted OR = 7.5 and 3.2 respectively). No significant association was found with other exposures such as latex glove use, chlorinated products / bleach or glutaraldehyde. **CONCLUSION:** RNs and ANs presented a higher risk of reported asthma than administrative staff. The highest risk was associated with tasks involving dilution of disinfection products by manual mixing, suggesting possible exposure to repeated peaks of concentrated products known to be

strong respiratory irritants. Workplace interventions should be conducted in order to more clearly determine QAC exposure and improve disinfection procedures. This article is protected by copyright. All rights reserved.

22. Vandenplas, O., et al., *Asthma related to cleaning agents: a clinical insight*. *BMJ Open*, 2013. **3**(9): p. e003568.

OBJECTIVE: To determine the agents causing asthmatic reactions during specific inhalation challenges (SICs) in workers with cleaning-related asthma symptoms and to assess the pattern of bronchial responses in order to identify the mechanisms involved in cleaning-related asthma. **DESIGN:** A retrospective case series analysis. **SETTING:** The study included all participants who completed an SIC procedure with the cleaning/disinfection products suspected of causing work-related asthma over the period 1992-2011 in a tertiary centre, which is the single specialised centre of the French-speaking part of Belgium where all participants with work-related asthma are referred to for SIC. **RESULTS:** The review identified 44 participants who completed an SIC with cleaning/disinfection agents. Challenge exposure to the suspected cleaning agents elicited a $\geq 20\%$ fall in forced expiratory volume in 1 s (FEV1) in 17 (39%) participants. The cleaning products that induced a positive SIC contained quaternary ammonium compounds (n=10), glutaraldehyde (n=3), both of these agents (n=1) and ethanalamines (n=2). Positive SICs were associated with a significant decrease in the median (IQR) value of the provocative concentration of histamine causing a 20% fall in FEV1 (PC20) from 1.4 (0.2-4.2) mg/mL at baseline to 0.5 (0.4-3.0) mg/mL after the challenge and a significant increase in sputum eosinophils from 1.8 (0.8-7.2)% at baseline to 10.0 (4.1-15.9)% 7 h after the challenge exposure while these parameters did not significantly change in participants with a negative SIC. Overall, 11 of 17 participants with positive SICs showed greater than threefold decrease in postchallenge histamine PC20 value, a $>2\%$ increase in sputum eosinophils, or both of these outcomes. **CONCLUSIONS:** These data indicate that a substantial proportion of workers who experience asthma symptoms related to cleaning materials show a pattern of bronchial reaction consistent with sensitiser-induced occupational asthma. The results also suggest that quaternary ammonium compounds are the principal cause of sensitiser-induced occupational asthma among cleaners.

23. Vizcaya, D., et al., *Functional and biological characteristics of asthma in cleaning workers*. *Respir Med*, 2013.

OBJECTIVES: Cleaning workers have an increased risk of asthma but the underlying mechanisms are largely unknown. We studied functional and biological characteristics in asthmatic cleaners and compared these to healthy cleaners. **METHODS:** Forty-two cleaners with a history of asthma and/or recent respiratory symptoms and 53 symptom-free controls were identified. Fractional exhaled nitric oxide (FeNO) was measured and forced spirometry with reversibility testing was performed. Total IgE, pulmonary surfactant protein D and the 16 kDa Clara Cell secretory protein were measured in blood serum. Interleukins and other cytokines, growth factors, cysteinyl leukotrienes and 8-isoprostane were measured in exhaled breath condensate. Information on occupational and domestic use of cleaning products was obtained in an interview. Associations between asthma status, specific characteristics and the use of cleaning products were evaluated using multivariable linear and logistic regression analyses. **RESULTS:** Asthma was associated with an 8% (95% confidence interval (CI) 1-15%) lower postbronchodilator FEV1, a higher prevalence of atopy (42% vs. 10%) and a 2.9 (CI 1.5-5.6) times higher level of total IgE. Asthma status was not associated with the other respiratory biomarkers. Most irritant products and sprays were more often used by asthmatic cleaners. The use of multiuse products, glass cleaners and

polishes at work was associated with higher FeNO, particularly in controls. CONCLUSIONS: Asthma in cleaning workers is characterised by non-reversible lung function decrement and increased total IgE. Oxidative stress, altered lung permeability and eosinophilic inflammation are unlikely to play an important underlying role, although the latter may be affected by certain irritant cleaning exposures.

24. Jacek, M.M., et al., *Work-related asthma in the Educational Services industry: California, Massachusetts, Michigan, and New Jersey, 1993-2000*. American Journal of Industrial Medicine, 2008. **51**(1): p. 47-59.

To characterize work-related asthma (WRA) cases working in the educational services industry identified by state-based occupational disease surveillance systems. We examined 2,995 WRA cases reported from 1993 to 2000 to four states: California, Massachusetts, Michigan, and New Jersey. A total of 265 (9%) WRA cases were employed in the educational services industry; 69% of cases were classified as new-onset asthma and 31% as work-aggravated asthma. New-onset asthma cases were further classified as occupational asthma (61%) or as reactive airways dysfunction syndrome (8%). The most frequently reported occupation was teachers and teachers' aides (54%). The most frequently reported agents were indoor air pollutants (28%), unspecified mold (16%), dusts (14%), and cleaning products (7%). Asthma within the educational services industry is an occupational health problem. The health of school employees should also be considered when initiatives addressing asthma among schoolchildren are instituted. The identification, elimination, and/or control of respiratory hazards are important factors for the protection of staff and students alike. Am. J. Ind. Med. 51:47-59, 2008. © 2007 Wiley-Liss, Inc.

25. Bello, A., et al., *Characterization of occupational exposures to cleaning products used for common cleaning tasks--a pilot study of hospital cleaners*. Environ Health, 2009. **8**: p. 11.

BACKGROUND: In recent years, cleaning has been identified as an occupational risk because of an increased incidence of reported respiratory effects, such as asthma and asthma-like symptoms among cleaning workers. Due to the lack of systematic occupational hygiene analyses and workplace exposure data, it is not clear which cleaning-related exposures induce or aggravate asthma and other respiratory effects. Currently, there is a need for systematic evaluation of cleaning products ingredients and their exposures in the workplace. The objectives of this work were to: a) identify cleaning products' ingredients of concern with respect to respiratory and skin irritation and sensitization; and b) assess the potential for inhalation and dermal exposures to these ingredients during common cleaning tasks. METHODS: We prioritized ingredients of concern in cleaning products commonly used in several hospitals in Massachusetts. Methods included workplace interviews, reviews of product Materials Safety Data Sheets and the scientific literature on adverse health effects to humans, reviews of physico-chemical properties of cleaning ingredients, and occupational hygiene observational analyses. Furthermore, the potential for exposure in the workplace was assessed by conducting qualitative assessment of airborne exposures and semi-quantitative assessment of dermal exposures. RESULTS: Cleaning products used for common cleaning tasks were mixtures of many chemicals, including respiratory and dermal irritants and sensitizers. Examples of ingredients of concern include quaternary ammonium compounds, 2-butoxyethanol, and ethanolamines. Cleaning workers are at risk of acute and chronic inhalation exposures to volatile organic compounds (VOC) vapors and aerosols generated from product spraying, and dermal exposures mostly through hands. CONCLUSION: Cleaning products are mixtures of many chemical ingredients that may impact workers' health through air and dermal exposures. Because cleaning exposures are a function of product formulations and product application procedures,

a combination of product evaluation with workplace exposure assessment is critical in developing strategies for protecting workers from cleaning hazards. Our task based assessment methods allowed classification of tasks in different exposure categories, a strategy that can be employed by epidemiological investigations related to cleaning. The methods presented here can be used by occupational and environmental health practitioners to identify intervention strategies.

26. Dassonville, C., et al., *Assessment and predictor determination of indoor aldehyde levels in Paris newborn babies' homes*. *Indoor Air*, 2009. **19**(4): p. 314-23.

Exposure to indoor chemical air pollutants expected to be potentially involved in allergic respiratory diseases in infants is poorly documented. A specific environmental investigation included in a birth cohort study was carried out to first assess indoor airborne aldehyde levels, using passive devices and their variability within 1 year (1, 6, 9 and 12 months) in the bedroom of 196 Paris infants, and second, to identify predictors for aldehyde concentrations using interviewer administered questionnaires about housing factors. Comfort parameters and carbon dioxide levels were measured simultaneously. Aldehydes were detected in almost all dwellings and geometric mean levels (geometric standard deviation) at the first visit were respectively for formaldehyde, acetaldehyde, hexanal, and pentanal 19.4 (1.7) microg/m³, 8.9 (1.8) microg/m³, 25.3 (3.1) microg/m³, 3.7 (2.3) microg/m³, consistent with earlier published results. Generalized Estimating Equation multivariate analyses showed that, apart from comfort parameters, aeration and season, the main indoor aldehyde sources were either continuous (building materials and coverings especially when they were new) or discontinuous (smoking, use of air fresheners and cleaning products, DIY etc...). Finally, the data collected by questionnaires should be sufficient to enable us to classify each infant in our cohort study according to his/her degree of exposure to the main aldehydes. PRACTICAL IMPLICATIONS: This analysis contributed to document indoor aldehyde levels in Parisian homes and to identify factors determining these levels. In the major part of newborn babies' homes, indoor formaldehyde levels were above the guideline value of 10 microg/m³ proposed by the French Agency for Environmental and Occupational Health Safety for long-term exposure. Given this result, it is essential to study the health impact of exposure to aldehydes especially formaldehyde on the incidence of respiratory and allergic symptoms, particularly during the first months of life.

