



Safer Products and Practices for Disinfecting and Sanitizing Surfaces



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Acknowledgements

This report is the product of more than two years of effort by San Francisco Department of the Environment staff and consultants – primarily the Green Purchasing Institute - as well as a number of very helpful reviewers. Special thanks are due to SFE consultant Susan Kegley, who completed a series of background studies on various disinfectant active ingredients that fed into this report. Justine Weinberg of the Occupational Health Branch at the California Department of Public Health was especially thorough in her comments and helpful throughout the writing phase. Consultants Ann Blake and Kelly Moran also provided valuable comments. Luz Agana and Karen Cohn of the Environmental Health Section of San Francisco's Department of Public Health have contributed their research findings and comments related to their recent project assessing alternatives to chlorine bleach for sanitizing surfaces in child care centers. Finally, Bridget Williams and Cal Baier-Anderson of the U.S. Environmental Protection Agency (U.S. EPA) Design for the Environment Program provided valuable feedback based on DfE's own reviews of disinfectant products.

Cover photo: Scanning electron micrograph of methicillin-resistant *Staphylococcus aureus* (MRSA) and a dead human neutrophil, courtesy of the National Institute of Allergy and Infectious Diseases.

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Overview

Nearly all public facilities – such as schools, parks and office buildings – use a substantial amount of surface sanitizing and disinfecting products while cleaning their restrooms and other public spaces. These products are inherently toxic, as they are formulated to kill living organisms. As such, the U.S. Environmental Protection Agency (U.S. EPA) and California Department of Pesticide Regulation (CA DPR) register all surface sanitizers and disinfectants as pesticides. Although all of these “antimicrobial” products have risks, there are a few types that pose greater, long-term risks to custodial workers and building occupants because they contain active ingredients that have been found to cause asthma (e.g., chlorine bleach/sodium hypochlorite, peroxyacetic acid, and quaternary ammonium compounds), cancer (e.g., ortho-phenylphenol), skin sensitization (e.g., chlorine bleach, pine oil, and thymol) or other health hazards. Several also pose environmental risks as well, such as silver and quaternary ammonium chloride compounds.

Surface sanitizers and disinfectants with more benign health and environmental impacts are available and often have equivalent or greater efficacy. However, these products have been difficult for purchasers to identify because US law prohibits the use of ecolabels on EPA-registered pesticides, and because of the complex nature of the problem; that is, consideration must be given to efficacy against a variety of pathogens, as well as factors such as surface compatibility and dwell time. The U.S. EPA’s Design for the Environment (DfE) program is currently completing an [Antimicrobial Pesticides Pilot Project](#) that promises to assist consumers in this regard.¹ However, the breadth of DfE-Recognized products was inadequate at the time of this writing to meet the needs of the City & County of San Francisco.

In keeping with San Francisco’s Precautionary Principle Ordinance², the City’s Department of the Environment contracted with the Green Purchasing Institute – in collaboration with the Responsible Purchasing Network – to conduct an alternatives analysis of non-food-contact surface sanitizers and disinfectants appropriate for public facilities. GPI also evaluated antimicrobial products that may be needed to address specific situations such as bodily fluid spills, *Norovirus* outbreaks, or athlete’s foot fungus in locker rooms.

The resulting alternatives analyses (Tables 1 & 4) provide an overview of health and environmental risks, efficacy claims, dwell times and surface compatibilities. The analysis includes a review of the available information on the active ingredients themselves as well as an evaluation of specific products. This report concludes that San Francisco should focus on hydrogen peroxide, lactic acid, and citric acid-based disinfectants and sanitizers, with silver-based products also considered appropriate for very limited circumstances. The analysis also identifies examples of safer products (those with a relatively lower toxicity profile) that are registered as effective non-food-contact surface sanitizers and disinfectants.

Product attributes are detailed in Appendix A. Appendix B lists evaluated products registered for use in preventing the growth of athlete’s foot fungus in areas such as locker room floors, cleaning up after bodily fluid spills, or addressing a *Norovirus* outbreak. Appendix C highlights several “best practices” relating to the selection, dilution and use of surface sanitizers and disinfectants.

Definitions

The U.S. Environmental Protection Agency (U.S. EPA) registers all non-food-contact surface sanitizers and disinfectants as pesticides. Below are some important definitions.

Non-Food-Contact Surface Sanitizers

According to the U.S. EPA, a non-food-contact surface sanitizer is “a substance, or mixture of substances, that reduces the bacterial population in the inanimate environment by significant numbers, (e.g., 3-log₁₀ reduction) or more, but does not destroy or eliminate all bacteria.”³ This 3-log reduction in bacteria equates to reduction of the test organisms by 99.9%. As such, these products are

used to reduce, but not necessarily eliminate, microorganisms from inanimate surfaces.

The required test organisms for this type of sanitizer are *Staphylococcus aureus* plus either *Klebsiella pneumoniae* or *Enterobacter aerogenes*. In order for a product to be registered by the U.S. EPA as a sanitizer for non-food-contact surfaces, it must demonstrate the ability to cause a bacterial reduction of at least 99.9% within 5 minutes.⁴ Efficacy claims against additional pathogens will be listed on the label.

Surface sanitizers tend to be less concentrated than disinfectants and, therefore, less expensive. For example, one concentrated Accelerated Hydrogen Peroxide (AHP™) product called *Oxivir Five 16* is registered as a non-food-contact surface sanitizer when it is diluted 1:128, and it is registered as a healthcare environment disinfectant at a stronger dilution of 1:16. That makes the sanitizing solution of Oxivir 1/8th, or about 12% of the cost of the disinfecting solution.

Often, the use of surface sanitizers (instead of disinfectants) can save time because their dwell time is typically shorter. In such cases, a product (with the same AI concentration) can be registered as a sanitizer with one dwell time (up to 5 minutes) and as a disinfectant with another, longer dwell time (up to 10 minutes). Pre-diluted, ready-to-use (RTU) products such as *Lysol Brand III Disinfecting All Purpose Cleaner*,⁵ which contains 3.2% lactic acid, exemplify this. This product is a non-food-contact surface sanitizer in 30 seconds and a disinfectant in 10 minutes.

In some cases, where the disinfectant concentration is stronger than the sanitizer, users may need to undertake an extra step of rinsing off the disinfectant solution after the requisite dwell time in order to prevent exposure to the chemical by facility users or corrosive effects to surface materials. For example, Ecolab's *65 Disinfecting Heavy Duty Bathroom Cleaner*, a concentrate that contains 3.05% caprylic acid, is registered as a healthcare-environment disinfectant when ¾ cup (6 oz.) of it is diluted with one gallon of water and left on the surface for 10 minutes. According to the EPA-approved label for this product, after the requisite dwell time, users are supposed to wipe the surface with a damp cloth or sponge, and then rinse it with potable water. In contrast, no rinse step is required when this product is used as a non-food-contact surface sanitizer (i.e., diluted only 3 oz. per gallon of water). Not only is the dwell time cut in half, but also the residual solution can be left on the surface to air dry.

Surface Disinfectants

According to the U.S. EPA, a disinfectant is a “substance, or mixture of substances, that destroys or irreversibly inactivates bacteria, fungi and viruses, but not necessarily their spores.”⁶ In order for a product to be registered by the U.S. EPA as a surface disinfectant, it must demonstrate the ability to prevent the test bacteria from growing in 59 out of 60 samples when left on for the stated dwell time, which may be no more than 10 minutes.⁷

The U.S. EPA has three classifications of disinfecting claims, each with their own test organisms⁸. In order of ‘strength’, they are as follows:

ⁱAlthough many companies, microbiologists, and other experts in the field often refer to a disinfectant as causing 99.999% (5-log) kill in no more than 10 minutes, the U.S. EPA does not define disinfectants in these terms. Rather, this is an estimate, or assumption, and perhaps an attempt to align the definition of ‘disinfectant’ with that of ‘food-contact surface sanitizer’ (99.999% kill required in 1 minute or less) or ‘non-food-contact surface sanitizer’ (99.9% kill in 5 minutes or less). It is not an official definition and cannot be referenced in the U.S. EPA or other regulatory agency literature.

1. *Healthcare Environment Disinfecting Claim:* To make this claim, a disinfectant must meet test requirements (prevent bacteria from growing in 59/60 trials) for *Staphylococcus aureus*, *Salmonella enterica*, and *Pseudomonas aeruginosa* in 10 minutes or less. Healthcare environment disinfectants are not required to claim efficacy against any viruses or fungi, although many do.
2. *General or Broad Spectrum Disinfecting Claim:* To make this claim, a disinfectant must meet test requirements for at least two bacteria: *Staphylococcus aureus* (gram-positive) and *Salmonella enterica* (gram-negative) in 10 minutes or less.
3. *Limited Efficacy Disinfecting Claim:* To make this claim, a disinfectant must meet test requirements for either *Staphylococcus aureus* (representing gram-positive bacteria) OR *Salmonella enterica* (representing gram-negative bacteria), but not both in 10 minutes or less. Pinalen, which lists 5% pine oil as its only active ingredient, is an example of a “limited disinfectant against gram-negative bacteria”.⁹ Another example is *Windex Multi-surface Antibacterial*¹⁰ (with 0.18% lactic acid), which claims efficacy against *Salmonella* but not *Staphylococcus*. Its U.S. EPA-approved label provides instructions on how “to disinfect and kill gram-negative bacteria on hard, non-porous surfaces.”

Some disinfectants can make different disinfecting claims depending on the dwell time or dilution that is used. For example, the U.S. EPA-approved label for the concentrated chlorine bleach product included in this evaluation states that it is registered as a *general* disinfectant when it is diluted ½ cup per gallon of water with a five-minute dwell time. In contrast, it is registered as a *healthcare-environment* disinfectant only when (at the same dilution) it is left on the surface for 10 minutes, because that is the dwell time needed to kill *Pseudomonas aeruginosa*.

Compared to non-food-contact surface sanitizers, disinfectants are often much stronger and, therefore, more expensive. Or, in some cases, they simply need to be left on the surface longer to achieve a higher efficacy against bacteria and other pathogens. For more information on where to use sanitizers, disinfectants, or green cleaners, refer to Appendix C: *Best Practices for Cleaning, Sanitizing, and Disinfecting*.

While disinfectants are required to *demonstrate* efficacy only against a small number of bacteria, they are typically effective against a wide range of bacteria (including, in some cases, antibiotic-resistant strains such as MRSA) as well as viruses (such as influenza (flu) virus and HIV), and/or fungi (such as athlete’s foot fungus, mold and mildew). Because of the increasing concern about viruses such as the Influenza “flu” virus, *Norovirus*, HIV, and others, there is an increasing use of disinfectants that are also registered as virucides (see below).

Disinfectants and non-food-contact surface sanitizers may not be appropriate for use on surfaces that contact food. For these applications a product specifically registered as a food-contact surface sanitizer must be employed, and these are subject to different efficacy criteria.

Other definitions

- *Cleaner-Disinfectant:* According to the U.S. EPA, “an antimicrobial agent identified as a ‘one-step’ cleaner-disinfectant, cleaner-sanitizer, or one intended to be effective in the presence of organic soil must be tested for efficacy by the appropriate method(s) which have been modified to include a representative organic soil such as 5% blood serum.” The agency warns that even when such products are used, “when the surface to be treated has heavy soil deposits, a cleaning step must be recommended prior to application of the antimicrobial agent.”¹¹
- *Dwell time:* Dwell time is the length of time a product must remain wet on a surface to reach the kill level specified on the label. Together, efficacy and dwell time indicate how effectively and quickly a surface sanitizing or disinfecting product works compared to others in its class.

- *Efficacy*: Efficacy here refers only to the level of microbial kill against specific bacteria, viruses and/or fungi claimed on the most current U.S. EPA-approved label for a given product. In many cases a compound may actually be capable of killing many other kinds of microbes, but the manufacturer has chosen to submit data only on a more limited subset.
- *Fungicide*: An antimicrobial product may be labeled as a *fungicide* if it is registered by the U.S. EPA as effective against at least one fungus such as athlete's foot fungus, *Candida albicans*, mold or mildew. To make this claim about a specific fungus, a product must completely kill the test microorganism on the surfaces tested in 59 out of 60 attempts.¹²
- *Germicide*: A product may be labeled a *germicide* if it is registered by the U.S. EPA as a general disinfectant (effective against both *Staphylococcus* and *Salmonella* bacteria) AND a virucide or a fungicide.
- *Respiratory sensitizer*: Under the Globally Harmonized System of Classifying and Labeling of Chemicals (GHS)¹³, a respiratory sensitizer is a "substance that induces hypersensitivity of the airways following inhalation of the substance."
- *Reactive Airway Dysfunction Syndrome (RADS)*: RADS chemicals can cause an asthma-like syndrome after a single exposure to high levels of an irritating vapor, fume, or smoke.¹⁴
- *Virucide*: An antimicrobial product may be labeled as a *virucide* if the U.S. EPA registers it as effective at killing a least one virus. Such claims may be made for products that are also bacterial disinfectants or sanitizers and must be restricted to those viruses that have actually been tested.¹⁵

Methods

Scope

This *Alternatives Analysis* is based on a comparison of 11 active ingredients commonly found in non-food-contact surface sanitizers and disinfectantsⁱⁱ. Beside disinfectant products, we also examined data on electrolyzed water and steam devices, although this review was limited. Active ingredients reviewed were:

- Caprylic acid (aka Octanoic acid)
- Citric acid
- Hydrogen peroxide (H₂O₂), including stabilized or "accelerated" products
- Lactic acid
- Ortho-phenylphenol (OPP)
- Peroxyacetic acid (PAA) + hydrogen peroxide (H₂O₂)
- Pine oil
- Quaternary ammonium chloride compounds ("quats")
- Silver + citric acid (or hydrogen peroxide)
- Sodium hypochlorite (e.g., chlorine bleach, CAS #7681-52-9)
- Thymol (a component of thyme oil)

The recommendations in this report are based on two levels of review:

ⁱⁱ Note: Hydrogen chloride, not evaluated in this assessment, is also found as a breakdown product in some disinfectants. It is toxic, very acidic and corrosive, and listed by AOEC as an asthmagen associated with Reactive Airways Dysfunction Syndrome (RADS).

- (1) *Active Ingredient Review*, which summarizes:
 - a. Health risks (such as the potential to cause cancer, asthma, or corrosive damage to the eyes or skin); and
 - b. Environmental risks (such as the potential to persist in the environment, harm fish and other aquatic species, or cause eutrophication).

The active ingredient review focused on chronic health and environmental hazards because these hazards are less dependent on ingredient concentration.

- (2) *Sample Product Review*, which summarizes a broader array of health and environmental risks as well as the efficacy claims, dwell times and surface and chemical compatibilities of 28 sample registered disinfectants containing one of the 11 active ingredients (“AIs”) listed above. The intent was to evaluate sample products that represent active ingredient concentrations found in available products. Usually this meant a complete evaluation of two products per active ingredient (one concentrate and one ready-to-use formulation), although the actual number of products reviewed varied. In addition, several other products were partially reviewed, largely to determine whether products with different concentrations of AIs listed similar health effects, efficacy or dwell time. See Appendix D, Table 8 for the list of sample disinfecting products that were included in this alternatives assessment. Overall, 33 disinfectants and 24 non-food-contact sanitizers were reviewed. (Note that a separate table of non-food-contact sanitizers was not included because the differences in efficacy were found to be negligible. Instead, information on the sanitizing efficacy and dwell time of the evaluated disinfectants was noted in Appendix D, Table 9.)

Review at the product level permitted a review of acute hazards such as eye and skin irritation. While these are key worker health issues, they were assigned less priority for products available in closed-loop dilution systems, which prevent workers from being exposed to concentrated products.

Information Sources

In the *Active Ingredient Review*, the primary information sources included the U.S. EPA’s Reregistration Eligibility Documents (REDs) for each antimicrobial ingredient studied, material safety data sheets (MSDSs) for the active ingredient, data available in summary format through the Pharos Project¹⁶, and peer-reviewed scientific journal articles. The Pharos Project ranking system is informed by the benchmarking system of the Green Screen for Safer Chemicals¹⁷ developed by Clean Production Action. The foundation of the Green Screen method is the Principles of Green Chemistry¹⁸ and the work of the US Environmental Protection Agency’s (EPA’s) Design for the Environment (DfE). In addition, the assessment relied on the following sources to evaluate specific health risks:

- *Cancer*: California’s “Prop 65” *List of Chemicals Known to the State of California to Cause Cancer, Birth Defects and Other Reproductive Harm*¹⁹ (with a cancer notation); National Toxicology Program’s *Report on Carcinogens (12th Edition)*; and the International Agency for Research on Cancer (IARC)’s *Agents Classified by the IARC Monographs* document.²⁰
- *Reproductive toxicity*: California’s “Prop 65” *List of Chemicals Known to the State of California to Cause Cancer, Birth Defects and Other Reproductive Harm* (with a notation about reproductive or developmental effects).
- *Asthma*: Association of Occupational and Environmental Clinics’ (AOEC) list of asthmagens²¹ and the National Institutes of Health’s 2011 report, *Healthy Environments: A Compilation of Substances Linked to Asthma*.²²
- *Skin Sensitization*: European Union’s REACH designation code of R43: “May cause sensitization by skin contact”.²³

In the *Sample Product Review*, the primary information sources included the most recent U.S. EPA-approved product label, information found in the CA DPR Product/Label Database, and the MSDS for at least one concentrated and one pre-diluted, ready-to-use (RTU) product per active ingredient or combination of active

ingredients (e.g., silver + citric acid or PAA + H₂O₂). Some of the information that was typically found in these information sources included each product's:

- Skin, eye and respiratory irritation potential
- pH
- HMIS score (which evaluates a product for health, flammability, and reactivity)
- Registered efficacy against specific bacteria, viruses, and/or fungi
- Registered dwell time (which may vary by pathogen, product concentration, application method, or other factors)
- Surface compatibility
- Presence of chemicals not listed as active ingredients that may contribute to the product's health/environmental impacts or efficacy (e.g., phosphorus, ethyl alcohol or quats)

The AI-level assessment gives information on chronic issues such as cancer and asthma risks, while the product-level evaluation better represents acute hazards of the product as formulated.

Evaluation and Coding Methods

Below is a description of the methods that were used to code and evaluate the information collected during this review.

- **Cancer**
 - 0/Green: Carcinogenicity to Humans Not Known or Suspected: This chemical is not on the CA Prop 65 List with a cancer notation, is not listed in the National Toxicology Program (NTP) *Report on Carcinogens (12th Edition)* as a "Known" or "Reasonably Anticipated Human Carcinogen", or is not on the following IARC cancer lists 1: "Carcinogenic to Humans", 2A: "Probably Carcinogenic to Humans", or 2B: "Possibly Carcinogenic to Humans". In addition, there is no mention of carcinogenicity in the U.S. EPA RED or MSDS for this active ingredient; and no known studies raising concern about carcinogenicity were found.
 - 1/Yellow – Suspected Human Carcinogen: This chemical is listed as "Reasonably Anticipated as a Human Carcinogen" in the NTP *Report on Carcinogens (12th Edition)*²⁴; is on the IARC 2A List ("Probably Carcinogenic to Humans") or 2B List ("Possibly Carcinogenic to Humans"); or "Suspected Carcinogen" is mentioned in the EPA RED or the active ingredient's MSDS.
 - 2/Red – Known Human Carcinogen: This chemical is on the CA Prop 65 List with a "cancer" notation; is listed as a "Known Human Carcinogen" in the NTP's *Report on Carcinogens (12th Edition)*; or is on the IARC Group 1 List ("Carcinogenic to Humans").
- **Reproductive or Developmental Toxicity**
 - 0/Green – Reproductive or Developmental Toxicity Not Known or Suspected: This chemical is not on the CA Prop 65 List with a reproductive or developmental toxicity notation and no references to birth defects or other reproductive or developmental toxicity issues were found in the EPA RED or the MSDS for this active ingredient.
 - 1/Yellow – Suspected Reproductive or Developmental Toxicity: "Suspected Reproductive or Developmental Toxin" is mentioned in the EPA RED, in the chemical's MSDS or in scientific literature.
 - 2/Red – Known Reproductive or Developmental Toxicity: This chemical is on the CA Prop 65 List with a reproductive or developmental toxicity notation. Alternatively, known reproductive or developmental toxicity is mentioned in the EPA RED, the chemical's MSDS or in other weight of evidence lists.

- **Respiratory Irritation**

- 0/Green – Not a Respiratory Irritant: Representative products do not claim any respiratory irritation on the EPA-approved product label or product MSDS.
- 1/Yellow – Mild Respiratory Irritant: “Mild” or “may be” were the strongest terms used to describe respiratory irritation on the EPA-approved product label or product MSDS.
- 2/Light Orange – Moderate Respiratory Irritant: “Moderate” was the strongest term used to describe respiratory irritation on the EPA-approved product label or product MSDS. If a document stated only “this product is irritating to the respiratory system” without a qualifier, it received a ‘moderately irritating’ rating.
- 3/ Orange – Severe Respiratory Irritant: Respiratory irritation was described as ‘severe’ on the EPA-approved product label or the product MSDS contained the phrase “causes severe but not permanent burns to the respiratory tract”.
- 4/Red – Permanent Damage to Respiratory System: The EPA-approved product label or the product MSDS contained the phrase “corrosive”, “causes permanent burns” or “causes permanent damage” to the respiratory tract.

- **Asthma**

- No/Green – Not listed as an Asthmagen: Not listed as an asthmagen (A) in the Association of Occupational and Environmental Clinics (AOEC) Exposure Code Lookup Database.²⁵
- Yes/Red – Asthmagen: Listed as an asthmagen (A) in the AOEC Exposure Code Lookup Database. This includes asthmagens that AOEC lists as causing respiratory sensitization (Rs), reactive airway dysfunction syndrome (RADS), or both (Rrs), as well as those that are generally accepted as an asthmagen (G).

- **Skin Irritation and Sensitization**

- 0/Green – No Evidence of Skin Irritation: There was no mention of dermal or skin irritation on the EPA-approved product label or the product MSDS.
- 1/Yellow – Mildly Irritating to the Skin: ‘Mild’ was the strongest term used to describe dermal or skin irritation on the EPA-approved product label or product MSDS.
- 2/Light Orange – Moderately Irritating to the Skin: ‘Moderate’ was the strongest term used to describe dermal or skin irritation on the EPA-approved product label or product MSDS. If a document stated only “this product is irritating to the skin” without a qualifier, it received a ‘moderately irritating’ rating.
- 3/Orange – Severely Irritating to the Skin: ‘Severe’ was the strongest term used to describe dermal or skin irritation on the EPA-approved product label or product MSDS.
- 4/Red – Likely to Cause Permanent Damage to the Skin: The EPA-approved label or product MSDS mentioned “permanent skin burns” or “permanent skin damage”.
- S/Red – Skin Sensitizer: Dermal or skin sensitization was noted in the EPA RED or the MSDS for the active ingredient (AI), or the AI holds the European Union REACH risk designation R43: “May cause sensitization by skin contact”.

- **Eye Irritation**

- 0/Green – No Evidence of Eye Irritation: There was no mention of eye irritation on the EPA-approved product label or the product MSDS.

- 1/Yellow – Mildly Irritating to the Eyes: ‘Mild’ was the strongest term used to describe eye irritation on the EPA-approved product label or product MSDS.
 - 2/Light Orange – Moderately Irritating to the Eyes: ‘Moderate’ was the strongest term used to describe eye irritation on the EPA-approved product label or product MSDS. If a document stated, “this product is irritating to the eyes” without a qualifier, it received a ‘moderately irritating’ rating.
 - 3/Orange – Severely Irritating to the Eyes: ‘Severe’ was the strongest term used to describe eye irritation on the EPA-approved product label or product MSDS.
 - 4/Red – Likely to Cause Permanent Damage to the Eyes: The EPA-approved product label or product MSDS mentioned “permanent eye damage”, “corrosive effects on the eyes” or “blindness”.
- **HMIS(Hazardous Materials Identification System) Score**
 - 0/Green: 0 = Highest Number in HMIS Score (0=lowest hazard)
 - 1/Yellow: 1 = Highest Number in HMIS Score
 - 2/Orange: 2 = Highest Number in HMIS Score
 - 3/Red: 3 = Highest Number in HMIS Score (3=highest hazard)
- **pH**
 - 0/Green – Neutral: 6<pH<8
 - 1/Yellow: 4<pH<6 OR 8<pH<10
 - 2/Orange: 2<pH<4 OR 10<pH<12
 - 3/Red: pH<2 OR pH>12 (Corrosive)
- **Aquatic Toxicity**
 - The Pharos Project web tool¹⁶ was the primary data source for aquatic toxicity. “Acute” aquatic toxicity is defined by Pharos as cases where “a single exposure in a day may result in severe biological harm or death to fish or other aquatic organisms.” In the definition for “chronic” aquatic toxicity “long term exposure of months or years may result in irreversible harm to fish or other aquatic organisms.”
 - 0/Green – No Evidence of Aquatic Toxicity: No mention of toxicity to aquatic organisms in Pharos Project screening tool.
 - 1/Yellow – Moderate Aquatic Toxicity: ‘Medium hazard’ (acute aquatic toxicity) was the strongest term in the Pharos Project screening tool. No chronic aquatic toxicity noted.
 - 2/Orange– High Aquatic Toxicity: ‘High hazard’ (acute aquatic toxicity) was the strongest term in the Pharos Project screening tool. No chronic aquatic toxicity noted.
 - 3/Red – Very High Aquatic Toxicity: ‘Very high hazard’ was the strongest term in the Pharos Project screening tool – OR - ‘medium hazard’ for acute aquatic toxicity combined with at least medium hazard for chronic aquatic toxicity.

High acute aquatic toxicity for an active ingredient is of less concern if the chemical is rapidly degraded; thus, aquatic toxicity ratings should be examined together with persistence.

Note: Antimicrobial products intended for indoor use are not required by the U.S. EPA to supply information on aquatic toxicity on their product label; all aquatic toxicity information supplied is voluntary. Therefore, the absence of aquatic toxicity information on the U.S. EPA label is not an indication of lack of aquatic toxicity.

- **Persistence in the Environment**

- 0/Green – Low Persistence: This chemical would rate as a “low” level of persistence under the Green Screen for Safer Chemicals™ (v 1.2) threshold values.²⁶
- 1/Yellow – Medium Persistence: This chemical would rate as a “medium” level of persistence under the Green Screen for Safer Chemicals™ (v 1.2) threshold values.
- 2/Orange – High Persistence: This chemical would rate as a “high” level of persistence under the Green Screen for Safer Chemicals™ (v 1.2) threshold values.
- 3/Red – Very High Persistence: This chemical would rate as a “very high” level of persistence under the Green Screen for Safer Chemicals™ (v 1.2) threshold values.

- **Eutrophication**

- No/Green – Not Likely to Contribute to Eutrophication: Neither the EPA-approved product label nor the MSDS for any of the products evaluated list phosphorus-containing compounds as ingredients.
- Yes/Red – Contributes to Eutrophication: Either the EPA-approved product label or the MSDS for at least one of the products evaluated lists phosphorus-containing compounds as ingredients.

Active Ingredient Summary

A primary goal of this alternatives assessment is to find safer replacements for surface disinfectants and non-food-contact sanitizers carrying significant health and environmental risks. Other priorities for replacement include products that are packaged in aerosol containers – because they are relatively expensive and can increase exposure, particularly via inhalation – as well as products with a relatively long dwell time, limited efficacy, extreme pH, or surface compatibility issues.

From the perspective of environmental and health risks, not all antimicrobial active ingredients (AIs) are created equal. Table 1 summarizes the health and environmental hazards of various surface disinfectant active ingredients. These effects conceivably occur irrespective of the concentration of the AIs in the representative products that were evaluated. The alternatives analysis summary table below covers the following:

- *Health impacts*
 - Cancer
 - Reproductive and developmental toxicity
 - Asthma
 - Skin sensitization
- *Environmental impacts*
 - Aquatic toxicity
 - Persistence

Note that without persistence, high aquatic toxicity alone has less importance, since many chemicals are quickly degraded in the environment.

A more detailed table (Table 4, Appendix A) presents information about the attributes of the 28 representative surface disinfecting products, which vary based on the specific formulation of each product. These attributes include: registered efficacy claims against bacteria, viruses and fungi as well as dwell time for surface disinfecting and non-food-contact sanitizing; irritation effects; pH; HMIS scoring, and eutrophication potential (caused by the presence of phosphorus in the product).

Table 1. Summary of Health and Environmental Attributes of 11 Active Ingredients Commonly Found in Surface Disinfectants and Non-food Contact Sanitizers

ACTIVE INGREDIENT	CANCER	REPRODUCTIVE TOXICITY	ASTHMA	SKIN SENSITIZATION	AQUATIC TOXICITY	PERSISTENCE
Caprylic Acid	No	No	No	No	Med acute	Low
Citric Acid	No	No	No	No	None	Low
Hydrogen Peroxide	No ¹	No	No	No	High acute	Low
Lactic Acid	No	No	No	No	None	Low
Ortho-Phenylphenol (OPP)	Known	Suspected	No	No	Very high acute	Low
Peroxyacetic Acid (PAA)	No	No	Yes	No	Very high acute	Low
Pine Oil	No ²	No	No ³	Yes	None	Low
Quaternary Ammonium Chloride Compounds (Quats)	No	Suspected	Yes	One compound ⁴	High acute, med	Very High
Silver	No	No	No	No	High acute	Very High
Sodium Hypochlorite (Chlorine Bleach)	No	No	Yes	No	Very high acute	Low
Thymol	No	No ⁵	No	Yes	High acute	Low

¹ Not considered a human carcinogen, but categorized by ACGIH as a “confirmed animal carcinogen with unknown relevance to humans.” The EU concluded it is a mutagen and genotoxicant in some in vitro tests but that “the available studies are not in support of significant genotoxicity/mutagenicity ... under in vivo conditions.”

² Pine oil is not considered a human carcinogen. However, a recent study found that using pine oil-based cleaning products can create secondary pollutants such as formaldehyde, a known human carcinogen.

³ Pine oil is not an AOEC asthmagen, but some pine oil disinfectants also contain tall oil – a respiratory sensitizer and pine derivative.

⁴ Generally not considered skin sensitizers except for benzalkonium chloride, but quats have the European Union REACH Directive “R43” designation, meaning “May cause sensitization by skin contact.”

⁵ Thymol does not pass Green Screen for reproductive toxicity or genetic toxicity, but the reliability of the studies cited is low

Summary of Active Ingredients Rejected During Screening

Although all U.S. EPA-registered surface sanitizers and disinfectants are “pesticides”, they do not all carry equivalent health risks²⁷. Several active ingredients are not recommended for use, including chlorine bleach (sodium hypochlorite), quaternary ammonium chloride compounds (quats), and peroxyacetic acid, which are

known asthmagens. Ortho-phenylphenol (OPP) was rejected primarily because it is on the California “Prop 65” list with a “cancer” notation. Thymol and pine oil were rejected primarily because they are known skin sensitizers as well as other health and efficacy issues.

Below is a summary of each of these active ingredients, detailing health and environmental hazards as well as efficacy, dwell time and surface compatibilities based on a review of sample products:

Chlorine Bleach (Sodium Hypochlorite)

Sodium hypochlorite has been used extensively for decades as a surface disinfectant and sanitizer because it is readily available, relatively inexpensive, and versatile. At the disinfecting level, it has efficacy against a wide range of bacteria, viruses and fungi – although the concentration and dwell time needed to kill different pathogens varies.

Chlorine bleach has historically consisted of a solution of 5.25-6% sodium hypochlorite in “regular” brands and 6.15% in “ultra” brands, along with a small amount of sodium hydroxide (lye), a contaminant generated in the manufacturing process. However, in 2011, several manufacturers began marketing concentrated bleach products with an 8.25% sodium hypochlorite solution, significantly higher than previous formulations, and 2012 brought higher prevalence of these products in stores around the country (based on label updates for these products in mid- and late-2012). According to the National Resource Center for Health and Safety in Child Care and Early Education, several companies have communicated that they have discontinued manufacturing the 5.25%-6.15% sodium hypochlorite bleach solution and they will no longer be available at many stores.²⁸ And an onsite evaluation of drug and grocery chain stores in the San Francisco Bay area in 2013 revealed that the preponderance of chlorine bleach products with disinfecting or sanitizing claims contain 8.25% sodium hypochlorite. Consequently, the concentrated bleach product evaluated in this report, *Concentrated Clorox Regular Bleach*, EPA Registration No. 5813-100²⁹ contains this higher percentage of sodium hypochlorite.

Health: Concentrated chlorine bleach is corrosive to human skin, eyes and lungs. It has a very high pH (~12, which is considered caustic) according to the MSDS for the evaluated product. The U.S. EPA-approved label for the product that was included in this evaluation has the following precautionary statements: “DANGER” and “Causes irreversible eye damage and skin burns.” Sodium hypochlorite is on the AOEC’s list of asthmagens as a respiratory sensitizer (Rs). This means it can cause asthma in a previously healthy individual.³⁰ In addition, a study on occupational asthma conducted by four state health departments found 43 cases of “new onset asthma,” mostly among custodial workers, that were attributed to the use of chlorine bleach.³¹ In contrast, according to the US EPA, it is not a skin sensitizer.³²

Because many chlorine bleach products are packaged in open containers, there is significant risk of improper dilution – either too strong or too weak – as well as spills and splashing during mixing. The higher concentration of sodium hypochlorite elevates this concern.

Concentrated chlorine bleach is also corrosive to many surfaces. Using chlorine bleach regularly on floors, for example, can eat away at floor polish, resulting in the need to strip and wax floors more often. This is both costly and hazardous to workers. According to the U.S. Centers for Disease Control, when chlorine bleach is mixed with acids (such as vinegar) or other ingredients in cleaners (particularly ammonia compounds), it can form and release chlorine gas (a respiratory sensitizer) and chloramine gas, both of which can be fatal if inhaled.

Environment: When released into surface water or the wastewater system, chlorine bleach can react with organic matter and form carcinogenic chlorinated compounds such as trihalomethanes³³.

Efficacy: Chlorine bleach products are often registered as both non-food-contact surface sanitizers and disinfectants. When used as directed on the U.S. EPA-approved label as a disinfectant sodium hypochlorite can have broad-spectrum efficacy against bacteria, viruses and fungi. The concentrated chlorine bleach product

reviewed (*Concentrated Clorox Regular Bleach*, which contains 8.25% sodium hypochlorite as its as the only listed active ingredient, is registered as a *general* disinfectant when it is diluted ½ cup per gallon with a 5-minute dwell time. When those instructions are followed, this product kills 13 strains of bacteria, 20 types of viruses (including all three bloodborne pathogens: HIV as well as hepatitis B and C viruses), and three categories of fungi (athlete's foot fungus, mildew, and *Candida albicans*, a type of yeast).

This product is also registered as a *healthcare-environment* disinfectant, but only when its dwell time is doubled to 10 minutes, which is the time needed to kill *Pseudomonas aeruginosa*, a test organism. By quadrupling the strength of the bleach solution (to two cups per gallon of water) and leaving it on the surface for 10 minutes, this product can kill *Mycobacterium bovis*, the pathogen responsible for tuberculosis (TB). Then, after the properly diluted solution has been left on the surface the requisite dwell time, it must be rinsed off with clean water. A new solution of chlorine bleach should be prepared daily as it loses potency.

Concentrated Clorox Regular Bleach (with 8.25% sodium hypochlorite) claims to be a non-food-contact surface sanitizer when diluted ½ cup per gallon, with a much shorter dwell time of 30 seconds. Two test bacteria (*Staphylococcus aureus* and *Klebsiella pneumoniae*) are the only pathogens listed under the label's section on efficacy claims for non-food-contact sanitizing. This product is also registered as a food-contact surface sanitizer, when it is diluted two teaspoons per gallon of water and left on the surface for two minutes.

There is at least one RTU product containing sodium hypochlorite as its only active ingredient that is registered as a disinfectant (*Bleach-Rite Disinfecting Spray with Bleach*³⁴). It contains about 1% (0.94%) of this active ingredient. While it has a shorter dwell time than the diluted concentrate (one minute versus five minutes), it claims efficacy against fewer types of bacteria (10 strains, including MRSA), viruses (11, including HIV, influenza A (flu) virus, and *Norovirus*) and fungi (two, including athlete's foot fungus) than the diluted concentrate described above. With a two-minute dwell time, this product is also effective against TB. Although it is registered as a healthcare-environment disinfectant, it does not meet the *California Bloodborne Pathogen Standard* because it does not claim efficacy against hepatitis B or C viruses.

*Clorox Commercial Solutions Anywhere Hard Surface Sanitizing Spray*³⁵ is a ready-to-use product that contains a much lower concentration of sodium hypochlorite (0.0095%). It is *not* registered as a bacterial disinfectant and has no efficacy against viruses or fungi. However, it is non-food-contact surface sanitizer with efficacy against six strains of bacteria with a one-minute dwell time. It is also registered as a food-contact surface sanitizer with a two-minute dwell time.

Ortho-Phenylphenol (OPP)

Products that contain ortho-phenylphenol (OPP) are not recommended because this active ingredient is a human cancer-causing agent. All of the OPP-containing disinfectants evaluated also have a relatively long (10-minute) dwell time. Both concentrated and pre-diluted, ready-to-use (RTU) products are registered for use in California, although they all contain at least one other active ingredient such as other phenolic compounds (e.g., ortho-benzyl-para-chlorophenol and/or para-tert-amylphenol), quaternary ammonium chloride compounds, and/or ethyl alcohol. No non-food-contact surface sanitizers containing OPP were found.

Health: Ortho-phenylphenol (CAS #90-43-7) is listed as a "chemical known to the State of California to cause cancer."³⁶ U.S. EPA-approved labels for products containing OPP typically state they are irritating to the eyes, respiratory system, and skin. The concentrated OPP product evaluated (*Ecolab's 23 TB Disinfectant and Deodorizer*) is corrosive, with a DANGER precautionary signal word on its label, warning that it causes both eye and skin damage. According to the MSDS for this product, it has a very high pH (12 to 13).³⁷ Several ready-to-use OPP products – some of which are labeled as deodorizers as well as disinfectants – are packaged in aerosol containers, which can increase exposure via inhalation.

Environment: According to the RED for this chemical, OPP is very toxic to aquatic life³⁸ – although it has a half-life of 14 days, indicating it is unlikely to persist in the environment.

Efficacy: Ortho-phenylphenol (OPP) is typically found in surface disinfectants that can be used in healthcare environments, although neither of the two products evaluated meet the US or California *Bloodborne Pathogen Standard* because they are not registered to kill hepatitis B or C viruses. In addition, neither product is registered as a non-food-contact surface sanitizer. The concentrated OPP product evaluated (Ecolab's *23 TB Disinfectant & Deodorizer*³⁹) claims broad-spectrum efficacy against 23 bacterial strains including MRSA, nine types of viruses including *Herpes Simplex Type I*, HIV and influenza A (flu) virus, as well as two types of fungi – athlete's foot fungus and *Candida albicans*. To disinfect against these organisms, one ounce of this product must be added to each gallon of water (for a 1:128 dilution) and "allowed to remain wet [on the treated surface] for 10 minutes." This product claims efficacy against *Norovirus* and is registered as a tuberculocide when its concentration in the use-solution is doubled to two ounces per gallon, with the same 10-minute dwell time.

The RTU sample OPP product (*Airysol Brand Multi-Purpose Disinfectant Cleaner II*⁴⁰) claims efficacy against only the three required test bacteria to make disinfecting claims in a hospital environment plus five viruses (H1N1, Herpes Types 1 and 2, HIV, and influenza A (flu) virus). It is not registered to kill *E. coli*, MRSA or TB bacteria or any fungi (although it "prevents mold and mildew on hard surfaces"). Neither of these sample products meets either the US OSHA or California *Bloodborne Pathogen Standard* because they do not have registered efficacy against either Hepatitis B or C viruses.