27. Zock, J.P., et al., *Domestic use of hypochlorite bleach, atopic sensitization, and respiratory symptoms in adults*. *Journal of Allergy and Clinical Immunology*, 2009. **124**(4): p. 731-738.

Background: Professional use of hypochlorite (bleach) has been associated with respiratory symptoms. Bleach is capable of inactivating allergens, and there are indications that its domestic use may reduce the risk of allergies in children. Objective: To study the associations between household use of bleach and atopic sensitization, allergic diseases, and respiratory health status in adults. Methods: We identified 3626 participants of the European Community Respiratory Health Survey 11 in 10 countries who did the cleaning in their homes and for whom data on specific serum IgE to 4 environmental allergens were available. Frequency of bleach use and information on respiratory symptoms were obtained in face-to-face interviews. House dust mite and cat allergens in mattress dust were measured in a subsample. Associations between the frequency of bleach use and health outcomes were evaluated by using multivariable mixed logistic regression analyses. Results: The use of bleach was associated with less atopic sensitization (odds ratio [OR], 0.75; 95% CI, 0.63-0.89). This association was apparent for specific IgE to both indoor (cat) and outdoor (grass) allergens, and was consistent in various subgroups,

including those without any history of respiratory problems (OR, 0.85). Dose-response relationships ($P < .05$) were apparent for the frequency of bleach use and sensitization rates. Lower respiratory tract symptoms, but not allergic symptoms, were more prevalent among those using bleach 4 or more days per week (OR, 1.24-1.49). The use of bleach was not associated with indoor allergen concentrations. Conclusion: People who clean their homes with hypochlorite bleach are less likely to be atopic but more likely to have respiratory symptoms. (J Allergy Clin Immunol 2009;124:7318.)

28. Hahn, S., et al., *Consumer exposure to biocides--identification of relevant sources and evaluation of possible health effects*. Environ Health, 2010. **9**: p. 7.

BACKGROUND: Products containing biocides are used for a variety of purposes in the home environment. To assess potential health risks, data on products containing biocides were gathered by means of a market survey, exposures were estimated using a worst case scenario approach (screening), the hazard of the active components were evaluated, and a preliminary risk assessment was conducted. **METHODS:** Information on biocide-containing products was collected by on-site research, by an internet inquiry as well as research into databases and lists of active substances. Twenty active substances were selected for detailed investigation. The products containing these substances were subsequently classified by range of application; typical concentrations were derived. Potential exposures were then estimated using a worst case scenario approach according to the European Commission's Technical Guidance Document on Risk Assessment. Relevant combinations of scenarios and active substances were identified. The toxicological data for these substances were compiled in substance dossiers. For estimating risks, the margins of exposure (MOEs) were determined. **RESULTS:** Numerous consumer products were found to contain biocides. However, it appeared that only a limited number of biocidal active substances or groups of biocidal active substances were being used. The lowest MOEs for dermal exposure or exposure by inhalation were obtained for the following scenarios and biocides: indoor pest control using sprays, stickers or evaporators (chlorpyrifos, dichlorvos) and spraying of disinfectants as well as cleaning of surfaces with concentrates (hydrogen peroxide, formaldehyde, glutardialdehyde). The risk from aggregate exposure to individual biocides via different exposure scenarios was higher than the highest single exposure on average by a factor of three. From the 20 biocides assessed 10 had skin-sensitizing properties. The biocides isothiazolinone (mixture of 5-chloro-2-methyl-2H-isothiazolin-3-one and 2-methyl-2H-isothiazolin-3-one, CMI/MI), glutardialdehyde, formaldehyde and chloroacetamide may be present in household products in concentrations which have induced sensitization in experimental studies. **CONCLUSIONS:** Exposure to biocides from household products may contribute to induction of sensitization in the population. The use of biocides in consumer products should be carefully evaluated. Detailed risk assessments will become available within the framework of the EU Biocides Directive.

29. Zock, J., D. Vizcaya, and N. Le Moual, *Update on asthma and cleaners*. Current Opinion in Allergy & Clinical Immunology, 2010. **10**(2): p. 114-120.

Purpose of review: The present study summarizes the recent literature on the relation between cleaning exposures and respiratory health, in particular asthma, including reviews, epidemiological surveys, surveillance programmes and exposure studies. The authors also aimed to identify gaps in the current knowledge and to recommend future research on the topic., **Recent findings:** A large international general population study showed an increased risk of new-onset asthma associated with cleaning work, with professional use of cleaning products and with domestic use of cleaning sprays. Three surveillance studies confirm the recognition of

occupational asthma cases among cleaners and among others who use cleaning products at work. Six workforce-based studies show that respiratory symptoms are partly work-related, and are associated with certain specific exposures including sprays, chlorine bleach and other disinfectants., Summary: Recent studies have strengthened the evidence of asthma and other adverse respiratory effects in cleaning workers. Similar effects are seen in other settings in which cleaning products are used such as healthcare professionals and homemakers. Both new-onset asthma and work-exacerbated asthma due to cleaning exposures may play a role. Exposure to cleaning sprays, chlorine bleach and other disinfectants may be particularly relevant. The predominant effect mechanisms remain largely unclear and may include both specific sensitization and irritant-related features., (C) 2010 Lippincott Williams & Wilkins, Inc.

30. De Coster, S. and N. van Larebeke, *Endocrine-disrupting chemicals: associated disorders and mechanisms of action*. J Environ Public Health, 2012. **2012**: p. 713696.

The incidence and/or prevalence of health problems associated with endocrine-disruption have increased. Many chemicals have endocrine-disrupting properties, including bisphenol A, some organochlorines, polybrominated flame retardants, perfluorinated substances, alkylphenols, phthalates, pesticides, polycyclic aromatic hydrocarbons, alkylphenols, solvents, and some household products including some cleaning products, air fresheners, hair dyes, cosmetics, and sunscreens. Even some metals were shown to have endocrine-disrupting properties. Many observations suggesting that endocrine disruptors do contribute to cancer, diabetes, obesity, the metabolic syndrome, and infertility are listed in this paper. An overview is presented of mechanisms contributing to endocrine disruption. Endocrine disruptors can act through classical nuclear receptors, but also through estrogen-related receptors, membrane-bound estrogen-receptors, and interaction with targets in the cytosol resulting in activation of the Src/Ras/Erk pathway or modulation of nitric oxide. In addition, changes in metabolism of endogenous hormones, cross-talk between genomic and nongenomic pathways, cross talk with estrogen receptors after binding on other receptors, interference with feedback regulation and neuroendocrine cells, changes in DNA methylation or histone modifications, and genomic instability by interference with the spindle figure can play a role. Also it was found that effects of receptor activation can differ in function of the ligand.

31. Bernard, A., et al., *Impact of chlorinated swimming pool attendance on the respiratory health of adolescents*. Pediatrics, 2009. **124**(4): p. 1110-8.

OBJECTIVE: The goal was to estimate the burden of allergic diseases associated with chlorinated pool exposure among adolescents. METHODS: We examined 847 students, 13 to 18 years of age, who had attended outdoor or indoor chlorinated pools at various rates. Of them, 114 had attended mainly a copper-silver pool and served as a reference group. We measured total and aeroallergen-specific immunoglobulin E (IgE) levels in serum and screened for exercise-induced bronchoconstriction. Outcomes were respiratory symptoms, hay fever, allergic rhinitis, and asthma that had been diagnosed at any time (ever asthma) or was being treated with medication and/or was associated with exercise-induced bronchoconstriction (current asthma). RESULTS: Among adolescents with atopy with serum IgE levels of >30 kIU/L or aeroallergen-specific IgE, the odds ratios (ORs) for asthma symptoms and for ever or current asthma increased with the lifetime number of hours spent in chlorinated pools, reaching values of 7.1 to 14.9 when chlorinated pool attendance exceeded 1000 hours. Adolescents with atopy with chlorinated pool attendance of >100 hours had greater risk of hay fever (OR: 3.3-6.6), and those with attendance of >1000 hours had greater risk of allergic rhinitis (OR: 2.2-3.5). Such associations were not found among adolescents without atopy or with copper-silver pool

attendance. The population attributable risks for chlorinated pool-related ever-diagnosed asthma, hay fever, and allergic rhinitis were 63.4%, 62.1%, and 35.0%, respectively.

CONCLUSION: Chlorinated pool exposure exerts an adjuvant effect on atopy that seems to contribute significantly to the burden of asthma and respiratory allergies among adolescents.