Peroxyacetic Acid (PAA) (Usually in combination with hydrogen peroxide)

Peroxyacetic acid (CAS #79-21-0), also called peracetic acid, (CAS #89370-71-8) is often combined with hydrogen peroxide (H₂O₂) in surface sanitizers and disinfectants. In California, there are many products containing this combination of AIs registered as both disinfectants and non-food-contact surface sanitizers. (Some are registered as food-contact surface sanitizers as well.) Products containing PAA are not recommended, however, because the AOEC lists it as a substance that causes asthma via respiratory sensitization. Moreover, concentrated products containing this combination of active ingredients are corrosive and have other very strong health warnings. These problems are exacerbated by the fact that these products are not currently packaged in a closed-loop delivery system, leaving workers at risk of exposure to the concentrate. In addition, as disinfectants, these products have a relatively long dwell time (10 minutes) and their efficacy against viruses is very limited.

Health: As noted above, peroxyacetic acid (PAA) is listed as an asthmagen via respiratory sensitization by the AOEC, an authoritative body on this subject. In addition, concentrated products containing PAA + H₂O₂ have some of the strongest acute health warnings of any types of disinfectants. For example, the U.S. EPA-approved label for *SaniDate 5.0* includes the following precautionary statement: "DANGER: Corrosive. Causes irreversible eye damage and skin burns. May be fatal if inhaled or absorbed through the skin.... Do not breathe vapors or spray mist."⁴¹ This product contains relatively high concentrations of these two AIs: 23% hydrogen peroxide and 5.3% PAA, and has a highly acidic pH of 1.3. The health risks posed by this product are exacerbated by the fact that the product is available in an open container that can enable workers to become directly exposed to the concentrate.

In contrast, *SaniDate Ready to Use*, which lists only 0.108% H₂O₂ on its label, has no such health warnings.⁴² (Note: Although this product does not list PAA on its label or MSDS, the manufacturer confirmed that it does contain a small amount of this AI, which is a respiratory sensitizer in this pre-diluted product.) This RTU product is considered a less-toxic alternative to *SaniDate 5.0* in this analysis because it lacks the acute toxicity hazards of the concentrate. Nevertheless, neither product is recommended because of PAA's potential to cause asthma.

Efficacy: Disinfecting products containing PAA + H₂O₂ are typically registered to kill a broad range of bacteria but their efficacy against viruses is very limited. For example, *SaniDate 5.0*, when used as a disinfectant (diluted 0.5 ounces per gallon of water with a 10-minute dwell time) has registered efficacy against 16 types of bacteria (including antibiotic-resistant strains such as MRSA), but only three types of viruses (human and avian influenza

(flu) virus as well as canine distemper virus). This product also is registered to kill two types of fungi (including athlete's foot fungus) and inhibits (but does not kill) mold and mildew.^{43,44} SaniDate 5.0 is not registered to kill any of the three major bloodborne pathogens (HIV, HBV, or HCV). Consequently, it is not a good choice for cleanup of bodily fluids.

Surface disinfectants containing PAA + H₂O₂ are only available in concentrated form; they tend to be registered as sanitizers (for both food-contact and non-food-contact surfaces) as well, which adds to their versatility. No RTU products with this combination of AIs were found to be registered as disinfectants, although at least two are registered as sanitizers, including *SaniDate Ready to Use*, which was evaluated in this report.

As a non-food-contact surface sanitizer, the primary concentrated product evaluated (*SaniDate 5.0*⁴⁵) claims bacterial efficacy against only the two test organisms (*Staphylococcus aureus* and *Klebsiella pneumoniae*) with a relatively short dwell time of one minute. In contrast, while *SaniDate Ready to Use*⁴⁶ is also registered as a non-food-contact surface sanitizer against the two test organisms, it has a much longer, 5-minute dwell time and is not registered as a disinfectant at all. (It is, however, registered as a *food-contact* surface sanitizer with a 1-minute dwell time.)

Pine Oil

Pine oil (CAS #89370-71-8) has a variety of health concerns and typically offers limited efficacy. In addition, there are many pine oil-containing cleaning products on the market that are not registered as antimicrobials since pine oil is widely used as a scent, which may confuse consumers.

Health: Pine oil is severely irritating to the eyes, moderately irritating to the skin, and may cause skin rashes and other allergic skin reactions. It is considered a "weak allergen and severe skin irritant" by the National Library of Medicine.⁴⁷ Pine oil is not on the AOEC's list of asthmagens; however, some pine oil disinfectants also contain tall oil – a respiratory sensitizer that is also a pine derivative – in addition to pine oil. Pine oil is considered a skin sensitizer, carrying the European Union's REACH Directive hazard code R43: "May cause a skin sensitization reaction." Although pine oil is not considered a cancer-causing agent, a recent study conducted in a simulated residential setting found that using pine oil-based cleaning products can create secondary pollutants such as formaldehyde, a known human carcinogen, which can linger for 12 hours after cleaning a surface.^{48,49} There are many documented poisoning incidents involving pine oil-based cleaning products.⁵⁰ Pine oil can permeate the skin and may cause central nervous system effects and kidney damage.⁵¹

Environment: No environmental or aquatic toxicity information is available on the product labels, but the U.S. EPA categorizes pine oil as slightly toxic to fish and aquatic invertebrates. Pine oil breaks down into formaldehyde, which is more severely toxic to fish, and aquatic invertebrates.⁵²

Efficacy: Antimicrobial surface cleaning products that contain pine oil as their only active ingredient are registered as disinfectants and non-food-contact surface sanitizers primarily against bacteria. Pinalen, which lists 5% pine oil as its only active ingredient, is a "*limited* disinfectant against gram-negative bacteria" only; it has no efficacy claims against fungi or viruses.⁵³ This concentrated product, which is diluted 21 oz. per gallon of water, is one of the few pine oil products that does not list isopropyl alcohol on its MSDS.⁵⁴

Clorox Commercial Solutions Pine-Sol Brand Cleaner (EPA Registration No. 5813-83-AA-67619), which is a ready-to-use *general* disinfectant that contains a higher percentage of pine oil (8.7%), claims efficacy against two strains of bacteria (*Staphylococcus* and *Salmonella*) as well as athlete's foot fungus (but no viruses). This product also contains isopropyl alcohol, according to its MSDS⁵⁵, which may add to its efficacy, even though it is not listed as an AI on its U.S. EPA-approved label.

Several pine oil disinfectants that claim efficacy against viruses are formulated with quaternary ammonium chloride compounds (quats) in addition to pine oil. These products tend to be concentrates that carry a

“DANGER: Corrosive” warning. We were unable to find any concentrated disinfecting products non-food-contact sanitizers that contain pine oil as their *only* active ingredient.

The typical dwell time for pine oil-based disinfecting products is 10 minutes. This includes products containing pine oil as the only active ingredient, and products that contain quats as active ingredients in addition to pine oil.

Some pine oil-containing products are listed as a ready-to-use (RTU) product for disinfection and a concentrate that users are instructed to dilute with water for cleaning. While this adds to its versatility, it can create confusion. For example, the EPA-approved label for *Clorox Commercial Solutions Pine-Sol Brand Cleaner* (EPA Registration No. 5813-83-AA-67619) directs users to dilute the product ¼ cup per gallon for general cleaning – or to clean and deodorize bathrooms. However, this product must be used full-strength in order to work as a disinfectant. The cost and/or strong smell of using the undiluted concentrate may deter some users from considering this type of disinfecting product practical, especially given its limited efficacy and 10-minute dwell time.

Note: A 2013 walkthrough of several grocery and drug stores in the San Francisco Bay area revealed that the predominant Pine-Sol product on the shelves, *Original Pine-Sol Multi-Surface Cleaner* (EPA Registration No. 5813-101), does not list pine oil as an active ingredient at all. Instead, the only AI listed is 1.75% glycolic acid. Even the MSDS for this product does not include pine oil on the list of ingredients it contains.⁵⁶

Quaternary Ammonium Chloride Compounds (“Quats”)

Quaternary ammonium chloride compounds are among the most commonly used type of active ingredient for disinfecting and sanitizing both non-food-contact and food-contact surfaces. This is largely because products formulated with “quats” are readily available, versatile and relatively inexpensive (particularly highly concentrated formulations). In addition, they typically offer very broad-spectrum efficacy and do not have the unpleasant odor of chlorine bleach-based products.

The primary downsides of quats include their health hazards – including, notably, asthma – and environmental impacts, their relatively long dwell time (typically 10 minutes), their incompatibility with other commonly used cleaning products, and their ability to corrode floor polish and other surfaces⁵⁷. Many concentrated products containing quats require a wipe or rinse step after disinfection to protect human health and prevent sticky residues on treated surfaces that may contribute to antimicrobial resistance.

Health: All quaternary ammonium compounds are on AOEC’s asthmagen list as respiratory sensitizers. This includes, but is not limited to, the following:

- Alkyl dimethyl benzyl ammonium chlorides (ADBACs) (CAS #8001-54-5)
- Benzalkonium chloride (CAS #139-07-1)
- Benzyl-C12-18-alkyldimethyl, chlorides (CAS #68391-01-5)
- Dialkyl methyl benzyl ammonium chloride (CAS #73049-75-9)
- Didecyl dimethyl benzyl ammonium chlorides (DDACs) (CAS #7173-51-5)
- Quaternary ammonium chloride compounds, not otherwise specified (NOS)

One quat compound, benzalkonium chloride, also carries the European Union REACH Directive “R43” designation, meaning “May cause sensitization by skin contact.” However, other quats are not classified as skin sensitizers, and the National Institutes of Health concludes that benzalkonium chloride is a “rare” skin sensitizer⁵⁸.

The U.S. EPA classifies quats as “severe skin and eye irritants.”^{59,60} Moreover, at least one of the evaluated RTU product labels (*Professional Lysol Brand Disinfectant Antibacterial Kitchen Cleaner*) noted that, “prolonged or frequent skin contact may cause allergic reactions in some individuals.”⁶¹ The MSDS for the concentrated “quat” product evaluated for this report, Virex II/256 warns that it can cause corrosive effects to the nose, throat and respiratory tract; skin and eye burns; and permanent skin and eye damage, including blindness.⁶² The pre-

diluted quat products evaluated had less serious acute health warnings; none were labeled as corrosive. For example, the Lysol product listed above has a label warning stating that it “causes substantial but temporary eye injury.” The EPA-approved label for *Clorox Disinfecting Wipes*, another RTU quat product that was evaluated, states that it “causes moderate eye irritation.” No warning for skin irritation or sensitization is given for this product, although it does tell users to “wash thoroughly with soap and water after handling.” (Note: while this product label encourages parents to “be ready for school by including *Clorox Disinfecting Wipes* on your back to school shopping list,” it also has the following warning: “Keep out of reach of children.”)

Some surface disinfectants and sanitizers that contain quats but have a neutral pH are marketed as environmentally preferable products because they can replace quats that are caustic (i.e., with an extremely high pH of >12). In this assessment, all concentrated quats in this evaluation were labeled “corrosive” even if they had a neutral pH. For example, Rochester Midland’s *Enviro Care Neutral Disinfectant*, which is a concentrated quaternary disinfectant with a pH of 7.2 to 8.2, has the following precautionary statement on its U.S. EPA-approved label and MSDS: “DANGER: Corrosive, Causes irreversible eye damage.”^{63,64} This is of particular concern because the product is packaged in a container that can allow direct contact with the concentrate. Conversely, none of the ready-to-use (RTU) quat products evaluated were labeled corrosive.

Although not on California’s Prop 65 list as reproductive or developmental toxins, a June 2008 article in *Nature* highlighted a researcher who noted low fertility and small fetuses in mice that lived in cages cleaned with quaternary ammonium chloride compounds. In the presence of quaternary ammonium chloride salts, only 10% of female mice could conceive; a change to a different disinfectant solved the reproductive and developmental toxicity problems in the laboratory mice.⁶⁵

Environment: Quats are highly toxic to fish and other aquatic organisms, according to the U.S. Environmental Protection Agency’s RED for ADBACs and DDACs, two common categories of quats.^{66,67} This toxicity is exacerbated by the fact that quats do not readily degrade; instead they tend to concentrate in sewage sludge when sanitizers and disinfectants are flushed down the drain or down toilets during the cleaning of restrooms. There is also concern about these compounds inhibiting the activity of denitrifying bacteria in sewage sludge that are necessary for the breakdown of biological materials.⁶⁸ They bind readily to soils, and have half-lives ranging from five months (low persistence) to five years (highly persistent) depending on the study referenced.^{69,70,iii} In addition, studies have shown that certain quats contribute to antibiotic resistance in bacteria, including co-resistance and cross-resistance between quats and a range of other clinically important antibiotics and disinfectants.^{71,72}

Efficacy: Quats typically have some of the highest claimed efficacies of the surface disinfectants and sanitizers, but their dwell time is relatively long (10 minutes). The U.S. EPA-approved label for the sample concentrated disinfectant product containing “quats” that was evaluated for this report (Virex II 256⁷³) states the following: “When used as directed at a 1:256 dilution (1/2 oz. per gallon), this product contains 660 ppm of active quaternary germicide making it highly effective against a wide variety (broad-spectrum) of pathogenic microorganisms (including bacteria, antibiotic resistant bacteria, viruses, fungi, mold and mildew).” Specifically, this product has registered efficacy against 55 strains of bacteria as well as 12 strains of antibiotic resistant bacteria such as MRSA – although it does not have registered efficacy against *Mycobacterium bovis* (which can

ⁱⁱⁱ All of the guideline studies in the environmental fate part of the ADBAC RED indicate that ADBAC is essentially stable in the environment, with half-lives up to five years in an abiotic environment. ADBAC is hydrolytically stable under abiotic and buffered conditions with a half-life ranging from 150 to 379 days, depending on pH. ADBAC is completely stable to decomposition catalyzed by light in pH 7 buffered aqueous solutions. However, the registrant prepared a review of the open literature, unpublished documents, and meeting proceedings to make the case to EPA that ADBAC would biodegrade quickly. They concluded that ADBAC had a biodegradation half-life of 13 days. EPA accepted this conclusion, but there are no data presented in the RED supporting this conclusion. ADBACs have high water solubility but bind strongly to soils.

cause TB). It has registered efficacy against 20 types of viruses and meets both the U.S. OSHA and California *Bloodborne Pathogen Standards* because it kills HIV (with a one-minute dwell time) as well as HBV and HCV (with a 5-minute dwell time). Its label does not list efficacy against *Norovirus* (responsible for stomach flu) or *Rhinovirus* (which can cause the common cold), however. This product is registered as a fungicide, listing efficacy against athlete's foot fungus, mold/mildew and *Candida* (yeast).

The pre-diluted, ready-to-use liquid product that was evaluated, *Citrus Scent Professional Lysol Brand Disinfectant Antibacterial Kitchen Cleaner*, is a "germicide" that contains approximately 1% ADBAC quats, and is registered to kill far fewer pathogens than the concentrated product described above. This includes eight strains of bacteria, including MRSA, and five types of viruses, including influenza A (flu) virus and HIV, but not the other bloodborne pathogens (HBV or HCV). Similarly, this product "inhibits or controls" mold and mildew, but it does not claim to kill any fungi (including mold, mildew or athlete's foot fungus). It is a bacterial disinfectant and virucide with a 10-minute dwell time, and a "mildewstat" with a three-minute dwell time. This product kills HIV and is a non-food-contact surface sanitizer with a 30-second dwell time.⁷⁴

Clorox Disinfecting Wipes, which contains an even lower percentage of quaternary ammonium chloride compounds (0.29%) than the Lysol RTU product described above, also has registered efficacy against eight strains of bacteria (but MRSA is not included). It disinfects against seven types of viruses, including influenza A (flu) virus, herpes, and HIV, but not the other bloodborne pathogens (HBV or HCV). It is not registered as a fungicide and does not claim to inhibit mold or mildew. Users are directed to "use enough wipes for treated surface to remain visibly wet for 4 minutes." This product is registered as a non-food-contact surface sanitizer against only the two test bacteria (*Staphylococcus* and *Salmonella*) with a 30-second dwell time.⁷⁵

Quaternary ammonium chloride compounds are sometimes added to surface disinfectants and sanitizers to boost the efficacy of other active ingredients. During this review, the authors found several products containing quats as well as one or more of the following ingredients: citric acid, hydrogen peroxide, lactic acid, ortho-phenylphenol, pine oil, and thymol. In most of these products, the quats were listed as an additional active ingredient on the U.S. Environmental Protection Agency-approved product label. In at least two other cases, however, the quats were listed on the Material Safety Data Sheet (MSDS) for the product, but not on the product label as an AI. For example, *Oxyfect-H*,⁷⁶ which contains 1-5% quaternary ammonium chloride compounds (as well as H₂O₂), is marketed as a "peroxide hospital disinfectant cleaner"⁷⁷. The manufacturer (Betco) claimed in a phone conversation that the quats are included in the formulation as a surfactant designed to improve the cleaning ability of the product.

Thymol

Thymol (CAS #89-83-8) is derived from the cooking herb thyme, and is a major component of thyme oil. Thyme oil is intentionally added to food and "generally recognized as safe" by the US Food and Drug Administration (FDA) and the U.S. EPA.⁷⁸ Nevertheless, products containing thymol are not recommended because this AI is a skin sensitizer and has other health concerns, particularly in concentrated formulations. It also has a relatively long dwell time (10 minutes for disinfection).

Health: In its pure form thymol is corrosive to the eyes and severely irritating to the skin and respiratory system. The concentrated product that was included in this evaluation (*Thymo-Cide*, which contains 13% of this active ingredient) has the following precautionary statement on its U.S. Environmental Protection Agency-approved label: "DANGER: Corrosive. Causes irreversible eye damage." In contrast, the ready-to-use liquid thymol-based product that was evaluated, Method's *Antibac Antibacterial Kitchen Cleaner*, which contains .05% thymol, states on its label that is non-irritating and non-corrosive.⁷⁹

Thymol was listed as an asthmagen via respiratory sensitization (Rs) for a brief time in 2012, but it was removed in August 2012 and it is now listed with an R, which means there is currently not enough evidence to classify it as an asthmagen. (It is worth noting that thyme – the plant – is listed as a respiratory sensitizer (Rs) in the

AOEC database due to the incidence asthma after exposure to thyme dust in processing facilities.) In a pilot test of safer disinfectant products that was undertaken in several childcare centers by the San Francisco Department of Public Health, many users reported that they disliked the fragrance of thymol.

Thymol has been identified as a skin sensitizer in U.S. EPA's 2002 *Biopesticides Registration Action Document* (BRAD).⁸⁰ It does not pass the Green Screen review for reproductive toxicity or genetic toxicity, although the reliability of the studies cited is low.⁸¹ Exposure to the concentrated thymol-based product included in this evaluation (Thymo-cide) points to potential central nervous system effects. Its U.S. EPA-approved label includes the following warnings: "Harmful if absorbed through the skin" and "Measures against circulatory shock, respiratory depression, and convulsion may be needed."⁸²

Environment: Thymol degrades or dissipates fairly rapidly in the environment. The half-life for dissipation is 16 days in water and five days in soil. Volatilization is thought to be the primary pathway for dissipation.⁸³

Efficacy: Most of the disinfecting and non-food-contact surface sanitizing products containing thymol as their only active ingredient that are approved for use in California have AI concentrations ranging from 0.05% (in ready-to-use products) to 13% (in concentrates). All of the sample products that were evaluated are disinfectants capable of killing bacteria, viruses and in at least one case, athlete's foot fungus and TB. Only the concentrated formulation evaluated (*Thymo-Cide*) is registered to kill antibiotic-resistant strains of bacteria such as MRSA. It is registered only as a disinfectant (not a sanitizer) with efficacy against five strains of bacteria, five types of viruses, *Mycobacterium bovis* (which can cause tuberculosis), and athlete's foot fungus. It does not meet either the US OSHA or California *Bloodborne Pathogen Standard* because it is only registered to kill HIV (in one minute) but not HBV or HCV.