32. D'Alpaos, V., et al., *Inhalation challenges with occupational agents: threshold duration of exposure*. *Respir Med*, 2013. **107**(5): p. 739-44.

OBJECTIVES: The aim of this study was to characterize the threshold duration of exposure needed to elicit an asthmatic reaction during specific inhalation challenges (SIC) with various occupational agents and to determine the duration of exposure that should be completed before the test can be considered negative. METHODS: This retrospective study analysed the cumulative duration of challenge exposure that was required to elicit a $\geq 20\%$ fall in forced expiratory volume in one second in 335 consecutive subjects with a positive SIC. RESULTS: The threshold duration of challenge exposure required to induce an asthmatic reaction was ≤ 60 min in 179 (53%) subjects, between 61 and 120 min in 74 (22%) subjects, and longer than 120 min in 82 (25%) subjects. The multivariate linear regression analysis showed that a longer duration of exposure was associated with exposure to low-molecular-weight agents ($p < 0.001$), a higher level of baseline non-specific bronchial hyperresponsiveness to histamine ($p = 0.015$), increasing age ($p = 0.011$), and a shorter duration of asthma symptoms at work ($p = 0.060$). CONCLUSIONS: This study demonstrates that the sensitivity of SICs for diagnosing OA is highly dependent upon the duration of the challenge exposure. These data may provide useful guidance for improving the reliability of SICs performed with realistic methods of exposure.

33. Quirce, S. and P. Barranco, *Cleaning agents and asthma*. *J Investig Allergol Clin Immunol*, 2010. **20**(7): p. 542-50; quiz 2p following 550.

Although cleaners represent a significant part of the working population worldwide, they remain a relatively understudied occupational group. Epidemiological studies have shown an association between cleaning work and asthma, but the risk factors are uncertain. Cleaning workers are exposed to a large variety of cleaning products containing both irritants and sensitizers, as well as to common indoor allergens and pollutants. Thus, the onset or aggravation of asthma in this group could be related to an irritant-induced mechanism or to specific sensitization. The main sensitizers contained in cleaning products are disinfectants, quaternary ammonium compounds (such as benzalkonium chloride), amine compounds, and fragrances. The strongest airway irritants in cleaning products are bleach (sodium hypochlorite), hydrochloric acid, and alkaline agents (ammonia and sodium hydroxide), which are commonly mixed together. Exposure to the ingredients of cleaning products may give rise to both new-onset asthma, with or without a latency period, and work-exacerbated asthma. High-level exposure to irritants may induce reactive airways dysfunction syndrome. Cleaning workers may also have a greater relative risk of developing asthma due to prolonged low-to-moderate exposure to respiratory irritants. In addition, asthma-like symptoms without confirmed asthma are also common after exposure to cleaning agents. In many cleaners, airway symptoms induced by chemicals and odors cannot be explained by allergic or asthmatic reactions. These patients may have increased sensitivity to inhaled capsaicin, which is known to reflect sensory reactivity, and this condition is termed airway sensory hyperreactivity.

34. Fuentes-Leonarte, V., J.M. Tenias, and F. Ballester, *Levels of pollutants in indoor air and respiratory health in preschool children: A systematic review*. *Pediatr Pulmonol*, 2009. **44**(3): p. 231-43.

The aim of this paper is thus to identify, evaluate, and summarize in a systematic fashion all the epidemiological studies that have analyzed the association between exposure to specific indoor

air pollutants and respiratory disease among children under the age of five. A search was carried out in the main biomedical bibliographica sources in December 2006 and updated in February 2008. The study period covered 12 years (1996-2007). All the selected papers were carefully read. We focused on studies that analyzed at least one indicator of respiratory health and which included one or more indoor air pollutants in relation to the respiratory health of children under the age of 5. Studies that analyzed passive smoking as the sole source of indoor air pollution were not included. Fourteen studies were considered to be relevant. The most analyzed pollutant was nitrogen dioxide, followed by volatile organic compounds, airborne particulates and other pollutants; phthalates and CO₂. The literature reviewed within our criteria seems to indicate that several indoor pollutants, even at the moderate levels found in the developed countries, could be harmful to the respiratory health of very young children. Future research should focus on conducting more studies, preferably making use of cohorts, with adequate techniques for measuring indoor pollution levels. *Pediatr Pulmonol.* 2009; 44:231-243. (c) 2009 Wiley-Liss, Inc.

35. Medina-Ramon, M., et al., *Asthma, chronic bronchitis, and exposure to irritant agents in occupational domestic cleaning: a nested case-control study.* *Occupational & Environmental Medicine*, 2005. **62**(9): p. 598-606.

Background: Women employed in domestic cleaning are at increased risk for symptoms of obstructive lung disease, but the agents responsible are unknown., Aims: To investigate common tasks and products in occupational domestic cleaning in relation to respiratory morbidity., Methods: Case-control study in domestic cleaning women nested within a large population based survey of women aged 30-65 years; 160 domestic cleaning women with asthma symptoms, chronic bronchitis symptoms, or both and 386 without a history of respiratory symptoms were identified. Detailed exposures were evaluated for 40 cases who reported still having symptoms at the recruitment interview, and 155 controls who reported not having symptoms. All tasks performed and products used when cleaning houses were determined in a face-to-face interview. Lung function, methacholine challenge, and serum IgE testing were performed. Personal exposure measurements of airborne chlorine and ammonia were performed in a subsample. Associations between asthma, chronic bronchitis, and cleaning exposures were evaluated using multiple logistic regression analysis., Results: Airborne chlorine (median level 0-0.4 ppm) and ammonia (0.6-6.4 ppm) were detectable during occupational domestic cleaning activities. Cases used bleach more frequently than controls; adjusted odds ratio (OR) for intermediate exposure was 3.3 (95% CI 0.9 to 11) and for high exposure 4.9 (1.5 to 15). Other independent associations included accidental inhalation of vapours and gases from cleaning agents and washing dishes. These associations were more pronounced for cases with asthma symptoms than for those with symptoms of chronic bronchitis, but were not related to sensitisation to common allergens., Conclusions: Asthma symptoms in domestic cleaning women are associated with exposure to bleach and possibly other irritant agents. The public health impact of the use of irritant cleaning products could be widespread since the use of these products is common both in the workplace and at home., (C) 2005 BMJ Publishing Group Ltd

36. Medina-Ramon, M., et al., *Short-term respiratory effects of cleaning exposures in female domestic cleaners.* *Eur Respir J*, 2006. **27**(6): p. 1196-203.

Symptoms of obstructive lung disease in domestic cleaners have been related to the use of bleach and other irritant cleaning products. The short-term effects of cleaning exposures on respiratory symptoms and peak expiratory flow (PEF) were investigated in domestic cleaners with respiratory disorders. In a panel study, 43 female domestic cleaners with a recent history of

asthma and/or chronic bronchitis completed a 2-week diary, collecting information on respiratory symptoms, PEF and cleaning exposures. Mixed regression models were used to assess daily changes in symptoms and PEF associated with specific cleaning exposures. The probability of having work-related asthma was individually assessed by a computerised diagnostic system and an occupational asthma expert. Lower respiratory tract symptoms were more common on working days and were predominantly associated with exposure to diluted bleach, degreasing sprays/atomisers and air fresheners. Associations with upper respiratory tract symptoms and PEF were less apparent. Eleven (30%) subjects scored positively for work-related asthma. It is concluded that exposure to certain irritant cleaning products aggravates lower respiratory tract symptoms in female domestic cleaners with asthma or chronic bronchitis.

37. Bornehag, C.G., et al., *The association between asthma and allergic symptoms in children and phthalates in house dust: a nested case-control study*. *Environ Health Perspect*, 2004. **112**(14): p. 1393-7.

Global phthalate ester production has increased from very low levels at the end of World War II to approximately 3.5 million metric tons/year. The aim of the present study was to investigate potential associations between persistent allergic symptoms in children, which have increased markedly in developed countries over the past three decades, and the concentration of phthalates in dust collected from their homes. This investigation is a case-control study nested within a cohort of 10,852 children. From the cohort, we selected 198 cases with persistent allergic symptoms and 202 controls without allergic symptoms. A clinical and a technical team investigated each child and her or his environment. We found higher median concentrations of butyl benzyl phthalate (BBzP) in dust among cases than among controls (0.15 vs. 0.12 mg/g dust). Analyzing the case group by symptoms showed that BBzP was associated with rhinitis ($p = 0.001$) and eczema ($p = 0.001$), whereas di(2-ethylhexyl) phthalate (DEHP) was associated with asthma ($p = 0.022$). Furthermore, dose-response relationships for these associations are supported by trend analyses. This study shows that phthalates, within the range of what is normally found in indoor environments, are associated with allergic symptoms in children. We believe that the different associations of symptoms for the three major phthalates-BBzP, DEHP, and di-n-butyl phthalate-can be explained by a combination of chemical physical properties and toxicologic potential. Given the phthalate exposures of children worldwide, the results from this study of Swedish children have global implications.

38. Choi, H., et al., *Common household chemicals and the allergy risks in pre-school age children*. *PLoS One*. **5**(10): p. e13423.

BACKGROUND: The risk of indoor exposure to volatile organic compounds (VOCs) on allergic airway diseases in children remains unknown. **OBJECTIVE:** We examined the residential concentrations of VOCs, emitted from building materials, paints, furniture, and other lifestyle practices and the risks of multiple allergic diseases as well as the IgE-sensitization in pre-school age children in Sweden. **METHODS:** In a case-control investigation (198 case children with asthma and allergy and 202 healthy controls), air samples were collected in the room where the child slept. The air samples were analyzed for the levels of eight classes of VOCs. **RESULTS:** A natural-log unit of summed propylene glycol and glycol ethers (PGEs) in bedroom air (equal to interquartile range, or 3.43 - 15.65 microg/m³) was associated with 1.5-fold greater likelihood of being a case (95% CI, 1.1 - 2.1), 1.5-fold greater likelihood of asthma (95% CI, 1.0 - 2.3), 2.8-fold greater likelihood of rhinitis (95% CI, 1.6 - 4.7), and 1.6-fold greater likelihood of eczema (95% CI, 1.1 - 2.3), accounting for gender, secondhand smoke, allergies in both parents, wet

cleaning with chemical agents, construction period of the building, limonene, cat and dog allergens, butyl benzyl phthalate (BBzP), and di(2-ethylhexyl)phthalate (DEHP). When the analysis was restricted to the cases, the same unit concentration was associated with 1.8-fold greater likelihood of IgE-sensitization (95% CI, 1.1 - 2.8) compared to the non-IgE sensitized cases. No similar associations were found for the other classes of VOCs. CONCLUSION: We propose a novel hypothesis that PGEs in indoor air exacerbate and/or induce the multiple allergic symptoms, asthma, rhinitis and eczema, as well as IgE sensitization respectively.

39. Carson, R.T., et al., *Use of antibacterial consumer products containing quaternary ammonium compounds and drug resistance in the community*. J Antimicrob Chemother, 2008. **62**(5): p. 1160-2.
40. California Environmental Protection Agency/Air Resources Board, *Air pollution and contaminants at child-care and preschool facilities in California*, California Environmental Protection Agency/Air Resources Board, Editor 2012.
41. Engel, S.M., et al., *Prenatal Phthalate Exposure is Associated with Childhood Behavior and Executive Functioning*. Environ Health Perspect.

Background: Experimental and observational studies have reported biological consequences of phthalate exposure relevant to neurodevelopment. Objective: To examine the association of prenatal phthalate exposure with offspring behavior and executive functioning at ages 4 to 9 years. Methods: The Mount Sinai Children's Environmental Health Study enrolled a multiethnic prenatal population in New York City between 1998 and 2002 (n= 404). Third trimester maternal urines were collected and analyzed for phthalate metabolites. Children (n = 188, n = 365 visits) were assessed for cognitive and behavioral development between the ages of 4 and 9 years. Results: In multivariate adjusted models, increased loge concentrations of low molecular weight (LMW) phthalate metabolites were associated with poorer scores on the Aggression (beta = 1.24, 95% Confidence Interval [CI] 0.15, 2.34), Conduct Problems (beta = 2.40, 95% CI 1.34, 3.46), Attention Problems (beta = 1.29, 95% CI 0.16, 2.41), and Depression (beta = 1.18, 95% CI 0.11, 2.24) clinical scales; and Externalizing Problems (beta = 1.75, 95% CI 0.61, 2.88) and Behavioral Symptom Index (beta = 1.55, 95% CI 0.39, 2.71) composite scales. Increased loge concentrations of LMW phthalates were also associated with poorer scores on the Global Executive Composite index (beta = 1.23, 95% CI 0.09, 2.36), and the Emotional Control scale (beta = 1.33, 95% CI 0.18, 2.49). Conclusion: Behavioral domains adversely associated with prenatal exposure to LMW phthalates in our study are commonly found to be affected in children clinically diagnosed with Conduct or Attention-Deficit Hyperactivity Disorders.

42. Hegstad, K., et al., *Does the wide use of quaternary ammonium compounds enhance the selection and spread of antimicrobial resistance and thus threaten our health?* Microb Drug Resist, 2010. **16**(2): p. 91-104.

Quaternary ammonium compounds (QACs) are widely used biocides that possess antimicrobial effect against a broad range of microorganisms. These compounds are used for numerous industrial purposes, water treatment, antifungal treatment in horticulture, as well as in pharmaceutical and everyday consumer products as preserving agents, foam boosters, and detergents. Resistance toward QACs is widespread among a diverse range of microorganisms and is facilitated by several mechanisms such as modifications in the membrane composition, expression of stress response and repair systems, or expression of efflux pump genes.

Development of resistance in both pathogenic and nonpathogenic bacteria has been related to application in human medicine and the food industry. QACs in cosmetic products will inevitably come into intimate contact with the skin or mucosal linings in the mouth and thus are likely to add to the selection pressure toward more QAC-resistant microorganisms among the skin or mouth flora. There is increasing evidence of coresistance and cross-resistance between QACs and a range of other clinically important antibiotics and disinfectants. Use of QACs may have driven the fixation and spread of certain resistance cassette collectors (class 1 integrons), currently responsible for a major part of antimicrobial resistance in gram-negative bacteria. More indiscriminate use of QACs such as in cosmetic products may drive the selection of further new genetic elements that will aid in the persistence and spread of antimicrobial resistance and thus in limiting our treatment options for microbial infections.

43. Soumet, C., et al., *Resistance to phenicol compounds following adaptation to quaternary ammonium compounds in Escherichia coli*. *Vet Microbiol*, 2012. **158**(1-2): p. 147-52.

Bacterial adaptation to quaternary ammonium compounds (QACs) is mainly documented for benzalkonium chloride (BC) and few data are available for other QACs. The aim of this study was to assess the effects of repeated exposure to different quaternary ammonium compounds (QACs) on the susceptibility and/or resistance of bacteria to other QACs and antibiotics. *Escherichia coli* strains (n=10) were adapted by daily exposure to increasingly sub-inhibitory concentrations of a QAC for 7 days. Three QACs were studied. Following adaptation, we found similar levels of reduction in susceptibility to QACs with a mean 3-fold increase in the minimum inhibitory concentration (MIC) compared to initial MIC values, whatever the QAC used during adaptation. No significant differences in antibiotic susceptibility were observed between the tested QACs. Antibiotic susceptibility was reduced from 3.5- to 7.5-fold for phenicol compounds, beta lactams, and quinolones. Increased MIC was associated with a shift in phenotype from susceptible to resistant for phenicol compounds (florfenicol and chloramphenicol) in 90% of *E. coli* strains. Regardless of the QAC used for adaptation, exposure to gradually increasing concentrations of this type of disinfectant results in reduced susceptibility to QACs and antibiotics as well as cross-resistance to phenicol compounds in *E. coli* strains. Extensive use of QACs at sub-inhibitory concentrations may lead to the emergence of antibiotic-resistant bacteria and may represent a public health risk.

44. Nazaroff, W.W. and C.J. Weschler, *Cleaning products and air fresheners: exposure to primary and secondary air pollutants*. *Atmospheric Environment*, 2004. **38**(18): p. 2841-2865.

Building occupants, including cleaning personnel, are exposed to a wide variety of airborne chemicals when cleaning agents and air fresheners are used in buildings. Certain of these chemicals are listed by the state of California as toxic air contaminants (TACs) and a subset of these are regulated by the US federal government as hazardous air pollutants (HAPs). California's Proposition 65 list of species recognized as carcinogens or reproductive toxicants also includes constituents of certain cleaning products and air fresheners. In addition, many cleaning agents and air fresheners contain chemicals that can react with other air contaminants to yield potentially harmful secondary products. For example, terpenes can react rapidly with ozone in indoor air generating many secondary pollutants, including TACs such as formaldehyde. Furthermore, ozone-terpene reactions produce the hydroxyl radical, which reacts rapidly with organics, leading to the formation of other potentially toxic air pollutants. Indoor reactive chemistry involving the nitrate radical and cleaning-product constituents is also of concern, since it produces organic nitrates as well as some of the same oxidation products generated by ozone and hydroxyl radicals. Few studies have directly addressed the indoor concentrations of

TACs that might result from primary emissions or secondary pollutant formation following the use of cleaning agents and air fresheners. In this paper, we combine direct empirical evidence with the basic principles of indoor pollutant behavior and with information from relevant studies, to analyze and critically assess air pollutant exposures resulting from the use of cleaning products and air fresheners. Attention is focused on compounds that are listed as HAPs, TACs or Proposition 65 carcinogens/reproductive toxicants and compounds that can readily react to generate secondary pollutants. The toxicity of many of these secondary pollutants has yet to be evaluated. The inhalation intake of airborne organic compounds from cleaning product use is estimated to be of the order of 10 mg d⁻¹ person⁻¹ in California. More than two dozen research articles present evidence of adverse health effects from inhalation exposure associated with cleaning or cleaning products. Exposure to primary and secondary pollutants depends on the complex interplay of many sets of factors and processes, including cleaning product composition, usage, building occupancy, emission dynamics, transport and mixing, building ventilation, sorptive interactions with building surfaces, and reactive chemistry. Current understanding is sufficient to describe the influence of these variables qualitatively in most cases and quantitatively in a few.