The RTU product, Method's *Antibac Antibacterial Kitchen Cleaner*^{iv} (which contains 0.05% thymol) claims disinfectant efficacy against five strains of bacteria, four types of viruses (e.g., influenza (flu) virus, ~~and~~ *Rhinovirus* (common cold) and HIV) with a 10-minute dwell time. With a 30-second contact time, this product is registered as a sanitizer for use on non-food-contact surfaces. No rinsing is required of either of the evaluated sample products.

Electrolyzed Water Devices

Electrolysis is chemical decomposition caused by passing an electric current through a solution containing ions. Electrolysis of water solutions can generate chemicals that have antimicrobial properties. There has been a recent upsurge in interest in devices claiming to use electrolytic processes to disinfect or sanitize surfaces. These are sometimes called "ionized water" devices by vendors.

There are two general categories of electrolyzed water devices:

- 1) Devices that require the addition of salt (NaCl) to the solution before electrolysis, such as the EcaFlo® Anolyte product (US EPA Reg. No. 82341-1).
- 2) Devices that use tap water, alone, such as the Activelon® and Ionator EXP® products.

Health: Type 1 devices produce hypochlorite ions, that is, a dilute chlorine bleach solution, which would account for the reported antimicrobial activity. One advantage of using such a device is that the user is never exposed to corrosive bleach concentrates, with their attendant skin and eye irritation hazards. However, in other respects, these devices seem to offer no advantage over chlorine bleach. Sodium hypochlorite, as well as chlorine gas and HCl, has been designated as astmagens by the Association of Occupational and Environmental Clinics (AOEC), and would also have corrosive effects on some surfaces (see section on chlorine bleach above).

^{iv} This product is also marketed as Seventh Generation's *Disinfecting Multi-Surface Cleaner*.

The chemical mechanisms at work in Type 2 devices remain unclear, and thus the health impacts are difficult to evaluate. Interviews with Activelon company representatives confirmed that no nitrate or chloride salts had been added to water solutions before they were electrolyzed and tested for antimicrobial activity. This means that the electrolyzed water from these devices would not contain hypochlorite ions as in Type 1 devices. Company representatives cited the role of “nanobubbles” in delaying the mixing of electrolytic products but did not have a definitive or scientifically documented theory to explain the claims of antimicrobial activity.

For this reason, the San Francisco Department of the Environment conducted tests of electrolyzed water for the presence of metal ions that could account for antimicrobial activity. Testing revealed that water from the devices contained hexavalent chromium, a potent genotoxic ion categorized as a human carcinogen and reproductive hazard⁸⁴. While only three devices were tested^v with San Francisco tap water, all devices released hexavalent chromium in small amounts^{vi}. Preliminary calculations determined that this amount of hexavalent chromium would not pose a worker hazard under the OSHA “PEL” (permissible exposure limits^{vii}), however, it is unknown whether the substance would accumulate on surfaces.

Environment: The materials needed to generate the disinfectant in Type 1 devices are low-toxicity compounds (water and salt), which – unlike many chlorine products - can be safely stored and transported. As with bleach, no residual disinfectant or sanitizer remains on treated surfaces. While the portability of some of these devices is another desirable attribute, the use of batteries may have environmental disadvantages.

Efficacy: As previously mentioned, Type 1 devices produce a dilute chlorine bleach solution, which would account for reported antimicrobial activity. For Type 2 devices, Activelon commissioned lab tests that demonstrated a >99.999% reduction in *E. coli*, *Pseudomonas aeruginosa*, and *S. aureus*. However, Activelon had not conducted the testing with sufficient controls and replications to prove the IonatorEXP™’s effectiveness as a sanitizer^{viii}. Furthermore, separate testing conducted by the Massachusetts Toxics Use Reduction Institute found little or no antimicrobial activity from Type 2 devices.

Lack of U.S. EPA oversight for antimicrobial devices: Because the IonatorEXP® is a device rather than an antimicrobial substance, it is not registered as a pesticide product by the U.S. EPA; consequently, its efficacy claims are not regulated. Device manufacturers are only required to have an establishment number from the U.S. EPA, and antimicrobial or other product claims are not reviewed, although “false or misleading” claims are prohibited. The relatively meaningless U.S. EPA establishment numbers are unfortunately easily confused with U.S. EPA product numbers⁸⁵.

In summary, Type 1 devices may conceivably be effective as antimicrobials, based on the presence of chlorinated electrolytic products. However, there is no U.S. EPA registration system available to confirm their efficacy for consumers, and the chronic health impacts are likely to be similar to the use of bleach. With Type 2 devices, the lack of a plausible mechanism casts additional doubt on their germ-killing capabilities, and the presence of chromium ions in the water may pose some risk.

^v One commercial IonatorEXP® device, one home use IonatorHOM® device, and a commercial Activelon® Pro device

^{vi} Hexavalent chromium levels ranged from 68 – 349 ppb, with most falling near 100 ppb. The OSHA Permissible Exposure Level (PEL) for hexavalent chromium is 5µg/m³ for airborne exposures. The non-regulatory California public health goal for drinking water is 0.02 ppb, and the federal maximum contaminant level for total chromium is 50 ppb. Note that drinking water standards assume much greater exposures and are, therefore, not the most appropriate reference standards in this case.

^{vii} Assuming the OSHA risk assessment breathing rate of 9.6m³/workday and 120µg/L of Cr⁺⁶ (SF measurements), a worker would need to breathe in 0.4L/day to reach the 5 µg/m³ PEL. Drowning occurs after inhaling 0.25-0.5 L.

^{viii} At the same time, the U.S. EPA acknowledged that there is no evidence to prove that the IonatorEXP™ does *not* sanitize effectively.

Safer Sanitizers and Disinfectants

Although all surface sanitizers and disinfectants have risks, some active ingredients (AIs) appear safer for human health and the environment than others. As mentioned earlier, the U.S. EPA has not permitted the use of ecolabels on any registered pesticides (including surface sanitizers and disinfectants) that are offered for sale in the United States. While Green Seal and EcoLogo have developed certifications that cover disinfectant and sanitizing products, very few products have actually been certified to date.

1. EcoLogo, which is based in Canada and was recently acquired by UL Environment (ULE) has certified a few hydrogen peroxide antimicrobial cleaning products such as Accel Concentrate and Accel Tb, which are recommended in this report. While these products do not carry the ULE/EcoLogo label when sold in the U.S., the same products do so in Canada. Users can check the ULE/EcoLogo [website](#) to find disinfectants and disinfectant cleaners that have been certified by EcoLogo under its [CCD-166](#) standard. (These products are noted in *Appendix A: List of Sample Safer Disinfectants and Sanitizers* of this report, below.) *Note: Many disinfecting products that are certified by EcoLogo do not meet San Francisco's health and environmental criteria because they contain quaternary ammonium chloride compounds (which are asthmagens) or thymol (which is a skin sensitizer).*



2. Green Seal, a third-party certifier that is based in the United States, included surface sanitizers and disinfectants in the scope of its July 2013 *GS-53: Specialty Cleaning Products* standard, although it does not have any products certified under that standard to date.



Green Seal does list a few products that are certified to its GS-37 institutional cleaning products standard that have a dual labeling scheme. One example is *Alpha HP. Alpha HP Multi-Surface Cleaner* is a peroxide-based product carries Green Seal's eco-label (but no disinfecting or sanitizing claims) on its package and marketing materials. The exact same product, called *Alpha HP Multi-Surface Disinfectant Cleaner*, has the EPA-approved sanitizing and disinfecting claims on its package and marketing materials, but lacks the Green Seal eco-label. Such products are sometimes referred to as “co-labeled”. Deciding which product to choose creates a dilemma for users that want to get credit for using a “green” certified product but need to use a registered disinfectant or sanitizer.

3. The U.S. EPA's Design for the Environment (DfE) Program has been conducting a pilot project since 2011 to identify safer sanitizing and disinfecting active ingredients and set up an approval process for the products that contain them, including adherence to DfE's other product screening methods. As of February 2013, DfE has approved the following active ingredients: (1) Citric acid; (2) Hydrogen peroxide; (3) L-Lactic acid; (4) Ethanol; and (5) Isopropanol. According to the DfE website, products composed of one or more of these active ingredients may be considered for the DfE logo. In addition, six antimicrobial cleaning products have been authorized to use the DfE logo. These six products include four that use lactic acid as their active ingredient and two the use citric acid. (These products are noted in *Appendix A: List of Sample Safer Disinfectants and Sanitizers* of this report, below.) For more information on the Pesticide DfE Program, go to <http://www.epa.gov/pesticides/regulating/labels/design-dfe-pilot.html>.



In light of the paucity of U.S. EPA-registered products that are verified as meeting any third-party environmental standards, this assessment uses multiple criteria to identify safer disinfectant and sanitizing active ingredients (see Evaluation & Coding Methods section above). The safer ingredients we identified include:

1. Caprylic acid
2. Citric acid
3. Hydrogen peroxide (H₂O₂), including stabilized and the proprietary “accelerated” versions (AHP™)

4. Lactic acid
5. Silver + citric acid (or hydrogen peroxide)^{ix} [Limited Use]

Below is a summary of preferred active ingredients that are not carcinogens, reproductive toxicants, asthmagens, or skin sensitizers and do not have serious environmental concerns (with the possible exception of silver, which is recommended for limited applications but is persistent and has high aquatic toxicity). Sample safer alternative products representing each preferred active ingredient are detailed in *Appendix A: List of Sample Safer Disinfecting and Sanitizing Products*. Note that a complete review of all products containing each active ingredient was not possible, and for some categories there are many other products with similar active ingredients available. When feasible, Appendix A lists products with the same U.S. EPA registration number as those (with a different name) that were evaluated and recommended since they are required to have the same formulation. In addition, products that are certified by ULE/EcoLogo or approved in the Pesticide DfE Pilot Project are noted as such.

Caprylic Acid

Caprylic acid (CAS #124-07-2), also called octanoic acid, is not listed as an asthmagen or a skin sensitizer. Nevertheless, this active ingredient is highly acidic when formulated as a concentrate (pH = 1). Although the only caprylic acid-based product approved for use as a non-food-contact surface sanitizer or disinfectant in California is a concentrate that is labeled corrosive, it is recommended because it is packaged in a container that prevents exposure to this highly acid, concentrated solution. (Note: This product also contains up to 20% phosphoric acid, according to the MSDS, which contributes to its extremely low pH.) This healthcare-environment disinfectant is recommended for use despite its relatively long, 10-minute dwell time.

There are currently no pre-diluted RTU products with caprylic acid as the only active ingredient approved for use in California or the US. One caprylic acid-based RTU surface disinfectant (*Quantum Tb* by Ecolab) was registered by U.S. EPA until 2011.⁸⁶ This product is listed as “inactive” by the CA DPR.

Health: The representative concentrated caprylic acid-containing disinfectant evaluated is Ecolab’s 65 *Disinfecting Heavy-Duty Bathroom Cleaner*, which contains approximately 3% of this AI. It has the following warnings on its U.S. EPA-approved product label: “DANGER: Corrosive. Causes irreversible eye damage and skin burns.”⁸⁷ The pH of the concentrate is 1 and its MSDS indicates that in addition to caprylic acid, it also contains 5-20% citric acid (which is not listed as an active ingredient) as well as 2% phosphoric acid.⁸⁸ The MSDS states that the diluted solution is “moderately irritating to the eyes”. This product is designed as a dispensing-system concentrate, which means it only can be dispensed through dilution equipment. This promotes accurate dilution of the product and prevents users from coming into contact with the concentrated solution.

Environment: No environmental warnings are present on the labels or MSDSs of any of the evaluated products containing this AI, but some products evaluated contain phosphorus, which contributes to aquatic eutrophication

Efficacy: The concentrated product we evaluated (Ecolab’s 65 *Disinfecting Heavy-Duty Bathroom Cleaner*) is registered as a healthcare-environment disinfectant when it is diluted 6-8 ounces per gallon of water and left on the surface for 10 minutes. It claims efficacy against nine strains of bacteria (including MRSA), seven viruses (including influenza (flu) virus, rhinovirus (common cold) and HIV, but not the other bloodborne pathogens hepatitis A or B). It is also a registered fungicide against *Candida albicans* only, but not against athlete’s foot fungus, mold or mildew. According to the U.S. EPA-approved label for this product, after the requisite dwell time, users are supposed to wipe the surface with a damp cloth or sponge, and then rinse the surface with potable

^{ix} The U.S. EPA Design for the Environment Program’s pilot project has excluded silver and caprylic acid, but includes ethanol and isopropyl alcohol, AIs that we did not evaluate. Silver is recommended here only for very limited uses.

water. The need for these additional steps at the end of the disinfecting process may make this product less convenient to use as a disinfectant than other alternatives.

When this product is diluted further, three ounces per gallon, and left on the surface for five minutes, it is a registered non-food-contact surface sanitizer against two of the test bacteria: *Staphylococcus aureus* and *Enterobacter aerogenes*. No rinsing is required after this sanitizing process.

Citric Acid

Over a dozen citric acid-containing non-food-contact surface sanitizers and disinfectants are registered for use in California. The concentration of this active ingredient in these products ranges from 0.6% to 8%. Almost all are ready-to-use (RTU) formulations; and even those identified in this evaluation that were listed as concentrates are formulated to be diluted only when used as a sanitizer or cleaner, but must be used full-strength to qualify as a disinfectant. One of example of this is *Comet Disinfecting Bathroom Cleaner*, which is a disinfectant when undiluted, a sanitizer when diluted 1:4, and a daily cleaner when diluted 1:9 to 1:19.⁸⁹

Health: Citric acid (CAS #77-92-2) is a recommended active ingredient because it is not listed as a substance that causes asthma, reproductive or developmental harm, or skin sensitization. However, not surprisingly, many citric acid-based products are highly acidic (pH between 2 and 4) and report mild to moderate irritation to the eyes, skin and respiratory system..

Environment: Citric acid, in the concentrations found in antimicrobial cleaning products, is not known to have any aquatic toxicity or other environmental risks.

Efficacy: The efficacies of currently U.S. EPA-registered and CA DPR-approved citric acid-based antimicrobial surface cleaners vary widely among products. Some are only bacterial disinfectants while others can kill bacteria, viruses and, in some cases, athlete's foot fungus. Most (but not all) have a 10-minute dwell time for disinfection and a 5-minute dwell time for non-food-contact surface sanitizing, with some variation depending on the product and the organisms targeted.

All of the surface sanitizers and disinfectants with citric acid as their only active ingredient that were included in this evaluation are recommended. Products that contain other active ingredients such as quats, thymol, and pine oil in addition to citric acid are not recommended – with the exception of products that contain citric acid and silver, which is recommended for limited applications and discussed in detail below.

Below is an overview of the citric acid-containing non-food-contact surface sanitizers and disinfectants that are recommended in this assessment:

- *Clean-Cide*⁹⁰ is a ready-to-use product by Wexford Labs that contains 0.6% citric acid. It is available both a liquid and wipes. The reviewed product is the liquid, which is registered as healthcare-environment disinfectant with efficacy against eight strains of bacteria (including MRSA), 10 viruses (including HIV), athlete's foot fungus, and the organism that causes TB, with a 5-minute dwell time. With a 10-minute dwell time, it also kills Hepatitis B virus (HBV), which means it meets the federal (OSHA) and California *Bloodborne Pathogen Standards*, and one additional bacterial strain. This product is also registered as non-food-contact surface sanitizer with a 60-second dwell time, although it claims efficacy against two test bacteria only.
- *Comet Disinfecting Bathroom Cleaner*, which contains 6% citric acid as its only active ingredient, is registered as healthcare-environment germicide with efficacy against 17 strains of bacteria (including antibiotic-resistant organisms such as MRSA) and 10 viruses (including the two requisite bloodborne pathogens HIV and HBV as well as Norovirus). It is not registered as a fungicide or tuberculocide. To disinfect, users must apply it full-strength for 10 minutes, then rinse or wipe the surface clean. This

product is also registered as a non-food-contact surface sanitizer (with efficacy against two test bacteria only) when diluted 1:4, allowed to stand on the surface for 5 minutes, and then rinsed or wiped off.⁹¹

- Method's *Antibac Kitchen Cleaner*⁹² is an RTU product that contains 5% citric acid as its only active ingredient. As a disinfectant, this product claims efficacy against only 4 types of bacteria (*E. coli*, *Enterobacter*, *Salmonella*, and *Staph.*) and 2 viruses (*Rhinovirus* and Influenza A (flu) virus). It is also registered as non-food-contact surface sanitizer with efficacy against two test organisms only with a 5-minute dwell time.
- Two DFE-approved citric acid-based disinfectants (Spartan's *Green Solutions Restroom Cleaner*,⁹³ which contains 8% citric acid, and *Comet Bathroom Cleaner With Disinfectant*⁹⁴) are also among the recommended disinfecting products. However, these RTU products have a relatively long (10-minute) dwell time and more limited efficacy than the products listed above. For example, *Comet Bathroom Cleaner With Disinfectant* is a bacterial disinfectant only (i.e., it has no registered efficacy against any viruses or fungi.) Spartan's *Green Solutions Restroom Cleaner* (also called *Consume Bio-Bowl*) is registered as a disinfectant against three types of bacteria and two viruses (Influenza A (flu) virus and *Herpes Simplex 2* virus), while it lacks efficacy claims against HIV and most other viruses as well as fungi. Neither of these products are registered as a non-food-contact surface sanitizer.

Hydrogen Peroxide (H₂O₂)

This active ingredient category includes products containing H₂O₂ (CAS #7722-84-1) as their only active ingredient as well as products containing a stabilized form of hydrogen peroxide called "Accelerated" Hydrogen Peroxide (AHP™). AHP™ is a "patented synergistic blend" developed by the Virox company that claims to "dramatically increase the germicidal potency and cleaning performance" of H₂O₂. Products containing AHP™ typically contain a relatively low concentration of H₂O₂ (approximately 0.5% in ready-to-use solutions and 4.25% in concentrates) as well as phosphoric acid, surfactants, and other "inert" ingredients.⁹⁵..

Products containing hydrogen peroxide as their only active ingredient are recommended because this AI is not considered an asthmagen, carcinogen, reproductive toxin, or skin sensitizer. Products containing hydrogen peroxide include both concentrates and ready-to-use formulations. Many are registered only as bacterial sanitizers and virucides (not bacterial disinfectants). At least one line of products, which is marketed to healthcare facilities, has efficacy against a broad spectrum of bacteria, viruses and fungi.

Some products marketed as hydrogen peroxide disinfectants contain quaternary ammonium chloride compounds (quats), silver or other antimicrobial compounds. One example is Betco's *Oxyfect-H Peroxide Disinfectant Cleaner*, which lists H₂O₂ as the only active ingredient on its product label⁹⁶, while its MSDS lists quats as additional ingredients.⁹⁷ Be sure to check both the product's U.S. EPA-approved label⁹⁸ and MSDS before purchase.

Health: Hydrogen peroxide is not classified as an asthmagen by the AOEC, and the European Union does not consider it a skin sensitizer. While H₂O₂ is not on the State of California's Prop 65 list of chemicals known to cause cancer, birth defects or other reproductive harm, there is some suspicion that it could have carcinogenic impacts. The American Conference of Governmental Industrial Hygienists (ACGIH) has concluded that hydrogen peroxide is a "confirmed animal carcinogen with unknown relevance to humans",⁹⁹ and an EU study concluded that H₂O₂ is a mutagen and genotoxicant in some in vitro tests but that "the available studies are not in support of significant genotoxicity/mutagenicity of H₂O₂ under in vivo conditions."¹⁰⁰ Hydrogen peroxide is a natural byproduct of metabolic processes, and most animals produce enzymes that break down peroxides into harmless byproducts.¹⁰¹

Concentrated H₂O₂ is highly reactive and quite dangerous. While the chemical is corrosive to the eyes, skin and lungs at levels of 50% and above, in its diluted form it is relatively benign. (Most hydrogen peroxide-containing

products have $\leq 1\%$ of this active ingredient in their diluted state, and concentrates rarely exceed 5%) Both the ready-to-use (RTU) and the concentrated products, once diluted, have very few, if any, health warnings. Some labels claim mild skin irritation and mild to moderate eye irritation, while others do not; this could also stem from the products' relatively low pH (~1-3). Nevertheless, it is important for users of concentrated H_2O_2 products to choose products that are designed to work with automatic dilution systems in order to prevent worker exposure to concentrated solutions.