45. Singer, B.C., et al., *Cleaning products and air fresheners: emissions and resulting concentrations of glycol ethers and terpenoids*. *Indoor Air*, 2006. **16**(3): p. 179-91.

Experiments were conducted to quantify emissions and concentrations of glycol ethers and terpenoids from cleaning product and air freshener use in a 50-m³ room ventilated at approximately 0.5/h. Five cleaning products were applied full-strength (FS); three were additionally used in dilute solution. FS application of pine-oil cleaner (POC) yielded 1-h concentrations of 10-1300 microg/m³ for individual terpenoids, including alpha-terpinene (90-120), d-limonene (1000-1100), terpinolene (900-1300), and alpha-terpineol (260-700). One-hour concentrations of 2-butoxyethanol and/or d-limonene were 300-6000 microg/m³ after FS use of other products. During FS application including rinsing with sponge and wiping with towels, fractional emissions (mass volatilized/dispensed) of 2-butoxyethanol and d-limonene were 50-100% with towels retained, and approximately 25-50% when towels were removed after cleaning. Lower fractions (2-11%) resulted from dilute use. Fractional emissions of terpenes from FS use of POC were approximately 35-70% with towels retained, and 20-50% with towels removed. During floor cleaning with dilute solution of POC, 7-12% of dispensed terpenes were emitted. Terpene alcohols were emitted at lower fractions: 7-30% (FS, towels retained), 2-9% (FS, towels removed), and 2-5% (dilute). During air-freshener use, d-limonene, dihydromyrcenol, linalool, linalyl acetate, and beta-citronellol were emitted at 35-180 mg/day over 3 days while air concentrations averaged 30-160 microg/m³. PRACTICAL IMPLICATIONS: While effective cleaning can improve the healthfulness of indoor environments, this work shows that use of some consumer cleaning agents can yield high levels of volatile organic compounds, including glycol ethers--which are regulated toxic air contaminants--and terpenes that can react with ozone to form a variety of secondary pollutants including formaldehyde and ultrafine particles. Persons involved in cleaning, especially those who clean occupationally or often, might encounter excessive exposures to these pollutants owing to cleaning product emissions. Mitigation options include screening of product ingredients and increased ventilation during and after cleaning. Certain practices, such as the use of some products in dilute solution vs. full-strength and the prompt removal of cleaning supplies from occupied spaces, can reduce emissions and exposures to 2-butoxyethanol and other volatile constituents. Also, it may be prudent to limit use of products containing ozone-reactive constituents when indoor ozone

concentrations are elevated either because of high ambient ozone levels or because of the indoor use of ozone-generating equipment.

46. Schug, T.T., et al., *Endocrine disrupting chemicals and disease susceptibility*. J Steroid Biochem Mol Biol, 2011. **127**(3-5): p. 204-15.

Environmental chemicals have significant impacts on biological systems. Chemical exposures during early stages of development can disrupt normal patterns of development and thus dramatically alter disease susceptibility later in life. Endocrine disrupting chemicals (EDCs) interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, cardiovascular, metabolic and immune effects in humans. A wide range of substances, both natural and man-made, are thought to cause endocrine disruption, including pharmaceuticals, dioxin and dioxin-like compounds, polychlorinated biphenyls, DDT and other pesticides, and components of plastics such as bisphenol A (BPA) and phthalates. EDCs are found in many everyday products--including plastic bottles, metal food cans, detergents, flame retardants, food additives, toys, cosmetics, and pesticides. EDCs interfere with the synthesis, secretion, transport, activity, or elimination of natural hormones. This interference can block or mimic hormone action, causing a wide range of effects. This review focuses on the mechanisms and modes of action by which EDCs alter hormone signaling. It also includes brief overviews of select disease endpoints associated with endocrine disruption.

47. Virtanen, H.E. and A. Adamsson, *Cryptorchidism and endocrine disrupting chemicals*. Mol Cell Endocrinol, 2012. **355**(2): p. 208-20.

Prospective clinical studies have suggested that the rate of congenital cryptorchidism has increased since the 1950s. It has been hypothesized that this may be related to environmental factors. Testicular descent occurs in two phases controlled by Leydig cell-derived hormones insulin-like peptide 3 (INSL3) and testosterone. Disorders in fetal androgen production/action or suppression of Insl3 are mechanisms causing cryptorchidism in rodents. In humans, prenatal exposure to potent estrogen diethylstilbestrol (DES) has been associated with increased risk of cryptorchidism. In addition, epidemiological studies have suggested that exposure to pesticides may also be associated with cryptorchidism. Some case-control studies analyzing environmental chemical levels in maternal breast milk samples have reported associations between cryptorchidism and chemical levels. Furthermore, it has been suggested that exposure levels of some chemicals may be associated with infant reproductive hormone levels.

48. Arif, A.A. and G.L. Delclos, *Association between cleaning-related chemicals and work-related asthma and asthma symptoms among healthcare professionals*. Occup Environ Med, 2012. **69**(1): p. 35-40.

OBJECTIVES: Work-related asthma (WRA) is an important public health problem affecting one quarter of adults with asthma. Although cleaning substances are routinely used in hospitals, few studies have addressed their potential adverse respiratory health effects on healthcare professionals (HCPs). This study attempts to identify relationship between work-related exposure to cleaning-related chemicals and development of WRA among HCPs. **METHODS:** Of 5600 HCPs surveyed, 3650 responded to a validated questionnaire about their occupation, asthma diagnosis, variability of asthma symptoms at and away from work, and exposure to individual cleaning substances. Workplace asthma was defined as a categorical variable with four mutually exclusive categories: work-related asthma symptoms (WRAS), work-exacerbated asthma (WEA), occupational asthma (OA) and none. Multivariable logistic regression analysis was used to evaluate the association between self-reported use of cleaning substances and asthma outcomes among HCPs. **RESULTS:** Prevalences of WRAS, WEA and OA were 3.3%, 1.1%

and 0.8%, respectively. The prevalence estimates were generally higher among female than male HCPs. The odds of WRAS and WEA increased in a dose-dependent manner for exposure in the longest job to cleaning agents and disinfectants/sterilants, respectively. For exposure in any job, the odds of WRAS were significantly elevated for both factor 1 (bleach, cleaners/abrasives, toilet cleaners, detergents and ammonia) and factor 2 (glutaraldehyde/ortho-phthaldehyde, chloramines and ethylene oxide). Significantly elevated odds of WEA were observed for exposure to bleach, factor 2 and formalin/formaldehyde. Exposure to chloramines was significantly associated with an almost fivefold elevated odds of OA. CONCLUSIONS: HCPs are at risk of developing WRA from exposure to cleaning substances.

49. Siracusa, A., et al., *Asthma and exposure to cleaning products - a European Academy of Allergy and Clinical Immunology task force consensus statement*. Allergy, 2013.

Professional and domestic cleaning is associated with work-related asthma (WRA). This position paper reviews the literature linking exposure to cleaning products and the risk of asthma and focuses on prevention. Increased risk of asthma has been shown in many epidemiological and surveillance studies, and several case reports describe the relationship between exposure to one or more cleaning agents and WRA. Cleaning sprays, bleach, ammonia, disinfectants, mixing products, and specific job tasks have been identified as specific causes and/or triggers of asthma. Because research conclusions and policy suggestions have remained unheeded by manufacturers, vendors, and commercial cleaning companies, it is time for a multifaceted intervention. Possible preventive measures encompass the following: substitution of cleaning sprays, bleach, and ammonia; minimizing the use of disinfectants; avoidance of mixing products; use of respiratory protective devices; and worker education. Moreover, we suggest the education of unions, consumer, and public interest groups to encourage safer products. In addition, information activities for the general population with the purpose of improving the knowledge of professional and domestic cleaners regarding risks and available preventive measures and to promote strict collaboration between scientific communities and safety and health agencies are urgently needed.

50. Sastre, J., et al., *Airway response to chlorine inhalation (bleach) among cleaning workers with and without bronchial hyperresponsiveness*. Am J Ind Med, 2011. **54**(4): p. 293-9.

BACKGROUND: Symptoms of obstructive lung disease in domestic cleaning staff have been related to the use of bleach and other irritant cleaning products. MATERIAL AND METHODS: Included in the study were thirteen cleaning employees with work-related asthma-like symptoms, three asthmatic controls and three atopic subjects without bronchial hyperresponsiveness (BHR) who had no exposure to cleaning products. The study protocol consisted of a methacholine test, sputum induction and fraction of exhaled nitric oxide measurement (FENO) both at baseline and 24 hr after a 1-hr inhalation challenge with either placebo or bleach at a concentration of 0.4 ppm of chlorine. RESULTS: The inhalation of the placebo caused no bronchial reactions. Mean maximum fall in FEV(1) during challenge testing with bleach was significantly higher than the values obtained during the placebo challenge. Inhalation challenge with bleach elicited two isolated late asthmatic reactions and one dual asthmatic reaction. Of all the patients who underwent challenge testing with bleach, only one had a ≥ 2 -fold decrease in methacholine PC(20) 24 hr after the challenge. No significant correlation was found between maximum fall in FEV(1) and PC(20) methacholine. Following challenge testing with bleach, no clinically significant changes in sputum cell counts or FENO were detected. CONCLUSIONS: These results suggest that bleach inhalation at a concentration of 0.4 ppm-a concentration below 8-hr permissible occupational exposure level-brings about a

substantial decrease in FEV1 in subjects with and without BHR. Some subjects have a positive challenge response to bleach inhalation.

51. Aryal, N. and D. Reinhold, *PHYTOACCUMULATION OF ANTIMICROBIALS BY HYDROPONIC CUCURBITA PEPO*. International Journal of Phytoremediation, 2012. **15**(4): p. 330-342.

Consumer use of antimicrobial-containing products continuously introduces triclocarban and triclosan into the environment. Triclocarban and triclosan adversely affect plants and animals and have the potential to affect human health. Research examined the phytoaccumulation of triclocarban and triclosan by pumpkin (*Cucurbita pepo* cultivar Howden) and zucchini (*Cucurbita pepo* cultivar Gold Rush) grown hydroponically. Pumpkin and zucchini were grown in nutrient solution spiked with 0.315 µg/mL triclocarban and 0.289 µg/mL triclosan for two months. Concentrations of triclocarban and triclosan in nutrient solutions were monitored weekly. At the end of the trial, roots and shoots were analyzed for triclocarban and triclosan. Research demonstrated that pumpkin and zucchini accumulated triclocarban and triclosan. Root accumulation factors were 1.78 and 0.64 and translocation factors were 0.001 and 0.082 for triclocarban and triclosan, respectively. The results of this experiment were compared with a previous soil column study that represented environmentally relevant exposure of antimicrobials from biosolids and had similar root mass. Plants were not as efficient in removing triclocarban and triclosan in hydroponic systems as in soil systems. Shoot concentrations of antimicrobials were the same or lower in hydroponic systems than in soil columns, indicating that hydroponic system does not overpredict the concentrations of antimicrobials.

52. Bedoux, G., et al., *Occurrence and toxicity of antimicrobial triclosan and by-products in the environment*. Environ Sci Pollut Res Int, 2012. **19**(4): p. 1044-65.

INTRODUCTION AND AIMS: A review was undertaken on the occurrence, toxicity, and degradation of triclosan (TCS; 5-chloro-2,4-dichlorophenoxy)phenol) in the environment. TCS is a synthetic, broad-spectrum antibacterial agent incorporated in a wide variety of household and personal care products such as hand soap, toothpaste, and deodorants but also in textile fibers used in a range of other consumer products (e.g., toys, undergarments and cutting boards among other things). **OCCURRENCE:** Because of its partial elimination in sewage treatment plants, most reports describe TCS as one of the most commonly encountered substances in solid and water environmental compartments. It has been detected in a microgram per liter or microgram per kilogram level in sewage treatment plants (influent, effluent, and sludge), natural waters (rivers, lakes, and estuarine waters), and sediments as well as in drinking water. **TOXICITY:** Moreover, due to its high hydrophobicity, TCS can accumulate in fatty tissues and has been found in fish and human samples (urine, breast milk, and serum). TCS is known to be biodegradable, photo-unstable, and reactive towards chlorine and ozone. **DISCUSSION:** As a consequence, it can be transformed into potentially more toxic and persistent compounds, such as chlorinated phenols and biphenyl ethers after chlorination, methyl triclosan after biological methylation, and chlorinated dibenzodioxins after photooxidation. The toxicity of TCS toward aquatic organisms like fish, crustaceans, and algae has been demonstrated with EC50 values near TCS environmental concentrations. It has even been shown to produce cytotoxic, genotoxic, and endocrine disruptor effects. **CONCLUSION:** Furthermore, the excessive use of TCS is suspected to increase the risk of emergence of TCS-resistant bacteria and the selection of resistant strains.

53. Cherednichenko, G., et al., *Triclosan impairs excitation-contraction coupling and Ca²⁺ dynamics in striated muscle*. Proc Natl Acad Sci U S A, 2012. **109**(35): p. 14158-63.

Triclosan (TCS), a high-production-volume chemical used as a bactericide in personal care products, is a priority pollutant of growing concern to human and environmental health. TCS is capable of altering the activity of type 1 ryanodine receptor (RyR1), but its potential to influence physiological excitation-contraction coupling (ECC) and muscle function has not been investigated. Here, we report that TCS impairs ECC of both cardiac and skeletal muscle *in vitro* and *in vivo*. TCS acutely depresses hemodynamics and grip strength in mice at doses ≥ 12.5 mg/kg *i.p.*, and a concentration ≥ 0.52 μ M in water compromises swimming performance in larval fathead minnow. In isolated ventricular cardiomyocytes, skeletal myotubes, and adult flexor digitorum brevis fibers TCS depresses electrically evoked ECC within approximately 10-20 min. In myotubes, nanomolar to low micromolar TCS initially potentiates electrically evoked Ca^{2+} transients followed by complete failure of ECC, independent of Ca^{2+} store depletion or block of RyR1 channels. TCS also completely blocks excitation-coupled Ca^{2+} entry. Voltage clamp experiments showed that TCS partially inhibits L-type Ca^{2+} currents of cardiac and skeletal muscle, and [3 H]PN200 binding to skeletal membranes is noncompetitively inhibited by TCS in the same concentration range that enhances [3 H]ryanodine binding. TCS potently impairs orthograde and retrograde signaling between L-type Ca^{2+} and RyR channels in skeletal muscle, and L-type Ca^{2+} entry in cardiac muscle, revealing a mechanism by which TCS weakens cardiac and skeletal muscle contractility in a manner that may negatively impact muscle health, especially in susceptible populations.

54. Pannu, M.W., G.A. O'Connor, and G.S. Toor, *Toxicity and bioaccumulation of biosolids-borne triclosan in terrestrial organisms*. Environmental Toxicology and Chemistry, 2012. **31**(3): p. 646-653.

Triclosan (TCS) is a common constituent of personal care products and is frequently present in biosolids. Application of biosolids to land transfers significant amounts of TCS to soils. Because TCS is an antimicrobial and is toxic to some aquatic organisms, concern has arisen that TCS may adversely affect soil organisms. The objective of the present study was to investigate the toxicity and bioaccumulation potential of biosolids-borne TCS in terrestrial micro- and macro-organisms (earthworms). Studies were conducted in two biosolids-amended soils (sand, silty clay loam), following U.S. Environmental Protection Agency (U.S. EPA) guidelines. At the concentrations tested herein, microbial toxicity tests suggested no adverse effects of TCS on microbial respiration, ammonification, and nitrification. The no observed effect concentration for TCS for microbial processes was 10 mg/kg soil. Earthworm subchronic toxicity tests showed that biosolids-borne TCS was not toxic to earthworms at the concentrations tested herein. The estimated TCS earthworm lethal concentration (LC50) was greater than 1 mg/kg soil. Greater TCS accumulation was observed in earthworms incubated in a silty clay loam soil (bioaccumulation factor [BAF] = 12 ± 3.1) than in a sand (BAF = 6.5 ± 0.84). Field-collected earthworms had a significantly smaller BAF value (4.3 ± 0.7) than our laboratory values (6.5–12.0). The BAF values varied significantly with exposure conditions (e.g., soil characteristics, laboratory vs field conditions); however, a value of 10 represents a reasonable first approximation for risk assessment purposes. Environ. Toxicol. Chem. 2012;31:646–653. © 2011 SETAC

55. Pannu, M.W., et al., *Toxicity and bioaccumulation of biosolids-borne triclosan in food crops*. Environ Toxicol Chem, 2012. **31**(9): p. 2130-7.

Triclosan (TCS) is an antimicrobial compound commonly found in biosolids. Thus, plants grown in biosolids-amended soil may be exposed to TCS. We evaluated the plant toxicity and accumulation potential of biosolids-borne TCS in two vegetables (lettuce and radish) and a pasture grass (bahia grass). Vegetables were grown in growth chambers and grass in a

greenhouse. Biosolids-amended soil had TCS concentrations of 0.99, 5.9, and 11 mg/kg amended soil. These TCS concentrations represent typical biosolids containing concentrations of 16 mg TCS/kg applied at agronomic rates for 6 to 70 consecutive years, assuming no TCS loss. Plant yields (dry wt) were not reduced at any TCS concentration and the no observed effect concentration was 11 mg TCS/kg soil for all plants. Significantly greater TCS accumulated in the below-ground biomass than in the above-ground biomass. The average bioaccumulation factors (BAFs) were 0.43 +/- 0.38 in radish root, 0.04 +/- 0.04 in lettuce leaves, 0.004 +/- 0.002 in radish leaves, and <0.001 in bahia grass. Soybean (grain) and corn (leaves) grown in our previous field study where soil TCS concentrations were lower (0.04-0.1 mg/kg) had BAF values of 0.06 to 0.16. Based on the data, we suggest a conservative first approximate BAF value of 0.4 for risk assessment in plants.