Environment: The RTU and concentrated H_2O_2 products reviewed in this assessment have very few, if any, environmental warnings. Hydrogen peroxide is not toxic to aquatic species and it rapidly degrades in the environment into oxygen and water. Some AHP™ products are stabilized with phosphoric acid; if disposed down the drain, they can add phosphates to the aquatic environment, which can contribute to eutrophication.

Efficacy of H_2O_2 : Some of the evaluated antimicrobial products containing unstabilized H_2O_2 as their only active ingredient are registered as non-food-contact surface sanitizers (not disinfectants) that are also effective against viruses. For example, Envirox's *H₂Orange₂ Concentrate 117*¹⁰² (which contains 3.95% H_2O_2) is registered as a sanitizer with efficacy against six bacterial strains. As a virucide, it claims to kill HIV and Influenza (flu) virus^x, when it is diluted 10 ounces per gallon and left on the surface for 5 minutes. This product is meant for use with a dispensing system. *H₂Orange₂ 120 Ready to Use*¹⁰³ (which is also called *H₂Orange₂ One* and contains 1% H_2O_2) has similar efficacy as a bacterial sanitizer and virucide, but also kills athlete's foot fungus. It also has a 5-minute dwell time.

Spartan's *Peroxy II FBC Antibacterial Foaming Bath and Surface Cleaner* is another RTU product that contains 2.05% H_2O_2 (and lists citric acid as a non-active ingredient on its MSDS). It sanitizes non-food-contact surfaces in 2 minutes, claiming efficacy only against the two test bacteria. It is not registered as a bacterial disinfectant, virucide or fungicide.¹⁰⁴

A hydrogen peroxide disinfectant that has recently showed up on supermarket shelves is called *Lysol Power & Free Multi-Purpose Cleaner With Hydrogen Peroxide*. In contrast to several of the other H_2O_2 products described above, it is a registered bacterial disinfectant but not a sanitizer. This RTU cleaner (which is available as a liquid and wipes) contains approximately 1% hydrogen peroxide as its only active ingredient – although the MSDS also lists up to 1% citric acid. It has a 10-minute dwell time with registered efficacy against 6 strains of bacteria (gram positive and negative, including MRSA) and 5 viruses (including those responsible for colds and flu), but not any bloodborne pathogens (HIV, HBV or HCV). It is also a registered fungicide with efficacy against athlete's foot fungus.¹⁰⁵

In contrast, a product called *Clorox Healthcare Hydrogen Peroxide Disinfectant Cleaner*¹⁰⁶ is a ready-to-use disinfectant containing 1.4% H_2O_2 that makes claims against a much wider range of pathogens. This product, which is available as a liquid spray and wipes, has a very attractive one-minute dwell time and claims efficacy against over 20 strains of bacteria (including MRSA and other antibiotic-resistant strains of *Staphylococcus*), 18 viruses (including three bloodborne pathogens: HIV, Hepatitis B and C, as well as Herpes Simplex Types 1 and 2, Influenza (flu) virus, and *Norovirus*). It also kills athlete's foot fungus and *Candida albicans* in three minutes and is effective against TB in four minutes.

Like chlorine bleach, some hydrogen peroxide-based antimicrobial products can wear away surfaces such as metal and floor polish, especially if used regularly. Therefore, H_2O_2 -based antimicrobial products should be used primarily on tile floors, porcelain sinks, and on other compatible surfaces unless they are highly diluted. Unlike with bleach, however, no rinsing is required of any of the evaluated sample products unless they are used on

^x The U.S. EPA-approved label for *H₂Orange₂ Concentrate 117* states that this product also kills Herpes Type 2 and Hepatitis B virus. However, a fact sheet published by the manufacturer of this product, Envirox, notes that these virucidal claims may not be made in California. This fact sheet can be accessed at <http://enviroxclean.com/docs/Literature/1170411ONESHEET.pdf>.

food-contact surfaces.

Efficacy of AHP™: Products containing Accelerated Hydrogen Peroxide™ tend to be effective at killing a broader spectrum of pathogens with a shorter dwell time than products containing a similar amount of unstabilized hydrogen peroxide. One of the evaluated AHP™-containing products, *Oxivir Five 16*, is a healthcare-environment disinfectant with efficacy against 17 strains of bacteria (including several antibiotic-resistant strains such as MRSA), 17 viruses (including the bloodborne pathogens HIV, HBV and HCV as well as influenza (flu) virus, Norovirus, and Herpes), and athlete's foot fungus. This concentrated product, which contains 4.25% H₂O₂, and is diluted 1:16 (one cup per gallon of water), has a dwell time of five minutes for all pathogens except mold and mildew, which takes 10 minutes to kill. *Oxivir Five 16* offers users additional versatility because it is registered as a non-food-contact surface sanitizer (against seven strains of bacteria) when diluted 1:128 (one ounce per gallon) and at 1:256 it can be used as a non-disinfecting general purpose cleaner.¹⁰⁷



Another concentrated AHP-containing product, *Alpha-HP Multi-Surface Disinfectant* (EPA Reg. No. 70627-62^{xi}) is a more cost-effective disinfectant than *Oxivir Five 16*. While both products contain 4.25% H₂O₂ (as AHP™), Alpha-HP is diluted 1:64 (rather than 1:16). The trade-off is that it has a more limited registered efficacy and a longer, 10-minute, dwell time to kill bacteria. Nevertheless, it is registered to kill seven strains of bacteria (including MRSA) in five minutes and 14 viruses including all three bloodborne pathogens (HIV, HBV and HCV) as well as *Herpes Simplex 2*, *Norovirus* and *Rhinovirus* in 10 minutes. This product is not registered as a fungicide; so, it is not a good choice for addressing problems associated with athlete's foot fungus, mold or mildew. Like *Oxivir Five 16*, *Alpha-HP Multi-Surface Disinfectant* is registered as a non-food-contact surface sanitizer when it is diluted 1:128 and left on the surface for three minutes. When diluted 1:256 it can be used as a general-purpose cleaner without any antimicrobial claims.¹⁰⁸ Both AHP™ products above are sold as part of closed loop dispensing systems, which do not permit worker exposure to the concentrate.

One AHP™-containing ready-to-use (RTU) product™ was evaluated for this report, *Oxivir Tb*, has an even shorter disinfecting dwell time (one minute) against a wide array of bacteria (12 strains, including MRSA) and viruses (14 types including the bloodborne pathogens HIV, HBV and HCV, as well as the viruses that can cause colds (*Rhinovirus*), flu (*Influenza*), stomach flu (*Norovirus*), and herpes). It is also registered as a tuberculocide with a five-minute contact time, and in 10 minutes it kills athlete's foot fungus (although not other types of fungi such as mold or mildew). This product is also a non-food-contact surface sanitizer with efficacy against seven types of bacteria (including MRSA) with a short 30-second dwell time.¹⁰⁹ The use of a pre-diluted disinfectant can be expensive; however, its advantages of high efficacy and short dwell time – combined with the absence of carcinogens, asthmagens, and skin sensitizers – has made it an attractive option for many institutional facilities, particularly childcare centers.

Lactic Acid

There are only about a dozen non-food-contact surface sanitizing and/or disinfecting products containing lactic acid (CAS # 50-21-5) as their only active ingredient registered for use in California. All of them are available only as ready-to-use formulations with lactic acid concentrations ranging from 0.18% to 7.2%. There are no concentrated lactic acid disinfectants or non-food-contact surface sanitizers registered for use in California, making them less cost effective for institutional use.

Three of these products are approved by the U.S. EPA's Pesticide Design for Environment (DfE) Program.

^{xi} Another similarly named product, *Alpha HP* (U.S. EPA Registration No. 70627-54), has been replaced by the product that was evaluated for this report. There may be other products with a different name using this older EPA registration number, which is still active, available in the marketplace. Those products claim more limited efficacy than *Alpha-HP Multi-Surface Disinfectant Cleaner with EPA Registration No. 70627-62*).

These include:

- *Lysol Brand III Disinfecting All Purpose Cleaner* (U.S. EPA Reg. No. 777-100). This RTU product contains 3.2% lactic acid and is a health-care environment disinfectant.
- *B Cleaner* by International Consolidated Business (U.S. EPA Reg. No. 88472-1). This RTU product contains 3.7% lactic acid and is a registered disinfectant with efficacy against three bacteria (*Pseudomonas*, *Salmonella*, and *Staphylococcus*) in five minutes and a non-food contact surface sanitizer in one minute. Two products that utilize this registration number in California are *Bright Green Disinfecting All Purpose Cleaner* (88472-1-ZA-89054) and *Bright Green Disinfecting Bathroom Cleaner* (88472-1-AA-89054).
- *Toilet Bowl Cleaner* by International Consolidated Business (U.S. EPA Reg. No. 88472-2). This RTU toilet bowl cleaner contains 7.2% lactic acid and is registered as “a limited disinfectant against bacteria of intestinal origin” (i.e., gram-negative bacteria including salmonella, pseudomonas and rotavirus)” but no gram-positive bacteria such as *Staphylococcus aureus*, viruses or fungi. The product that utilizes this registration number in California is *Bright Green Antimicrobial Toilet Bowl Cleaner*.

Health: Lactic acid does not appear to pose chronic health risks. It is not a carcinogen, a reproductive or developmental toxin, an asthmagen nor a skin-sensitizing agent. The evaluated products produce slight to moderate eye and skin irritation.

Environment: Lactic acid poses no risks to the environment according to the product labels, MSDSs, and active ingredient information reviewed..

Efficacy: Each of the two sample products is registered as a disinfectant and non-food-contact surface sanitizer, depending on the dwell time used. Lactic acid disinfectants claim relatively poor efficacy. For example, *Windex Multi-Surface Antibacterial*,¹¹⁰ as its name implies, is a *limited-efficacy* disinfectant that is registered as effective against three bacteria only (no viruses or fungi) with a five-minute dwell time. Its sole active ingredient is 0.18% lactic acid. (Note: This product lists 1-5% isopropyl alcohol on its MSDS¹¹¹, which may boost its efficacy even though it is not listed as an active ingredient on the U.S. EPA-approved label for this product.)

Lysol Brand III Disinfecting All Purpose Cleaner,¹¹² which has significantly more lactic acid (3.2%), is registered against more organisms but has a longer 10-minute dwell time. It is a disinfectant that can be used in healthcare environments, but it is registered to kill only six bacteria (such as *Staphylococcus* and *Salmonella*) and four viruses (including influenza). It does not claim efficacy against MRSA or any fungi. In addition, neither of these products is registered against HIV or Hepatitis B or C viruses; therefore, they do not meet the suggested efficacy for use against bloodborne pathogens as referenced in the *California Bloodborne Pathogen Standard*.^{127,128}

As non-food-contact surface sanitizers, lactic acid-containing products typically have a very short dwell time. *Windex Multi-Surface Antibacterial*^{xii}, for example, has a notably short 10-second dwell time with registered efficacy against four bacteria (but no other pathogens). Similarly, *Lysol Brand III Disinfecting All Purpose Cleaner* is a registered non-food-contact surface sanitizer with efficacy against three bacteria (but no other pathogens) within 30 seconds.

^{xii} Note: In addition to approximately 1% lactic acid, this product contains up to 5% isopropyl alcohol as a non-active ingredient, which may boost its efficacy.

Silver

Silver is found in non-food-contact surface sanitizers and disinfectants, usually in combination with other active ingredients. Two of the California DPR-approved products we evaluated (*Critical Care* and *Pure Hard Surface*) are ready-to-use (RTU) products with different EPA registration numbers but the same formulation: 0.003% ionic silver (not nano-silver) and 4.84% citric acid. A third product, Core Products Company's *Hydroxi Pro Force D*, is another RTU formulation that contains 0.01% ionic silver plus 5% hydrogen peroxide. Because these solutions are pre-diluted and often packaged in a spray bottle, they are not likely to be cost-effective for disinfecting floors and other large surfaces. Their notable advantage is their efficacy against a wide range of bacteria (including MRSA) and viruses, along with up to 24-hour residual activity on a treated surface. However, they are more expensive than most other products and have elevated water quality concerns. Therefore, they may be most valuable for treating touch-point surfaces such as sink faucets, doorknobs, and toilet handles during outbreak or other high-alert situations when other products with fewer environmental concerns but lower efficacy are not sufficient.

Health: Silver has low toxicity to humans, and most silver that is ingested is rapidly excreted. Although exposure to high doses of silver can cause lung and kidney lesions or mild allergic reactions such as rashes, swelling and inflammation, the low levels of silver present in these surface disinfecting products is not anticipated to present the same risks. All of the products containing silver ions and citric acid that are registered by the U.S. EPA and carry a CAUTION signal word on their label.⁹ The sample disinfecting products containing silver and citric acid are mild skin and eye irritants with a highly acidic pH (2.0).¹⁰ The evaluated RTU product that contains silver and hydrogen peroxide, carries the same CAUTION signal word but slightly stronger health warnings. For example, it is considered moderately irritating to the eyes, skin and respiratory system, according to the MSDS for this product.¹¹³

Silver ions and citric acid are not classified as respiratory sensitizers or other types of asthmagens by the AOEC or other sources. Silver is not known to have human carcinogenic potential and does not appear to be a mutagen, according to the U.S. EPA RED for this AI. Silver is not listed by the State of California as a developmental or reproductive toxicant, and no other sources reviewed indicated that silver causes reproductive or developmental toxicity.

Environment: Some silver salts are very highly toxic to fish and other aquatic organisms, and silver is listed as a priority pollutant in the Clean Water Act.¹¹⁴ When entering the waste water system or natural waterways, silver may combine with other ions such as chloride, nitrate, or sulfur, sometimes increasing its toxicity and availability to marine organisms.¹¹⁵

As inorganic metal compounds, silver ions persist once released into the environment. The toxicity and bioaccumulation potential of silver are very low, with biomagnification very low in herbivores and with no evidence of biomagnification in carnivores.^{116,117} Silver is considered persistent but not bioaccumulative by Environment Canada based on the *Canada Domestic Substances List*¹¹⁸. Silver does biomagnify somewhat, however, in plants and bivalves (such as clams, to which it is toxic and inhibits reproduction).¹¹⁹ While these products are not likely to contribute significantly to the silver load in wastewater or sewage sludge at current use levels, the increasing use of silver as a biocide overall warrants considering how this product may contribute to the silver load in discharge waters. For these reasons, we restrict our recommendation for silver-based disinfectants to exceptional public health circumstances.

Efficacy: Disinfecting products containing silver and either citric acid or hydrogen peroxide have registered efficacy against a wide range of bacteria, viruses and fungi, with dwell times ranging from 30 seconds to 10 minutes. They are particularly effective at killing bacteria such as *E. coli*, *Salmonella*, and *Staphylococcus*, including antibiotic resistant strains such as MRSA. They can be particularly useful in the event of outbreaks of MRSA, influenza (flu) virus, or athlete's foot fungus, since the residue from these products does not need to be

rinsed off and can continue working as a disinfectant for up to 24 hours.

Although all the silver + citric acid products have the same percentage of active ingredients, they vary in claimed efficacy and dwell time. For example, *Pure Hard Surface* (EPA Reg. No. 72977-5) claims efficacy against 14 strains of bacteria (including MRSA in two minutes), 16 viruses (including HIV, HBV, and HCV in one minute), and athlete's foot fungus (in five minutes).¹²⁰ Consequently, it is appropriate for use under the recommendations of the *California Bloodborne Pathogen Standard*. In contrast, *Critical Care* (EPA Reg. No. 72977-3)^{xiii} is registered against 11 bacterial strains (including MRSA in two minutes), nine viruses (including HIV, but not HBV or HCV, with dwell times ranging from 30 seconds to 10 minutes) and athlete's foot fungus in 10 minutes).¹²¹ Users should check the label for the efficacy and application instructions of specific products.

Core Products Company's *Hydroxi Pro Force D*, which contains silver and hydrogen peroxide, is a healthcare-environment disinfectant with a 10-minute dwell time. It kills seven types of bacteria (including MRSA), five viruses (including HIV, Influenza (flu) virus, and Rhinovirus (the common cold virus)), and athlete's foot fungus. It also prevents the growth of (but does not completely kill) mold and mildew. (Note: This product is also registered under the name *Sanosil S010*, EPA Reg. No. 4526-1.)¹²²

Neither of the two products that contain silver and citric acid is registered as a non-food-contact surface sanitizer. At least one product – *Pure Hard Surface* – is registered as a food-contact surface sanitizer with a one-minute dwell time. *Hydroxi Pro Force D*, is registered as a non-food-contact surface sanitizer (against an unspecified number of bacteria) with a five-minute dwell time.

Promising Devices

Microfiber Cloths and Mops

Microfiber products do not kill germs, but are useful tools because of their enhanced cleaning ability – and effective cleaning can eliminate the vast majority of microbes on surfaces. Microfibers are densely constructed, polyester and polyamide (nylon) fibers, that are approximately 1/16 the thickness of a human hair. The positively charged microfibers attract dust (which has a negative charge) and are more absorbent than a conventional, cotton-loop mop. Microfiber materials also can be wet with disinfectants. They can reduce use of water and cleaning chemicals. They lessen physical strain, and one case study from the University of California Medical Center documented a reduction in workers compensation claims.¹²³ Because microfiber cloths attract more dust, particles, and microbes than a string mop (95% versus 68% according to an U.S. EPA case study on cleaning practices at the University of California, Davis Medical Center),¹²⁴ they are a preferred option for pre-cleaning. When used before an antimicrobial product, microfiber mops and cloths are expected to boost efficacy against target organisms. Because microfiber mop covers are changed after every one or two rooms, the risk of cross-contamination between areas is greatly reduced or eliminated, which is particularly important in a medical facility. However, because they only reduce bacterial populations by 95% when used alone, they are not a complete replacement for sanitizers or disinfectants.

Steam cleaning

Some steam cleaning devices are marketed for sanitizing or disinfecting surfaces, and show promise as a non-chemical approach for some situations. Hospitals have long used steam for sterilizing equipment, and there is significant scientific documentation of steam's effectiveness in killing microbes.¹²⁵ Most steam cleaning machines do not require the use of chemicals, although the high temperatures involved may affect certain

^{xiii} Critical Care uses the EPA Registration No. 72977-3, which was originally provided to a product called *Axen 30 Disinfectant, Virucide and Fungicide*. Other products using this EPA registration number that are approved for use in California include *PureGreen24* and *Germ Control 24*.

surfaces. Steam has the potential to cause serious burns, but has no other known health or environmental impacts. In routine use, there are some logistical problems with steam, for example, the heat may set off fire alarms in some cases.

A variety of steam cleaning devices is available: For example, the “Thermal Accelerated Nano Crystal Sanitation (TANCS®) Steam Vapor System” by Advanced Vapor Technologies LLC claims a 99.999% reduction in all microbes tested after seven seconds of treatment¹²⁶. Because the US EPA does not regulate pesticidal devices, however, there is no standardized, ready reference for efficacy. As such, it was beyond the scope of this report to compare the antimicrobial efficacy of specific steam cleaning products. A study currently underway in Massachusetts may soon shed more light on this technology.^{xiv}

Surface Compatibility

Not all antimicrobial products are compatible with all surfaces. Table 2 below lists each active ingredients’ surface incompatibilities based on information in the EPA-approved label and/or the MSDS of the evaluated products. It is important to note that the information reported for each active ingredient in the table may not apply to every evaluated product.