56. Tamura, I., et al., *Ecological risk assessment of urban creek sediments contaminated by untreated domestic wastewater: potential contribution of antimicrobials and a musk fragrance*. Environ Technol, 2013. **34**(9-12): p. 1567-75.

Despite the fact that some hydrophobic pharmaceuticals and personal care products (PPCPs) have been found to accumulate in river sediments, little is known about the contribution of these compounds to the toxicity of the whole sediment. We sampled river sediments from two urban creeks with an unsewered drainage area to investigate the toxicity for a benthic organism, *Chironomus yoshimatsui*. The concentrations of selected hydrophobic PPCPs, triclosan (TCS), triclocarban (TCC) and galaxolide (HHCB) were analysed using gas chromatographic mass spectroscopy or liquid chromatographic mass spectroscopy and were found to lie within the range 50 to 200 ng g⁻¹. The toxicity of the three individual contaminants for the chironomid was also determined. The toxicity of TCC was found to be the strongest, with an NOEC value of 2.5 microg g⁻¹. Combining the toxicity and measured environmental concentration, the ecological risk was assessed and the contribution of these contaminants to the whole sediment toxicity estimated, assuming additivity. The hazard quotient of all three compounds, determined without assessment factor, ranged between 0.01 and 0.1. The combined contribution of the three compounds to total sediment toxicity was as high as 8.2%, but other unknown factors may also make an important contribution.

57. Zhang, X., et al., *Fate and transport of fragrance materials in principal environmental sinks*. Chemosphere, 2013. **93**(6): p. 857-69.

Fragrance materials are widely present in the environment, such as air, water, and soil. Concerns have been raised due to the increasing utilization and suspected impact on human health. The bioaccumulating property is considered as one of the causes of the toxicity to human beings. The removal of fragrance materials from environmental sinks has not been paid enough attention due to the lack of regulation and research on their toxicity. This paper provides systematic information on how fragrance materials are transferred to the environment, how do they affect human lives, and what is their fate in water, wastewater, wastewater sludge, and soil.

58. Ferik, F., et al., *Benzalkonium chloride (BAC) and dimethyldioctadecyl-ammonium bromide (DDAB), two common quaternary ammonium compounds, cause genotoxic effects in mammalian and plant cells at environmentally relevant concentrations*. Mutagenesis, 2007. **22**(6): p. 363-370.

Quaternary ammonium compounds (QACs) are cationic surfactants that are widely used as disinfectants. In the present study, we tested two important representatives, namely, benzalkonium chloride (BAC) and dimethyldioctadecyl-ammonium bromide (DDAB) in four genotoxicity tests, namely, in the Salmonella/microsome assay with strains TA 98, TA 100 and

TA 102, in the single-cell gel electrophoresis (SCGE) assay with primary rat hepatocytes and in micronucleus (MN) assays with peripheral human lymphocytes and with root tip cells of *Vicia faba*. In the bacterial experiments, consistently negative results were obtained in the dose range between 0.001 and 110 {micro}g per plate in the presence and absence of metabolic activation while significant induction of DNA migration was detected in the liver cells. With BAC, a moderate but significant effect was found with an exposure concentration of 1.0 mg/l while DDAB caused damage at lower doses (0.3 mg/l). The effects were not altered when the nuclei were treated with formamidopyridine glycosylase, indicating that they are not due to formation of oxidized purines. The MN assays with blood cells were carried out under identical conditions to the SCGE experiments and a significant increase was seen at the highest dose levels (BAC: 1.0 and 3.0 mg/l; DDAB: 1 mg/l). Both compounds also caused significant induction of MN as well as inhibition of cell division in plant cells, the lowest effective levels were 1.0 and 10 mg/l for DDAB and BAC, respectively. Our findings show that both chemicals induce moderate but significant genotoxic effects in eukaryotic cells at concentrations which are found in wastewaters and indicate that their release into the environment may cause genetic damage in exposed organisms. Furthermore, the direct contact of humans to QAC-containing detergents and pharmaceuticals that contain substantially higher concentrations than those which were required to cause effects in eukaryotic cells in the present study should be studied further in regard to potential DNA-damaging effects in man.

59. Loraine, G.A. and M.E. Pettigrove, *Seasonal variations in concentrations of pharmaceuticals and personal care products in drinking water and reclaimed wastewater in southern California*. Environ Sci Technol, 2006. **40**(3): p. 687-95.

Southern California imports nearly all of its potable water from two sources: the Colorado River and the California State Water Project (Sacramento-San Joaquin River Basin). Sewage treatment plant effluent (STPE) heavily impacts both of these sources. A survey of raw and treated drinking water from four water filtration plants in San Diego County showed the occurrence of several polar organic "pharmaceuticals and personal care products" (PPCP). These included phthalate esters, sunscreens, clofibrate, clofribic acid, ibuprofen, triclosan, and DEET. Several of these were also found in the finished water, such as di(ethylhexyl) phthalate, benzophenone, ibuprofen, and triclosan. Occurrence and concentrations of these compounds were highly seasonally dependent, and reached maximums when the flow of the San Joaquin River was low and the quantity of imported water was high. The maximum concentrations of the PPCPs measured in the raw water were correlated with low flow conditions in the Sacramento-San Joaquin Delta that feeds the State Water Project. The PPCP concentrations in raw imported water in the summer months approached that of reclaimed nonpotable wastewater.

60. Macherius A Fau - Eggen, T., et al., *Uptake of galaxolide, tonalide, and triclosan by carrot, barley, and meadow fescue plants*. (1520-5118 (Electronic)).

Many xenobiotics entering wastewater treatment plants are known to be persistent during wastewater treatment and tend to adsorb to sewage sludge. The application of sewage sludge as fertilizer in agriculture may pose the risk of an incorporation of xenobiotics in the cultivated plants and, finally, an inclusion into the food chain. This study was performed to investigate the uptake of common sewage sludge contaminants, galaxolide, tonalide, and triclosan, by plants used for human consumption and livestock feeding. Barley, meadow fescue, and four carrot cultivars were sown and grown in spiked soils under greenhouse conditions. After harvesting the plants, roots and leaves were analyzed separately, and the respective bioconcentration factors were calculated. In carrots, a concentration gradient of the xenobiotics became evident that

decreased from the root peel via root core to the leaves. A significant influence of the differing root lipid contents on the uptake rates cannot be supported by our data, but the crucial influence of soil organic carbon content was confirmed. Barley and meadow fescue roots incorporated higher amounts of the target substances than carrots, but translocation into the leaves was negligible. The results indicated that an introduction of persistent semi- and nonpolar xenobiotics into the food chain via edible plants like carrots could be of certain relevance when sludge is applied as fertilizer. Due to low rates found for the translocation of the xenobiotics into the aerial plant parts, the entrance pathway into food products via feeding livestock is less probable.

61. Aiello, A.E., et al., *Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis*. Am J Public Health, 2008. **98**(8): p. 1372-81.

To quantify the effect of hand-hygiene interventions on rates of gastrointestinal and respiratory illnesses and to identify interventions that provide the greatest efficacy, we searched 4 electronic databases for hand-hygiene trials published from January 1960 through May 2007 and conducted meta-analyses to generate pooled rate ratios across interventions (N=30 studies). Improvements in hand hygiene resulted in reductions in gastrointestinal illness of 31% (95% confidence intervals [CI]=19%, 42%) and reductions in respiratory illness of 21% (95% CI=5%, 34%). The most beneficial intervention was hand-hygiene education with use of nonantibacterial soap. Use of antibacterial soap showed little added benefit compared with use of nonantibacterial soap. Hand hygiene is clearly effective against gastrointestinal and, to a lesser extent, respiratory infections. Studies examining hygiene practices during respiratory illness and interventions targeting aerosol transmission are needed.

62. Aiello, A.E., E.L. Larson, and S.B. Levy, *Consumer antibacterial soaps: effective or just risky?* Clin Infect Dis, 2007. **45 Suppl 2**: p. S137-47.

BACKGROUND: Much has been written recently about the potential hazards versus benefits of antibacterial (biocide)-containing soaps. The purpose of this systematic literature review was to assess the studies that have examined the efficacy of products containing triclosan, compared with that of plain soap, in the community setting, as well as to evaluate findings that address potential hazards of this use--namely, the emergence of antibiotic-resistant bacteria. METHODS: The PubMed database was searched for English-language articles, using relevant keyword combinations for articles published between 1980 and 2006. Twenty-seven studies were eventually identified as being relevant to the review. RESULTS: Soaps containing triclosan within the range of concentrations commonly used in the community setting (0.1%-0.45% wt/vol) were no more effective than plain soap at preventing infectious illness symptoms and reducing bacterial levels on the hands. Several laboratory studies demonstrated evidence of triclosan-adapted cross-resistance to antibiotics among different species of bacteria. CONCLUSIONS: The lack of an additional health benefit associated with the use of triclosan-containing consumer soaps over regular soap, coupled with laboratory data demonstrating a potential risk of selecting for drug resistance, warrants further evaluation by governmental regulators regarding antibacterial product claims and advertising. Further studies of this issue are encouraged.