Table 2. Potential surface incompatibilities for disinfectant active ingredients

ACTIVE INGREDIENT	SURFACE INCOMPATIBILITY
Caprylic Acid	Not for use on PVD-coated surfaces or soft metals. Reactive with metals.
Citric Acid	Do not use on marble, brass or varnished metals.
Hydrogen Peroxide	Not recommended for use on aluminum, wood, natural stone, porous plastic, rubber. Corrosive to metals.
Hydrogen Peroxide, Accelerated (AHP)	Not recommended for use on copper, brass, granite, marble or zinc.
Lactic Acid	Not recommended for use on finished wood, floors/ surfaces, marble, brass or acrylic plastic (including outdoor patio furniture).
Ortho-Phenylphenol (OPP)	Rinsing is not necessary except on floors are to be waxed or polished.
Peroxyacetic Acid (PAA)	Avoid metals.
Pine Oil	Not recommended for use on unfinished, unsealed, unpainted, waxed, oiled, or worn wood flooring.
Quaternary Ammonium Chloride Compounds (Quats)	Not recommended for use on finished wood floors, marble, copper, aluminum, brass, painted surfaces, fabric and acrylic plastic. Stainless steel may become damaged from prolonged exposure.
Silver + Citric Acid	May be slightly incompatible with aluminum and copper metals after prolonged exposure. Product is compatible with most metals including stainless steels."
Silver + Hydrogen Peroxide	Do not use on polished wood, painted surfaces, leather, rayon fabrics, or acrylic plastics.
Sodium Hypochlorite (Chlorine Bleach)	Prolonged contact with metal may cause pitting or discoloration. Do not use with copper and iron. Will corrode aluminum. May cause damage to fabric/clothing (bleaching).
Thymol	Prolonged soaking may cause damage to metal instruments.

^{xiv}Toxics Use Reduction Institute and the Univ. of Massachusetts/Lowell Clinical Science Lab are collaborating on this project; see http://www.turi.org/Our_Work/Green_Cleaning_Lab/Does_It_Clean/Green_Disinfection

The information in the table above has been aggregated by active ingredient (AI). The degree to which products containing each of these AIs (or combinations of AIs) corrode, discolor, or otherwise negatively impact various surfaces can be influenced by several factors, including the percentage of the AI and other ingredients in the formulation, the amount of time the product is left wet on the surface, the decision to wipe or since the disinfecting or sanitizing residue off the surface after use, and the frequency of application.

Chemical Compatibility

Surface disinfectants and sanitizers should not be mixed with each other or other cleaning chemicals. Doing so can sometimes cause dangerous – and potentially lethal – gases to form. Table 3 below lists each active ingredients' chemical incompatibilities based on information in the EPA-approved label and/or the MSDS of the evaluated products. It is important to note that the information reported for each active ingredient in the table may not apply to every evaluated product.

Table 3. Potential chemical incompatibilities for selected active ingredients

ACTIVE INGREDIENT	CHEMICAL INCOMPATIBILITY
Caprylic Acid	Mixing with bleach or other chlorinated products will cause chlorine gas.
Citric Acid	Do not mix with chlorine bleach or other cleaning products as irritating fumes may be formed.
Hydrogen Peroxide	Do not mix with bleach or other household products.
Hydrogen Peroxide, Accelerated (AHP)	Do not mix with ammonia, bleach, or other chlorinated compounds. May react to release hazardous gases.
Lactic Acid	Do not mix with bleach or other household chemicals.
Ortho-Phenylphenol (OPP)	Slightly reactive with acids.
Peroxyacetic Acid (PAA)	Avoid heat and contact with combustible materials. Not flammable, but may cause spontaneous ignition with oxidizing agents.
Pine Oil	Flammable. Avoid heat, sparks, open flames or other sources of ignition. Do not mix with other chemicals.
Quaternary Ammonium Chloride Compounds (Quats)	Mixing with sodium hypochlorite may release small amounts of formaldehyde gas. Do not mix with bleach or other household products.
Silver + Citric Acid	Incompatible with ammonia and hydroxides.
Silver + Hydrogen Peroxide	Incompatible with oxidizing and reducing agents.
Sodium Hypochlorite (Chlorine Bleach)	Reacts with other household chemicals such as toilet bowl cleaners, rust removers, vinegar, acids, or ammonia containing products to produce hazardous gases, such as chlorine and other chlorinated species.
Thymol	Incompatible with strong alkalis, cationics, nonionics.

Special Scenarios

For information on active ingredients and sample products effective against bloodborne pathogens (HIV and HBV, for cleaning up blood and other bodily fluid spills), athlete's foot fungus (for use in locker rooms, gymnasiums, and showers), and Norovirus, refer to Appendix C.

Conclusions

Safer Active Ingredients

In this alternatives analysis, a dozen active ingredients (AIs) – or combinations of AIs – have been evaluated for potential health and environmental risks. From a health perspective, the most serious health risks associated with surface disinfectants and sanitizers appear to be respiratory effects (asthma) and acute toxicity risks from handling corrosive concentrates, which can cause severe skin burns or permanent eye damage. Acute toxicity can be mitigated through the use of closed loop dilution systems, which prevent exposures to the concentrated products; however, asthmagens are not so easily avoided. There are also other chronic effects associated with some products that are known carcinogens and skin sensitizers. The AIs that fall into these categories include sodium hypochlorite (chlorine bleach), peroxyacetic acid, and quaternary ammonium chloride compounds (quats), which are all respiratory sensitizers; pine oil and thyme oil, which both skin sensitizers, and ortho-phenylphenol, which is a carcinogen. Among the AIs that are not known to cause cancer or asthma are hydrogen peroxide, citric acid, lactic acid, caprylic acid, and silver plus citric acid. Silver, however, is both expensive and toxic to aquatic organisms, making it a poor choice for large-scale use.

Efficacy

After comparing a variety of surface disinfectants and sanitizers, we have determined that there are some safer products available with preferable health and environmental profiles and equivalent or better efficacy than the traditional, more toxic products. The results are detailed in Appendix A, and a full analysis of representative concentrated and RTU products for each active ingredient are covered in detail in a supplemental spreadsheet available upon request.

Future Challenges

There are two sets of important data missing from these analyses: *Full ingredient disclosure* of chemicals in each of the analyzed products, and *standardized efficacy data on pesticidal devices* such as steam cleaners and electrolyzed water devices.

Full ingredient disclosure is critically important to any analysis of cleaning product safety, and is a central theme of various efforts underway to reform national and state chemicals policies. Until these reforms are successful, third-party certification programs and the US EPA's Design for the Environment Program have key roles to play, since - unlike the general public - these programs have access to full ingredient lists.

As discussed earlier, pesticidal devices are essentially unregulated at the federal level. Consumers therefore have no way of easily evaluating devices' effectiveness, since there is no accepted standard set of tests and protocols. The next best thing is a broad comparison of devices, using standardized protocols, by a third party. Steam cleaning devices, in particular, show promise as chemical-free disinfection, and we look forward to the results of efficacy testing currently underway at the Massachusetts Toxics Use Reduction Institute.

In summary, this report provides the City and County of San Francisco with the information necessary to identify effective disinfectants and sanitizers posing lower risks to human health and the environment, which supports the City's commitment to the Precautionary Principle. While our conclusions are constrained by data and regulatory limitations, they suggest reasonable steps to protect custodial workers and the general public.

Appendix A: List of Sample Safer Disinfecting and Sanitizing Products

The following surface disinfectants and non-food contact surface sanitizers are recommended by the San Francisco Department of the Environment because they contain active ingredients that are not carcinogens, reproductive or developmental toxins, asthmagens, or skin sensitizers and don't carry other significant health or environmental risks.

This list is not meant to be exhaustive. Instead, it shows how products with a given AI are expected to perform. New products enter the market regularly, and more options meeting these criteria are expected in the future. All products are registered as a disinfectant, non-food-contact sanitizer or both by the US Environmental Protection Agency (EPA) and are approved for use by the California Department of Pesticide Regulation. The list includes brands that have the same registration number as products that were evaluated and recommended in this assessment, as well as products with the same (or a similar) amount of an active ingredient (or combination of active ingredients).

Some of the preferred product examples are concentrated while others are ready-to-use (RTU) formulations. RTUs have the advantage of being pre-diluted, so the products tend to have relatively low hazards. They are, however, substantially more expensive, and concentrates are much preferred for environmental reasons: Since they contain 1/16 to 1/128 as much water, concentrates can be shipped much more cheaply, with less fuel use and therefore greenhouse gas impacts. The recommended concentrates have relatively few health warnings on their diluted use solution, but most are corrosive in their concentrated form. All concentrated disinfecting products should be used ONLY with automatic dilution equipment – preferably “closed loop” systems, which preclude any contact with the concentrated product. Pump-style dilution systems are generally insufficient, as they do not eliminate risks of spills or splashes of the corrosive materials.

More detailed information about each of the evaluated disinfectants, including recommended products, can be found in Table 4 below. The full Microsoft Excel file – with still more detail - is available on request.

Recommended Disinfectants

(Concentrated products - preferred for environmental reasons - are **highlighted**)

Caprylic/Octanoic Acid

- **Ecolab 65 Disinfecting Heavy-Duty Acid Bathroom Cleaner*** (Concentrate: 1:16-1:21, 10-minute dwell time)

Citric Acid

- **Clean-Cide Ready to Use Germicidal Detergent*** (RTU, 5-minute dwell time)
- **Clean-Cide Wipes** (RTU, 5-minute dwell time)
- **Comet Bathroom Cleaner With Disinfectant** (RTU, 10-minute dwell time)
- **Comet Disinfecting Bathroom Cleaner*** (RTU, 10-minute dwell time)
- **Green Solutions Restroom Cleaner** (RTU, 10-minute dwell time)
- **Method Antibac Kitchen/Bathroom Cleaner*** (RTU, 10-minute dwell time)
- **Professional Lysol Brand II Disinfectant Basin Tub & Tile** (RTU, 10-minute dwell time)

Hydrogen Peroxide (including “Accelerated” HP)

- **Accel Concentrate** (Concentrate: 1:16 dilution, 5-minute dwell time)
- **Alpha-HP Multi-Surface Disinfectant Cleaner*** (Concentrate, 1:64 dilution, 10-minute dwell time)
- **Carpe Diem Concentrate Five 16** (Concentrate, 1:16 dilution, 5-minute dwell time)
- **Oxivir Five 16*** (Concentrate, 1:16 dilution, 5-minute dwell time)
- **Accel Tb** (RTU, 1-minute dwell time)
- **Accel Tb Wipes** (RTU, 1-minute dwell time)
- **Carpe Diem Tb** (RTU, 1-minute dwell time)
- **Carpe Diem Tb Wipes** (RTU, 1-minute dwell time)
- **Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant*** (RTU, 1-minute dwell time for most organisms)
- **Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant Wipes** (RTU, 1-minute dwell time for most organisms)
- **Clorox Hydrogen Peroxide Cleaner Disinfectant** (RTU, 1-minute dwell time for most organisms)
- **Clorox Hydrogen Peroxide Cleaner Disinfectant Wipes** (RTU, 1-minute dwell time for most organisms)
- **Lysol Power & Free Bathroom Cleaner With Hydrogen Peroxide** (RTU, 10-minute dwell time)
- **Lysol Power & Free Multi-Purpose Cleaning Wipes With Hydrogen Peroxide** (RTU, 10-minute dwell time)
- **Optim Tb** (RTU, 1-minute dwell time)
- **Optim Tb Wipes** (RTU, 1-minute dwell time)
- **Oxivir Tb*** (RTU, 1-minute dwell time)

Lactic Acid

- **Bright Green Disinfecting All Purpose Cleaner** (RTU, 5-minute dwell time)
- **Bright Green Antimicrobial Toilet Bowl Cleaner** (RTU, 5-minute dwell time)
- **Scrubbing Bubbles Multi-Surface Bathroom Cleaner** (RTU, 5-minute dwell time)
- **Lysol Brand III Disinfecting All Purpose Cleaner*** (RTU, 5-minute dwell time)
- **Windex Disinfectant Cleaner/Windex Touch-Up Cleaner II** (RTU, 10-minute dwell time)
- **Windex Multi-Surface Antibacterial*/Windex Touch-Up Cleaner** (RTU, 5-minute dwell time)

Silver + Citric Acid (Limited Use Due to Water Quality Concerns from Large-Scale Application)

- **Critical Care** (RTU, 10-minute dwell time)
- **Fiberlock Technologies Shockwave Green 24 Botanical & Silver Disinfectant** (RTU, 10-minute dwell time)
- **Germ Control 24-Silver Formula** (RTU, 10-minute dwell time)
- **Pure Hard Surface** (RTU, 5-minute dwell time)
- **PureGreen24** (RTU, 10-minute dwell time)

Silver + Hydrogen Peroxide (Limited Use Due to Water Quality Concerns from Large-Scale Application)

- **Hydroxi Pro Force D** (RTU, 10 minute dwell time)
- **Sanosil S010** (RTU, 10 minute dwell time)

Recommended Non-food Contact Surface Sanitizers

(Concentrated products - preferred for environmental reasons - are highlighted)

Caprylic/Octanoic Acid

- **Ecolab 65 Disinfecting Heavy-Duty Acid Bathroom Cleaner*** (Concentrate, 1:40 dilution, 5-minute dwell time)

Citric Acid

- **Comet Disinfecting Bathroom Cleaner*** (Concentrate, 1:4 dilution, 5-minute dwell time)
- **Clean-Cide Ready to Use Germicidal Detergent*** (RTU, 60-second dwell time)
- **Clean-Cide Germicidal Wipes** (RTU, 60-second dwell time)
- **Method Antibac Kitchen/Bathroom Cleaner*** (RTU, 5-minute dwell time)
- **Professional Lysol Brand II Disinfectant Basin, Tub & Tile Cleaner** (RTU: 30-second dwell time)

Hydrogen Peroxide (including "Accelerated" HP)

- **Accel (Concentrate: 1:128, 3-minute dwell time)**
- **Alpha HP (Concentrate, 1:128 dilution, 3-minute dwell time)**
- **Alpha-HP Multi-Surface Disinfectant Cleaner* (Concentrate, 1:128 dilution, 3-minute dwell time)**
- **Carpe Diem Concentrate Five 16 (Concentrate: 1:128, 3-minute dwell time)**
- **Envirox Concentrate 118/H2Orange2 117*** (Concentrate, 5-minute dwell time)
- **Envirox H2Orange2 Superconcentrate 112 (Concentrate: 5:23 dilution, 5-minute dwell time)**
- **G-Force H2O2 Bathroom Cleaner Disinfectant (Concentrate, 1:128 dilution, 3-minute dwell time)**
- **Oxivir Five 16* (Concentrate, 1:128 dilution, 3-minute dwell time)**
- **Ramsey Bathroom Cleaner Disinfectant (Concentrate, 1:128 dilution, 3-minute dwell time)**
- **Accel Tb** (RTU, 30-second dwell time)
- **Accel Tb Wipes** (RTU, 30-second dwell time)
- **Carpe Diem Tb** (RTU, 30-second dwell time)
- **Carpe Diem Wipes** (RTU, 30-second dwell time)
- **Envirox H2Orange2 One*** (RTU, 5-minute dwell time)
- **Optim Tb** (RTU, 30-second dwell time)
- **Optim Tb Wipes** (RTU, 30-second dwell time)
- **Oxivir Tb*** (RTU, 30-second dwell time)

Lactic Acid

- **Bright Green Disinfecting All Purpose Cleaner** (RTU, 60-second dwell time)
- **Bright Green Disinfecting Bathroom Cleaner** (RTU, 60-second dwell time)
- **Bright Green Antimicrobial Toilet Bowl Cleaner** (RTU, 60-second dwell time) – limited efficacy
- **Lysol Brand III Disinfecting All Purpose Cleaner*** (RTU, 30-second dwell time)
- **Scrubbing Bubbles Multi-Surface Bathroom Cleaner** (RTU, 30-second dwell time)
- **Spartan Peroxy II FBC Antibacterial Foaming Bath & Surface Cleaner (RTU, 2-minute dwell time)**
- **Windex Disinfectant Cleaner/Windex Touch-Up Cleaner II** (RTU, 10-second dwell time)
- **Windex Multi-Surface Antibacterial*/Windex Touch-Up Cleaner** (RTU, 10-second dwell time) – also contains isopropyl alcohol

Table 4. Summary of product efficacy and health/environmental impacts for disinfectant and sanitizer products reviewed

Active Ingredient	Conc or RTU	Product	Disinfection			Sanitizing			Health							Environment				
			Dwell (min.)	Bact.	Viruses	Fungi	Sanitizer?	Dwell time (min.)	Signal Word	Cancer	Repro.	Respir.	Asthma	Skin	Eye	pH	HMIS	Aquatic	Persist.	Eutroph.
Caprylic acid (Octanoic acid)	Conc	Ecolab 65 Disinfecting Heavy-Duty Acid Bathroom Cleaner [1677-204]	10	9	7	1	Yes	5 min @ 3 oz/gal	DANGER - Corrosive	0	0	3	No	4	4	C	3	1	0	Yes
	RTU	Clean-Cide Ready to Use Germicidal Detergent [34810-35]	5	8	10	1	Yes	1 min	CAUTION	0	0	1	No	1	2	2-2.3	0	0	0	No
Citric acid	RTU	Comet Disinfecting Bathroom Cleaner [3573-54]	10	17	10	0	Yes	5 min @ 1:4	CAUTION	0	0	1	No	1	2	3	3	0	0	No
	RTU	Method Antibac Kitchen Cleaner [75277-2]	10	4	2	None	Yes	5	CAUTION	0 ¹	0	0	No	0	0	4-6	0	0	0	No
Hydrogen peroxide	RTU	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant [67619-24]	1	25	18	2	Yes	30 sec.	CAUTION	0 ¹	8	8	No	2	3	2	No info	2	0	No
	RTU	Lysol Power & Free Multi-Purpose Cleaner With Hydrogen Peroxide [777-117]	10	6	5	1	No	N/A	NONE	0 ¹	0	0	No	1	1	2.1-3.5	1	2	0	No
Hydrogen Peroxide, Accelerated (AHP)	Conc	Alpha-HP Multi-Purpose Disinfectant Cleaner [70627-62]	10	7	14	None	Yes	3 min @ 1:128	CAUTION	0 ¹	0	0	No	1	2	2.05	2	2	0	Yes
	Conc	Oxivir Five 16 Concentrate [70627-58]	5	17	17	1	Yes	3 min @ 1:128	CAUTION	0 ¹	0	0	No	1	2	1.9	2	2	0	Yes
	RTU	Oxivir Tb [70627-56]	1 (B,V), 10 (F)	12	14	1	Yes	30 sec	CAUTION	0 ¹	0	0	No	0	0	3	0	2	0	Yes
Lactic acid	RTU	Lysol Brand III Disinfectant All Purpose Cleaner (4 in 1) [777-100]	10	6	4	None	Yes	30 secs	CAUTION	0	0	0	No	0	2	3	2	0	0	No
	RTU	Windex Multi-Surface Antibacterial Cleaner [4822-549]	5	3	None	None	Yes	10 secs	CAUTION	0	0	0	No	0	2	2.3-3.3	3	0	0	No
Ortho-Phenylphenol (OPP)	Conc	Ecolab 23 TB Disinfectant and Deodorizer [303-223-ZB-1677]	10	23	9	2	No	N/A	DANGER - Corrosive	2	1	4	No	4	4	12-13	3	3	0	No
	RTU	Airysol Brand Multi-Purpose Disinfectant Cleaner [33176-6]	10	3	5	0	No	N/A	CAUTION	2	1	0	No	0	2	2.5-13	1	3	0	No
Peroxyacetic Acid (PAA)	Conc	SaniDate 5.0 [70299-19]	10	16	3	2	Yes	1.6 oz + 5 gals water	DANGER - Corrosive	0	0	2	Yes	4	4	1.33	2	3	0	No
Pine Oil	Conc	Pinalen [72138-4]	10	gram negative - unspec.	0	0	No	N/A	CAUTION	0 ²	0	0	No ³	25	2	12-13	1	0	0	No
	RTU	Clorox Commercial Solutions Pine-Sol Brand Cleaner 1 [5813- 83-AA-67619]	10	2	0	1	No	N/A	WARNING	0 ²	0	0	No ³	25	3	3-4	No info	0	0	No

Table 4. (Cont'd)

Active Ingredient	Conc or RTU	Product	Disinfection			Sanitizing			Health								Environment			
			Dwell (min.)	Bact.	Viruses	Fungi	Sanitizer?	Dwell time (min.)	Signal Word	Cancer	Repro.	Respir.	Asthma	Skin	Eye	pH	HMIS	Aquatic	Persist.	Eutroph.
Quaternary Ammonium Chloride Compounds (Quats)	Conc	Virex II/256 [70627-24]	10	67	20	5	Yes	1 min @ 1:256	DANGER - Corrosive	0	1*	4	Yes	4 ⁴	4	8.8	3	3	3	No
	Conc	Enviro Care Neutral Disinfectant [47371-131-ZA-527]	10	30	29	3	Yes	1 min @ 1:64	DANGER - Corrosive	0	1*	2	Yes	2 ⁴	4	7.2-8.2	2	3	3	No
	RTU	Clorox Disinfecting Wipes [5813-58]	4	8	8	0	Yes	30 secs	CAUTION	0	1*	0	Yes	1 ⁴	2	5-6	No info	3	3	No
	RTU	Professional Lysol Brand Disinfectant Antibacterial Kitchen Cleaner [777-66-ZG-675]	10	8	5	Limited	Yes	30 secs	WARNING	0	1*	0	Yes	1 ⁴	3	10.5 - 11.1	2	3	3	No
Silver+ citric acid	RTU	Critical Care [72977-3-69268]	2 (B) 10 (V,F)	11	9	1	No	N/A	CAUTION	0	0	0	No	0	1	2	0	2	3	No
	RTU	Pure Hard Surface [72977-5-ZA-73912]	2 min (B) 1 min (V) 5 min (F)	14	16	1	No	N/A	CAUTION	0	0	0	No	0	1	2	0	2	3	No
Silver + hydrogen peroxide	RTU	Hydroxi Pro Force D [84526-1-66515]	10	7	5	1	Yes	5	CAUTION	0 ¹	0	1	No	1	2	5	1	2	3	No
Sodium Hypochlorite (chlorine bleach)	Conc	Clorox Concentrated Regular Bleach 1 [5813-100]	5-10	13	19	3	Yes	30 secs	DANGER - Corrosive	0	0	4	Yes	4	4	12	No info	3	0	No
	RTU	Bleach-Rite Disinfecting Spray With Bleach [70590-2]	1	10	11	2	No	N/A	CAUTION	0	0	2	Yes	0	2	12.3	No info	3	0	No
Thymol	Conc	Wexford Thymo-cide [34810-18]	10	5	5	1	No	N/A	DANGER - Corrosive	0	0 ⁵	1	No	2S	4	3	3	2	0	No
	RTU	Method Antibac Antibacterial Kitchen Cleaner [84683-3-AA-75277] Same as Benefect	10	5	4	2	Yes	5	CAUTION	0	0 ⁵	0	No	0S	0	4-6	0	2	0	No

Conc or RTU	Concentrated (Conc) or Ready to Use (RTU) formulation	Dwell	Dwell time for disinfection claims (minutes)	Bact, Viruses, Fungi	Number of kill claims made by manufacturer for each kind of organism	Sanitizer? Dwell time	Yes=registered as a sanitizer at a different dilution. Dwell time for sanitizer (min.)
Cancer	0 = not known or suspected carcinogen; 1 = suspected carcinogen; 2= known carcinogen	Repro	0 = not known or suspected reproductive/developmental toxicant; 1 = suspected; 2 = known	Respir.	0 = no respiratory irritation; 1 = mild irritant; 2 = moderate; 3 = severe; 4 = permanent damage	Asthma	No = not on AOEC asthmagen list; Yes = on AOEC list
Skin	0 = no skin irritation; 1 = mild irritant; 2 = moderate; 3 = severe; 4 = permanent damage, S = skin sensitizer	Eye	0 = no eye irritation; 1 = mild irritant; 2 = moderate; 3 = severe; 4 = permanent damage	HMIS	Lists highest score on HMIS hazard communication system	Aquatic	0 = no aquatic toxicity noted; 1 = medium; 2 = high; 3 = very high, or medium acute + chronic aquatic toxicity
Persist	0 = none; 1 = low; 2= med; 3=high; 4=very high	Eutroph					

Appendix B: Sample Disinfectants for Special Situations

Products Effective Against Athlete's Foot Fungus

Although several products claim efficacy against the athlete's foot fungus (AFF), *Trichophyton mentagrophytes*, it typically takes 5 to 10 minutes to inactivate this fungus. Even disinfectants with a shorter dwell time to kill the required test bacteria often must be left on surfaces longer to be effective against AFF. For example, Clorox Hydrogen Peroxide Disinfectant Cleaner, a ready-to-use (RTU) disinfectant that is effective against 17 strains of bacteria and 17 viruses in one minute, requires a 5-minute dwell time to kill AFF. Table 5 details whether the sample products included in this evaluation claim efficacy against the athlete's foot fungus.

Table 5. Review of disinfectants claiming efficacy against athlete's food fungus

Active Ingredient		Dwell Time
RECOMMENDED PRODUCTS		
Caprylic Acid (aka Octanoic Acid)	None	N/A
Citric Acid	Clean-Cide Ready to Use Germicidal Detergent* Clean-Cide Germicidal Wipes RTU: 0.6% citric acid	5 minutes
	Professional Lysol Brand II Disinfectant Basin, Tub & Tile Cleaner RTU: 2.5% citric acid	10 minutes
Hydrogen Peroxide and "Accelerated" Hydrogen Peroxide (AHP™)	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant* Clorox Hydrogen Peroxide Cleaner Disinfectant Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant Wipes Clorox Hydrogen Peroxide Cleaner Disinfectant Wipes RTU: 1.4% hydrogen peroxide (H ₂ O ₂)	3 minutes
	Accel Concentrate (AHP™) Carpe Diem Concentrate Five 16 (AHP™) Oxivir Five 16* (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water)	5 minutes
	Accel Tb (AHP™) and Accel Tb Wipes (AHP™) Carpe Diem Tb (AHP™) and Carpe Diem Tb Wipes (AHP™) Optim Tb (AHP™) and Optim Tb Wipes (AHP™) Oxivir Tb* (AHP™) and Oxivir Tb Wipes (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	10 minutes
	Lysol Power & Free Multi-Purpose Cleaner With Hydrogen Peroxide Lysol Power & Free Multi-Purpose Cleaning Wipes With Hydrogen Peroxide RTU: 0.88% hydrogen peroxide (H ₂ O ₂)	10 minutes
Lactic Acid	None	N/A
LIMITED USE PRODUCTS (RECOMMENDED FOR APPROPRIATE OUTBREAK SITUATIONS ONLY)		
Silver + Citric Acid	Pure Hard Surface* RTU: 0.003% silver + 4.84% citric acid	5 minutes
	Critical Care* (Also, Fiberlock Technologies Shockwave Green 24 Botanical & Silver Disinfectant, Germ Control 24-Silver Formula and PureGreen24) RTU: 0.003% silver + 4.84% citric acid	10 minutes
Silver + Hydrogen Peroxide (H ₂ O ₂)	H2ydro2xi Pro Force D* (also Sanosil S010) RTU: 0.01% silver nitrate + 5% hydrogen peroxide	10 minutes

*Products with an asterisk were fully evaluated for toxicity and overall efficacy. Products without an asterisk have the relevant active ingredient(s) (and sometimes the same EPA registration number) but were evaluated only for their efficacy against Athlete's Foot Fungus.

Disinfectants Effective Against Bloodborne Pathogens (HIV and HBV In California)

Overview

In the case of a blood spill or another incident involving bodily fluids, *The California Bloodborne Pathogen Standard*¹²⁷ points to *A Best Practices Approach to Reducing Bloodborne Pathogen Exposure*, which recommends that facilities decontaminate the surface with one of the following:¹²⁸

1. Diluted bleach solutions, or
2. U.S. Environmental Protection Agency (EPA)-registered products (e.g., tuberculocides, sterilants and products effective against HIV or HBV)

The U.S. EPA has published a list of *U.S. EPA's Registered Antimicrobial Products Effective Against Human HIV-1 Virus and Hepatitis B Virus*. Unfortunately, the latest version posted on the U.S. EPA website is dated January 2009; see http://www.epa.gov/oppad001/list_d_hepatitisbhiv.pdf. A similar list is available for tuberculocides at http://www.epa.gov/oppad001/list_b_tuberculocide.pdf.

It is important to note that some products are registered as a virucide against HIV, and their EPA-approved labels give instructions for cleaning up blood, but they are not registered as effective against HBV. Though use of the suggested product parameters referred to in the *California Bloodborne Pathogen Standard* is not a requirement, prudence would suggest the use of a product that claims efficacy against both pathogens. Therefore, products are only listed below (Table 6) if they claim efficacy against both HIV and HBV.

Label Language to Look For

Typically, the label for a product that is recommended for use against bloodborne pathogens will contain the following type of information (from sample product *Clorox Healthcare Hydrogen Peroxide Disinfectant Cleaner* (EPA Reg. # 67619-24)).

Special Instructions for Use Against HIV-1, HBV, and HCV

This product kills HIV-1, HBV, and HCV on precleaned environmental surfaces/objects previously soiled with blood/body fluids in health care settings (hospitals, nursing homes) or other settings in which there is an expected likelihood of soiling of inanimate surfaces/objects with blood or body fluids, and in which the surfaces/objects likely to be soiled with blood or body fluids can be associated with the potential for transmission of Human immunodeficiency Virus (HIV-1) (associated with AIDS), Human Hepatitis B Virus (HBV) and Human Hepatitis C Virus (HCV).

Special instructions for using this product to clean and decontamination against HIV-1, HBV and HCV on surfaces/objects soiled with blood/body fluids. Personal Protection:

*When handling items soiled with blood or body fluids, use disposable impervious gloves, gowns, masks and eye coverings. **Cleaning Procedure:** Blood and other body fluids must be thoroughly cleaned from surfaces and other objects before applying this product. **Contact Time:** Allow surface to remain wet for HBV, HCV and HIV-1 for 30 seconds. The contact times for other bacteria, viruses, and fungi may differ. See product label for contact times. **Disposal of Infectious Materials:** Use disposable impervious gloves, gown, masks and eye coverings. Blood and other body fluids must be autoclaved and disposed of according to local regulations for infectious waste disposal.*

Table 6. Review of disinfectants effective against bloodborne pathogens

Active Ingredient	Disinfectants that Claim Efficacy Against HIV and HBV	Dwell Time
RECOMMENDED PRODUCTS		
Caprylic Acid (aka Octanoic Acid)	None	N/A
Citric Acid	Clean-Cide Ready to Use Germicidal Detergent* RTU: 0.6% citric acid	HIV: 5 minutes HBV: 10 minutes
	Clean-Cide Germicidal Wipes RTU: 0.6% citric acid	HIV: 5 minutes HBV: 10 minutes
	Comet Disinfecting Bathroom Cleaner* RTU: 6% citric acid	10 minutes
Hydrogen Peroxide and "Accelerated" Hydrogen Peroxide (AHP™) Hydrogen Peroxide (H ₂ O ₂)	Accel Concentrate (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water)	HIV: 1 minute HBV: 5 minutes
	Accel Tb and Optim Tb (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Accel Tb Wipes and Optim Tb Wipes (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Alpha-HP Multi-Surface Disinfectant Cleaner* (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:64 dilution (2 oz. per gallon of water) <i>Note: this product has a 10-minute dwell time for bacterial disinfection.</i>	HIV: 1 minute HBV: 5 minutes
	Carpe Diem Concentrate Five 16 (AHP™) Oxivir Five 16* Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water)	HIV: 1 minute HBV: 5 minutes
	Carpe Diem Tb and Oxivir Tb* (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute (including HIV, HBV & HCV)
	Carpe Diem Tb Wipes and Oxivir Tb Wipes (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute (including HIV, HBV & HCV)
	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant Wipes Clorox Hydrogen Peroxide Cleaner Disinfectant Wipes RTU: 1.4% hydrogen peroxide (H ₂ O ₂)	30 seconds
	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant* Clorox Hydrogen Peroxide Cleaner Disinfectant RTU: 1.4% hydrogen peroxide (H ₂ O ₂)	30 seconds (including HIV, HBV & HCV)
Lactic Acid	None	N/A
LIMITED USE PRODUCTS (RECOMMENDED FOR APPROPRIATE OUTBREAK SITUATIONS ONLY)		
Silver + Citric Acid	Pure Hard Surface* RTU: 0.003% silver + 4.84% citric acid	HIV: 30 seconds HBV: 1 minute HCV: 1 minute

*Products in this table with an asterisk were fully evaluated in this report for toxicity and overall efficacy. Other products in this table without an asterisk have the relevant active ingredient(s) (and sometimes the same EPA registration number) but were evaluated only for their efficacy against these two bloodborne pathogens (HIV and HBV)

Disinfectants Effective Against Norovirus

Not all disinfectants kill viruses. Table 7 lists the evaluated products that are registered for use in California and claim efficacy against norovirus (aka Norwalk virus), which can cause stomach flu or gastroenteritis. This table also notes the dwell time needed to kill Norovirus.

Table 7. Review of disinfectant efficacy against norovirus

Active Ingredient	Disinfectants That Claim Efficacy Against Norovirus	Dwell Time
RECOMMENDED PRODUCTS		
Caprylic Acid (Octanoic Acid)	Ecolab 65 Disinfecting Heavy-Duty Acid Bathroom Cleaner* Concentrate: 3.05% octanoic acid 6-8 oz. per gallon of water	10 minutes
Citric Acid	Clean-Cide Ready to Use Germicidal Detergent* RTU: 0.6% citric acid	5 minutes
	Clean-Cide Germicidal Wipes RTU: 0.6% citric acid	5 minutes
	Comet Disinfecting Bathroom Cleaner* RTU: 6% citric acid	10 minutes
Hydrogen Peroxide and “Accelerated” Hydrogen Peroxide (AHP™)	Accel Concentrate (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water)	5 minutes
	Accel Tb and Optim Tb (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Accel Tb Wipes and Optim Tb Wipes (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Alpha-HP Multi-Surface Disinfectant Cleaner* (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water) <i>10-minute dwell time for bacterial disinfection.</i>	5 minutes
	Carpe Diem Concentrate Five 16 and Oxivir Five 16* (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) 1:16 dilution (8 oz. per gallon of water)	5 minutes
	Carpe Diem Tb and Oxivir Tb* (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Carpe Diem Tb Wipes and Oxivir Tb Wipes (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂)	1 minute
	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant Wipes Clorox Hydrogen Peroxide Cleaner Disinfectant Wipes RTU: 1.4% hydrogen peroxide (H ₂ O ₂)	1 minute
	Clorox Healthcare Hydrogen Peroxide Cleaner Disinfectant* Clorox Hydrogen Peroxide Cleaner Disinfectant RTU: 1.4% hydrogen peroxide (H ₂ O ₂)	1 minute
Lactic Acid	<i>None</i>	N/A
LIMITED USE PRODUCTS (RECOMMENDED FOR APPROPRIATE OUTBREAK SITUATIONS ONLY)		
Silver + Citric Acid	Critical Care*, Fiberlock Technologies Shockwave Green 24 Botanical & Silver Disinfectant, Germ Control 24-Silver Formula and PureGreen24 RTU: 0.003% silver + 4.84% citric acid	10 minutes
	Pure Hard Surface* RTU: 0.003% silver + 4.84% citric acid <i>2-minute dwell time for bacterial disinfection</i>	1 minute
Silver + Hydrogen Peroxide (H₂O₂)	<i>None</i>	N/A

*Products in this table with an asterisk were fully evaluated for toxicity and efficacy in this report. Other products with the same active ingredients (and sometimes the same EPA registration number) were evaluated only for their efficacy against Norovirus.

Appendix C: Best Practices for Cleaning, Sanitizing and Disinfecting Surfaces

Product selection is only one element of a comprehensive risk reduction strategy for disinfection and sanitizing. The ways these products are used – or not used – are equally important. Below are our recommendations for best practices relating to the selection, dilution and use of antimicrobial cleaning products.

1.) Determine where and when disinfectants are needed. Use disinfectants and sanitizers only on

surfaces with high public health significance, where germs (such as flu virus) might be easily transferred to others, or where required by law. If sanitizers and/or disinfectants are needed, public agencies should establish procedures detailing where, when and how they should be used, and ensure that all janitorial staff are properly trained.

General guidelines for targeting disinfectant/sanitizer use:

- **Use disinfectants on touch points.** Products with general disinfecting claims are primarily needed for *touch points*: Faucets, doorknobs, sinks, toilet seats, railings, and other surfaces frequently touched by building occupants. To kill viruses or fungi, look for disinfectants specifically registered for use against these organisms, since some disinfectants are registered to kill only bacteria.
- **Non-food-contact surface sanitizers might be good enough** for routine use in areas such as restroom floors, walls, and toilets. These products kill target organisms to the 99.9% level, which is sufficient for most surfaces needing removal of microbes beyond the level achieved by using a non-antimicrobial cleaning product and water.
- **Know the laws and guidelines that apply to your facility.** Certain types of facilities have specialized cleaning, sanitizing and disinfection requirements. For example, licensed childcare operations often have specific requirements in diaper-changing and bathroom areas. Similarly, restrooms in correctional or healthcare facilities may fall under specific state or local regulations.
- **Food contact surfaces are a special case.** Public health regulations usually require surfaces that come in direct contact with food - primarily in the kitchen - to be pre-cleaned and then treated with a product that is approved for use as a food-contact surface sanitizer. Food-contact sanitizer products are outside the scope of this report.
- **Bodily fluids require special procedures and products.** Disinfectants claiming bloodborne pathogen efficacy may be needed if there is an incident resulting in contamination with bodily fluids (such as blood or vomit). Facilities should follow the OSHA *Bloodborne Pathogen Standard* in these cases, and stock at least one disinfectant with claims for HIV, HBV and HCV.
- **Other special situations may require more careful product selection.** Disinfectants that are registered to kill athlete's foot fungus are appropriate for locker rooms and gym areas. Flu epidemics require products registered for influenza, and more extensive use of disinfectants. Read labels carefully and consider clearly labeling which product is used for each situation.

2.) Clean first. Microbes adhere to organic matter, which means that effective cleaning is usually sufficient to eliminate 80-99% of germs¹²³. Surfaces such as mirrors (even restroom mirrors), windows and walls, for example, generally do not need to be treated with sanitizers or disinfectants. Instead, these surfaces should be cleaned with a Green Seal- or ULE/EcoLogo-certified general-purpose or glass cleaner. Public agencies should consider using microfiber mops and cloths since they are more effective at removing dirt and germs than conventional string mops. Microfiber systems are popular in health care facilities because they minimize transferring microbes from room to room because a new microfiber pad is used in each room.¹²⁹

In situations where disinfection is required, a two-step process is ideal: Clean the surfaces first, followed by a U.S. EPA-registered and California DPR-approved non-food-contact surface sanitizer or disinfectant. Although some products are labeled as one-step cleaner-disinfectants, it is not advisable to use them because it is difficult to monitor whether they are being used properly. Such products demonstrated their

efficacy to U.S. EPA in the presence of 5% organic matter. However, if a surface exceeds that level, the product will no longer be effective.

3.) Evaluate current products and identify safer alternatives. An important first step in developing a cleaning plan is to conduct a baseline assessment of the cleaners, sanitizers and disinfectants that are used on various surfaces in the facility's restrooms and other areas. It is important to develop an inventory of products currently in use on various surfaces in hallways, restrooms, offices, and other parts of the building.

The next step is to review two important documents for each of these products to identify its health and environmental risks: its material safety data sheet (MSDS) and its U.S. EPA-approved pesticide label. Together, these documents will help users identify many of the important health and environmental risks, as well as the efficacy and dwell time of products currently in use. As a general rule, target for elimination those products containing ortho-phenylphenol, chlorine bleach, quaternary ammonium chloride compounds (quats), peroxyacetic acid, pine oil, and thymol. Compare their efficacy to products containing hydrogen peroxide, citric acid, lactic acid, or caprylic acid and choose an alternative product with the efficacy you need.