63. St Sauver, J., et al., *Hygienic practices and acute respiratory illness in family and group day care homes*. Public Health Rep, 1998. **113**(6): p. 544-51.

OBJECTIVE: To describe hygiene practices in licensed group day care and family day care homes and the association between these practices and the prevalence of respiratory illnesses in the children in attendance. METHODS: Self-administered surveys were mailed to 137 group and 204 family day care providers. RESULTS: Wearing diapers and being younger than age three were

associated with a higher frequency of respiratory illness. Children attending family day care homes had more respiratory illness than children attending group day care homes. Infrequent washing of children's or providers' hands after nose wiping, after diapering, before meals, and before food preparation was significantly associated with a higher frequency of respiratory illness. Use of shared cloth towels instead of individual paper towels and washing of sleeping mats less than once a week were also associated with a higher frequency of respiratory illness. CONCLUSIONS: The findings underscore the importance of handwashing and other hygiene practices in reducing the spread of disease in day care settings.

64. Rosen, L., et al., *Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools*. *Prev Med*, 2006. **42**(1): p. 27-32.

BACKGROUND: Preschools are often focal points for the spread of illness among young children. The objective of this preschool intervention trial was to determine whether a hygiene program can promote handwashing and thereby reduce illness absenteeism. METHODS: This cluster randomized trial included 40 Jerusalem preschools with 1029 children for 6 baseline days and 66 study days, yielding 73,779 child days. The main outcomes were rates of handwashing and illness absenteeism. The intervention included an educational program and environmental changes. A simultaneous subtrial was run to test a home component. RESULTS: This multi-site intervention program produced sustained behavioral and environmental changes over a 6-month period. An approximately threefold increase in handwashing with soap was observed among preschool children exposed to the intervention. Neither the preschool nor the home intervention program reduced illness absenteeism or overall absenteeism. CONCLUSIONS: This trial illuminates the potential of the preschool as a promising venue for health promotion activities leading to sustained behavioral change, yet suggests the need for enhanced approaches for reducing illness absenteeism.

65. Corsi, R.L., J.A. Siegel, and C. Chiang, *Particle Resuspension During the Use of Vacuum Cleaners on Residential Carpet*. *Journal of Occupational and Environmental Hygiene*, 2008. **5**(4): p. 232-238.

Vacuuming is generally considered to be an important activity with respect to the cleanliness of indoor environments but may lead to short-term resuspension of particulate matter and elevated particle mass in indoor air. Because resuspended particles often contain toxicants, such as lead and pesticides, or consist of biological agents that can trigger allergic reactions, it is important to understand the role of vacuuming on short-term variations in indoor particulate matter concentrations. The inhalation of particles during vacuuming events may affect adversely those whose occupation requires them to clean a wide range of indoor environments, from homes to schools and offices, as well as those who occupy those environments. In response, a series of 46 experiments was completed to determine time-variant concentrations of both PM 10 and PM 2.5 during various vacuuming activities in 12 separate apartments. Experiments involved the use of two different non-HEPA vacuum cleaners and were completed with a vacuum cleaner activated (switched on) as well as deactivated (switched off). The latter was intended to provide insight on the potential for resuspension of particles by the mechanical agitation of vacuum cleaner movement across carpet. Separate experiments were completed also using mock vacuuming simulations, that is, walking on the carpet in a manner consistent with using a vacuum cleaner. Results are presented as incremental particulate matter concentration increases, relative to background (prevacuum) concentrations, and peak-to-background particle concentration ratios. Results indicate significant resuspension of PM 10 mass during vacuum cleaning, with a mean time-averaged PM 10 increase of greater than 17 $\mu\text{g}/\text{m}^3$ above background. Resuspension of PM 2.5 mass was determined to be small, that is, PM

10 mass was dominated by particles greater than 2.5 μ m. The frequency of vacuuming (between a 10-day standard frequency and several experiments at > 24 days between vacuuming) had little influence on resuspended particle mass. Resuspension by mechanical agitation (rolling of vacuum cleaner across carpet) with the vacuum cleaner switched off was determined to be substantial, with a mean time-averaged (during vacuuming) PM 10 increase of 35 μ g/m³ relative to background. Peak-to-background PM 10 concentrations exceeded 6 for some experiments and averaged between approximately 3 and 4 for experiments when the vacuum cleaner was switched on.

66. Song, L., J. Wu, and C. Xi, *Biofilms on environmental surfaces: evaluation of the disinfection efficacy of a novel steam vapor system*. Am J Infect Control, 2012. **40**(10): p. 926-30.

BACKGROUND: Environmental surfaces in health care settings are often contaminated by microorganisms, and biofilms can develop on the surfaces in these settings. Steam vapor technology is of potential use for disinfection of biofilms on the environmental surfaces. **METHODS:** We tested the disinfection efficacy of a thermal-accelerated nanocrystal sanitation (TANCS)-equipped steam vapor technology against biofilms through disinfecting biofilms developed by 4 bacterial strains-Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, and Staphylococcus aureus-on an identical test surface (ie, polycarbonate) and biofilms developed by E coli on 4 different test surfaces: polycarbonate, rubber, stainless steel, and ceramics. **RESULTS:** Our data show that a 3-second steam treatment rapidly killed each biofilm tested (>99.95% killing efficiency). For biofilms developed on different surfaces, 3-second steam treatment achieved 99.95% killing of E coli biofilms developed on different surfaces. Compared with chemical disinfection, steam treatment for <1 second a similar level of biofilm disinfection as provided by incubation with 10-ppm sodium hypochlorite (bleach) for 10-20 minutes of contact time. **CONCLUSIONS:** Our data suggest that the TANCS-equipped steam vapor disinfection is an emerging and potentially useful technology for disinfecting biofilms on environmental surfaces.

67. Rutala, W.A., M.F. Gergen, and D.J. Weber, *Microbiologic evaluation of microfiber mops for surface disinfection*. Am J Infect Control, 2007. **35**(9): p. 569-73.

BACKGROUND: Recently, health care facilities have started to use a microfiber mopping technique rather than a conventional, cotton string mop to clean floors. **METHODS:** The effectiveness of microfiber mops to reduce microbial levels on floors was investigated. We compared the efficacy of microfiber mops with that of conventional, cotton string mops in 3 test conditions (cotton mop and standard wringer bucket, microfiber mop and standard wringer bucket, microfiber system). Twenty-four rooms were evaluated for each test condition. RODAC plates containing D/E Neutralizing Agar were used to assess "precleaning" and "postcleaning" microbial levels. **RESULTS:** The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner (95% vs 68%, respectively). The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system (95% vs 95%, respectively). However, use of disinfectant did significantly improve microbial removal when a cotton string mop was used (95% vs 68%, respectively). **CONCLUSION:** The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner. The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system.

68. Tanner, B.D., *Reduction in infection risk through treatment of microbially contaminated surfaces with a novel, portable, saturated steam vapor disinfection system*. Am J Infect Control, 2009. **37**(1): p. 20-7.

BACKGROUND: Surface-mediated infectious disease transmission is a major concern in various settings, including schools, hospitals, and food-processing facilities. Chemical disinfectants are frequently used to reduce contamination, but many pose significant risks to humans, surfaces, and the environment, and all must be properly applied in strict accordance with label instructions to be effective. This study set out to determine the capability of a novel chemical-free, saturated steam vapor disinfection system to kill microorganisms, reduce surface-mediated infection risks, and serve as an alternative to chemical disinfectants. **METHODS:** High concentrations of *Escherichia coli*, *Shigella flexneri*, vancomycin-resistant *Enterococcus faecalis* (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), *Salmonella enterica*, methicillin-sensitive *Staphylococcus aureus*, MS2 coliphage (used as a surrogate for nonenveloped viruses including norovirus), *Candida albicans*, *Aspergillus niger*, and the endospores of *Clostridium difficile* were dried individually onto porous clay test surfaces. Surfaces were treated with the saturated steam vapor disinfection system for brief periods and then numbers of surviving microorganisms were determined. Infection risks were calculated from the kill-time data using microbial dose-response relationships published in the scientific literature, accounting for surface-to-hand and hand-to-mouth transfer efficiencies. **RESULTS:** A diverse assortment of pathogenic microorganisms was rapidly killed by the steam disinfection system; all of the pathogens tested were completely inactivated within 5 seconds. Risks of infection from the contaminated surfaces decreased rapidly with increasing periods of treatment by the saturated steam vapor disinfection system. **CONCLUSIONS:** The saturated steam vapor disinfection system tested for this study is chemical-free, broadly active, rapidly efficacious, and therefore represents a novel alternative to liquid chemical disinfectants.