4.) Follow label instructions regarding proper dilution, application and rinsing procedures, and dwell time. All antimicrobial products must be left on the surface for the required "dwell time" in order to be effective against the organisms claimed on the label. If a product is wiped or rinsed off before the required dwell time, it is not likely to effectively kill the germs you are trying to target. Some products must also be rinsed off to prevent exposure to building occupants who may touch the residual disinfectant, and to prevent corrosive damage to the surface.

5.) Avoid aerosol products. Aerosol cans often contain a significant amount of propellant, making the per-unit cost of product high compared to non-aerosol delivery systems¹³⁰. Most propellants have environmental concerns, and the use of aerosol products also increases exposure because the product is delivered in a fine mist, which can easily penetrate the lungs.

6.) Avoid antimicrobial air fresheners. Because disinfectants need to saturate a surface for 1 to 10 minutes in order to be effective, there is almost no germ-killing benefit from spraying disinfectants or sanitizers into the air. These products are often used to mask odors but result in unnecessary exposure, are generally not effective at killing germs, and can cause or aggravate asthma, adding to any health impacts of the active ingredient or other components. If you need an air freshener, choose one that does not have a U.S. EPA registration label on it. Even better, identify the source of the odor and devise a chemical-free solution such as improved ventilation, if possible.

7.) Select concentrates that come in closed-loop delivery systems. Concentrated cleaning, sanitizing and disinfecting products are the most cost-effective options¹³¹. Concentrates are also environmentally preferable, since they avoid the need to ship large volumes of water long distances. However, concentrates typically pose more serious acute health hazards – such as eye and skin irritation - than ready-to-use (RTU) formulations. For these reasons, we recommend closed-loop delivery systems, which are recognizable by the use of sealed bottles that can only be opened once they are fixed to the dilution apparatus. Workers cannot simply open these bottles and pour them into a bucket, and there is no possibility of contact with the concentrates. A poor second choice to closed-loop systems would be measuring pumps, which can be purchased separately and attached to the (unsealed) bottle.

Besides protecting workers, dilution systems also make it easy to dilute the product accurately, reducing the likelihood of making solutions that are too strong or too weak, which is the case when concentrates

are diluted by hand (e.g., using the “glug-glug” method). Proper dilution can also save money, since users are often tempted to err on the side of stronger solutions.

Appendix D: Sample Products Reviewed

Table 8. Sample Surface Disinfectants

Active Ingredient	Sample Disinfecting Products Evaluated	Company Name EPA Registration No.
RECOMMENDED PRODUCTS		
Caprylic Acid (Octanoic Acid)	65 Disinfecting Heavy-Duty Acid Bathroom Cleaner Concentrate: 3.05% octanoic acid; Disinfecting Dilution: 6-8 oz. per gallon of water (1:16-1:21) 10-minute dwell time for surface disinfecting (most organisms)	Ecolab, Inc. EPA Reg. No. 1677-204; Label: www.epa.gov/pesticides/chem_search/ppls/001677-00204-20120426.pdf
	Clean-Cide Ready to Use Germicidal Detergent RTU: 0.6% citric acid 5-minute dwell time for surface disinfecting (most organisms)	Wexford Labs EPA Reg. No. 34810-35; Label: www.epa.gov/pesticides/chem_search/ppls/034810-00035-20121024.pdf
Citric Acid	Comet Disinfecting Bathroom Cleaner (also called Comet Disinfecting-Sanitizing Bathroom Cleaner) RTU: 6% citric acid 10-minute dwell time for surface disinfecting	Procter & Gamble EPA Reg. No. 3573- 54; Label: www.epa.gov/pesticides/chem_search/ppls/003573-00054-20130404.pdf
	Method Antibac Kitchen Cleaner (Also called Antibac Bathroom Cleaner) RTU: 5% citric acid 10-minute dwell time for surface disinfecting	Method Products, Inc. EPA Reg. No. 75277-2; Label: www.epa.gov/pesticides/chem_search/ppls/075277-00002-20110706.pdf
	Alpha-HP Multi-Surface Disinfectant Cleaner (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂); 1:64 dilution 10-minute dwell time for surface disinfecting	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-62; Label: www.epa.gov/pesticides/chem_search/ppls/070627-00062-20110511.pdf
Hydrogen Peroxide (H₂O₂), including Accelerated (AHP™)	Clorox Healthcare™ Hydrogen Peroxide Cleaner Disinfectant (also called Clorox Hydrogen Peroxide Disinfecting Cleaner) RTU: 1.4% hydrogen peroxide (H ₂ O ₂) 1-minute dwell time (30-seconds for efficacy against many organisms)	Clorox Professional Products Company EPA Reg. No. 67619-24; Label: www.epa.gov/pesticides/chem_search/ppls/067619-00024-20120906.pdf
	Lysol Power & Free Multi-Purpose Cleaner With Hydrogen Peroxide RTU: 0.88% hydrogen peroxide (H ₂ O ₂) 10-minute dwell time for surface disinfecting	Reckitt Benckiser EPA Reg. No. 777-117; Label: www.epa.gov/pesticides/chem_search/ppls/000777-00117-20110930.pdf
	Oxivir Five 16 (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂); 1:16 dilution 5-minute dwell time for surface disinfecting (most organisms)	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-58; Label: www.epa.gov/pesticides/chem_search/ppls/070627-00058-20101119.pdf
	Oxivir Tb (AHP™) RTU (Liquid): 0.5% hydrogen peroxide (H ₂ O ₂) 1-minute dwell time for surface disinfecting (most organisms)	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-56; Label: www.epa.gov/pesticides/chem_search/ppls/070627-00056-20120920.pdf
	Lysol Brand III Disinfectant All Purpose Cleaner (also called Lysol Brand III Kills 99.9% of Virus & Bacteria All Purpose Cleaner) RTU: 3.2% lactic acid 10-minute dwell time for surface disinfecting	Reckitt Benckiser EPA Reg. No. 777-100; Label: www.epa.gov/pesticides/chem_search/ppls/000777-00100-20120801.pdf
	Windex Multi-surface Antibacterial (also called Windex Touch-Up Cleaner) RTU: 0.18% lactic acid 5-minute dwell time for surface disinfecting	S.C. Johnson & Son, Inc. EPA Reg. No. 4822-549; Label: www.epa.gov/pesticides/chem_search/ppls/004822-00549-20120619.pdf

Table 8 (cont'd)

Active Ingredient	Sample Disinfecting Products Evaluated	Company Name EPA Registration No.
LIMITED USE PRODUCTS (RECOMMENDED FOR APPROPRIATE OUTBREAK SITUATIONS ONLY)		
Silver + Citric Acid	Critical Care RTU: 0.003% silver + 4.846% citric acid 10-minute dwell time for surface disinfecting (for most viruses and fungi); 2-minute dwell time (for most bacteria)	Envirox, LLC EPA Reg. No. 72977-3-69268; Label: www.epa.gov/pesticides/chem_search/ppls/072977-00003-20100304.pdf
	Pure Hard Surface RTU: 0.003% silver + 4.846% citric acid 2-minute dwell time (covers all organisms except Athlete's Foot Fungus, which has a 5-minute dwell time)	Envirox, LLC EPA Reg. No. 72977-5-ZA-73912; Label: www.epa.gov/pesticides/chem_search/ppls/072977-00005-20110803.pdf
Silver + Hydrogen Peroxide (H₂O₂)	H2ydro2xi Pro Force D (also Sanosil S010) RTU: 0.01% silver nitrate + 5% hydrogen peroxide (H ₂ O ₂) 10-minute dwell time for surface disinfecting	Core Products Co, Inc. EPA Reg. No. 84526-1-66515; Label (84526-1): www.epa.gov/pesticides/chem_search/ppls/084526-00001-20130711.pdf
PRODUCTS NOT RECOMMENDED DUE TO HEALTH AND ENVIRONMENTAL CONCERNS		
Ortho-phenylphenol (OPP)	Airysol Brand Multi-Purpose Disinfectant Cleaner RTU: 0.10% ortho-phenylphenol (OPP) + 0.08% ortho-benzyl para-chlorophenol 10-minute dwell time for surface disinfecting	Amrep, Inc. EPA Reg. No. 33176-6; Label: www.epa.gov/pesticides/chem_search/ppls/033176-00006-20091119.pdf
	Ecolab 23 TB Disinfectant & Deodorizer Concentrate: 3.55% ortho-phenylphenol (OPP) + 5.32% ortho-benzyl para-chlorophenol + 1.81% para-tert-amylphenol 1:128 (1 oz. per gallon) dilution for disinfecting most listed organisms 1:64 dilution for efficacy against Norovirus and Tb 10-minute dwell time for disinfecting most listed organisms	Ecolab, Inc. EPA Reg. No. 303-223-ZB-1677; Label: www.epa.gov/pesticides/chem_search/ppls/000303-00223-20120517.pdf
Peroxyacetic Acid (PAA) + Hydrogen Peroxide (H₂O₂)	SaniDate 5.0 Concentrate: 5.3% peroxyacetic acid (PAA) + 23% hydrogen peroxide (H ₂ O ₂) 1:256 (½ oz. per gallon) dilution 10-minute dwell time	Biosafe Systems, LLC EPA Reg. No. 70299-19; Label: www.epa.gov/pesticides/chem_search/ppls/070299-00019-20120706.pdf
Pine Oil	Clorox Commercial Solutions Pine-Sol Brand Cleaner 1 RTU: 8.7% pine oil 10-minute dwell time <i>This product contains 1-5% isopropyl alcohol, according to its MSDS.</i>	Clorox Professional Products Company EPA Reg. No. 5813- 83-AA-67619 EPA Reg. No. 5813-83; Label: www.epa.gov/pesticides/chem_search/ppls/005813-00083-20111116.pdf
	Pinalen Concentrate: 5% pine oil 21 oz. per gallon dilution 10-minute dwell time for surface disinfecting <i>This product is only a limited efficacy disinfectant against gram-negative bacteria only.</i>	Industrias AIEn/White Cap, Inc. EPA Reg. No. 72138-4; Label: www.epa.gov/pesticides/chem_search/ppls/072138-00004-20120727.pdf
Quaternary Ammonium Chloride Compounds ("Quats")	Clorox Disinfecting Wipes RTU: Contain 0.29% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 0.145% alkyl dimethyl benzyl ammonium chloride (ADBAC) • 0.145% didecyl dimethyl ammonium chloride (ADBAC) 4-minute dwell time for surface disinfecting <i>MSDS also lists isopropanol</i>	The Clorox Company EPA Reg. No. 5813-58; Label: www.epa.gov/pesticides/chem_search/ppls/005813-00058-20111201.pdf

Table 8 (cont'd)

Active Ingredient	Sample Disinfecting Products Evaluated	Company Name EPA Registration No.
PRODUCTS NOT RECOMMENDED DUE TO HEALTH AND ENVIRONMENTAL CONCERNS		
Quaternary Ammonium Chloride Compounds (“Quats”)	Enviro Care Neutral Disinfectant Concentrate: 4.23% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 2.54% didecyl dimethyl ammonium chloride (DDAC) • 1.69% alkyl dimethyl benzyl ammonium chloride (ADBAC) Disinfectant dilution is 1:64 (2 oz., per gallon) 10-minute dwell time for surface disinfecting	Rochester Midland Corporation/Lonza Corporation EPA Reg. No. 47371-131-ZA-527; Label: www.epa.gov/pesticides/chem_search/ppls/047371-00131-20130702.pdf
	Professional Lysol Brand Disinfectant Antibacterial Kitchen Cleaner RTU: 0.1076% alkyl dimethyl benzyl ammonium chloride (ADBAC) 10-minute dwell time for surface disinfecting	Reckitt Benckiser, Inc. EPA Reg. No. 777-66-ZG-675; Label: www.epa.gov/pesticides/chem_search/ppls/000777-00066-20120719.pdf
	Virex II/256 Concentrate: 16.894% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 8.704% Didecyl dimethyl ammonium chloride (DDAC) • 8.190% Alkyl dimethyl benzyl ammonium chloride (ADBAC) Disinfectant dilution: 1:256 (1/2 oz. per gallon) 10-minute dwell time for surface disinfecting	Diversey, Inc. (Sealed Air) EPA Registration No. 70627-24; Label: www.epa.gov/pesticides/chem_search/ppls/070627-00024-20111216.pdf
Sodium Hypochlorite (Chlorine Bleach)	Bleach-Rite Disinfecting Spray With Bleach RTU: 0.94% sodium hypochlorite 1 minute dwell time for surface disinfecting (for most organisms)	Current Technologies, Inc. EPA Reg. No. 70590-2; Label: www.epa.gov/pesticides/chem_search/ppls/070590-00002-20120925.pdf
	Clorox Concentrated Regular Bleach 1 Concentrate: 8.25% sodium hypochlorite Disinfectant dilution: 1:32 (½ cup per gallon of water) (for most organisms) 5-minute dwell time for surface disinfecting (for most organisms) <i>10-minute dwell time for healthcare environment disinfection (including Pseudomonas aeruginosa). Also surface must be rinsed after disinfection.</i>	The Clorox Company EPA Registration No. 5813-100; Label: www.epa.gov/pesticides/chem_search/ppls/005813-00100-20130801.pdf
Thymol	Antibac Antibacterial Kitchen Cleaner (also called Benefect Daily Cleaner , Cleanwell Daily Cleaner , and Seventh Generation Bathroom Cleaner) RTU: 0.05% thymol 10-minute dwell time for surface disinfecting	Method Products, Inc. EPA Reg. No. 84683-3-AA-75277 (This product is registered under <i>Benefect Botanical Daily Cleaner Disinfectant</i> by OhSo Clean (84683-3); Label: www.epa.gov/pesticides/chem_search/ppls/084683-00003-20130829.pdf
	Thymo-cide Concentrate Concentrate: 13% thymol Disinfectant dilution: 1:256 (½ oz. per gallon of water) 10-minute dwell time for surface disinfecting	Wexford Labs, Inc. EPA Reg. No. 34810-18; Label: www.epa.gov/pesticides/chem_search/ppls/034810-00018-20110622.pdf

Table 9. Representative Non-food-contact Surface Sanitizers

Active Ingredient	Sample Non-Food-Contact Surface Sanitizing Products Evaluated	Company Name EPA Registration No.
RECOMMENDED PRODUCTS		
Caprylic Acid (Octanoic Acid)	65 Disinfecting Heavy-Duty Acid Bathroom Cleaner Concentrate: 3.05% octanoic acid Sanitizing dilution: 1:40 dilution (3 oz. per gallon) 5-minute dwell time for non-food-contact surface sanitizing	Ecolab, Inc. EPA Reg. No. 1677-204; Label: www.epa.gov/pesticides/chem_search/pls/001677-00204-20120426.pdf
Citric Acid	Clean-Cide Ready to Use Germicidal Detergent RTU: 0.6% citric acid 1-minute dwell time for non-food-contact surface sanitizing	Wexford Labs EPA Reg. No. 34810-35; Label: www.epa.gov/pesticides/chem_search/pls/034810-00035-20121024.pdf
	Comet Disinfecting Bathroom Cleaner (also called Comet Disinfecting-Sanitizing Bathroom Cleaner) RTU: 6% citric acid 5-minute dwell time for non-food-contact surface sanitizing	Procter & Gamble EPA Reg. No. 3573- 54; Label: www.epa.gov/pesticides/chem_search/pls/003573-00054-20130404.pdf
	Method Antibac Kitchen Cleaner (also called Antibac Bathroom Cleaner) RTU: 5% citric acid 5-minute dwell time for non-food-contact surface sanitizing	Method Products, Inc. EPA Reg. No. 75277-2; Label: www.epa.gov/pesticides/chem_search/pls/075277-00002-20111101.pdf
Hydrogen Peroxide (H₂O₂), including Accelerated Hydrogen Peroxide (AHP™)	Alpha-HP Multi-Surface Disinfectant Cleaner (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) Sanitizing dilution: 1:128 (1 oz. per gallon) 3-minute dwell time for non-food-contact surface sanitizing	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-62; Label: www.epa.gov/pesticides/chem_search/pls/070627-00062-20110511.pdf
	Envirox Concentrate 117 (also called H₂Orange₂ Concentrate 117) Concentrate: 3.95% hydrogen peroxide (H ₂ O ₂) Sanitizing dilution: 1:128 (10 oz. per gallon) 5-minute dwell time for non-food-contact surface sanitizing	Envirox, LLC EPA Reg. No. 69268-3; Label: www.epa.gov/pesticides/chem_search/pls/069268-00002-20111123.pdf
	H₂Orange₂ 120 Ready to Use (also called H₂Orange₂ One) RTU: 1% hydrogen peroxide (H ₂ O ₂) 5-minute dwell time for non-food-contact surface sanitizing	Envirox, LLC EPA Reg. No. 69268-3; Label: www.epa.gov/pesticides/chem_search/pls/069268-00003-20050607.pdf
	Oxivir Five 16 (AHP™) Concentrate: 4.25% hydrogen peroxide (H ₂ O ₂) Sanitizing dilution: 1:128 (1 oz. per gallon) 3-minute dwell time for non-food-contact surface sanitizing	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-58; Label: http://www.epa.gov/pesticides/chem_search/pls/070627-00058-20101119.pdf
	Oxivir Tb (AHP™) RTU: 0.5% hydrogen peroxide (H ₂ O ₂) 30-second dwell time for non-food-contact surface sanitizing	Diversey, Inc. (Sealed Air) EPA Reg. No. 70627-56; Label: www.epa.gov/pesticides/chem_search/pls/070627-00056-20120920.pdf
Lactic Acid	Lysol Brand III Disinfectant All Purpose Cleaner (also called Lysol Brand III Kills 99.9% of Virus & Bacteria All Purpose Cleaner) RTU: 3.2% lactic acid 30-second dwell time for non-food-contact surface sanitizing	Reckitt Benckiser EPA Reg. # 777-100; Label: www.epa.gov/pesticides/chem_search/pls/000777-00100-20120801.pdf
	Windex Multi-surface Antibacterial (also called Windex Touch-Up Cleaner) RTU: 0.18% lactic acid 10-second dwell time for non-food-contact surface sanitizing	S.C. Johnson & Son, Inc. EPA Reg. No. 4822-549; Label: www.epa.gov/pesticides/chem_search/pls/004822-00549-20120619.pdf

Table 9 (Cont'd)

Active Ingredient	Sample Non-Food-Contact Surface Sanitizing Products Evaluated	Company Name EPA Registration No.
LIMITED USE PRODUCTS (RECOMMENDED FOR APPROPRIATE OUTBREAK SITUATIONS ONLY)		
Silver + Citric Acid	None of the evaluated silver + citric acid-containing products are registered as sanitizers. They are only registered as disinfectants.	
Silver + Hydrogen Peroxide (H₂O₂)	H2ydro2xi Pro Force D (also Sanosil S010) RTU: 0.01% silver nitrate + 5% hydrogen peroxide (H ₂ O ₂) 5-minute dwell time for non-food-contact surface sanitizing	Core Products Co, Inc. EPA Reg. No. 84526-1-66515; Label (84526-1): www.epa.gov/pesticides/chem_search/pls/084526-00001-20130711.pdf
PRODUCTS NOT RECOMMENDED DUE TO HEALTH AND ENVIRONMENTAL CONCERNS		
Ortho-phenylphenol (OPP)	None of the evaluated OPP-containing products are registered as sanitizers. They are only registered as disinfectants.	
Peroxyacetic Acid (PAA) + Hydrogen Peroxide (H₂O₂)	SaniDate 5.0 Concentrate: 5.3% peroxyacetic acid (PAA) + 23% hydrogen peroxide (H ₂ O ₂) Sanitizing dilution: 1.6 oz. per 5 gallons 1-minute dwell time for non-food-contact surface sanitizing	Biosafe Systems, LLC EPA Reg. No. 70299-19; Label: www.epa.gov/pesticides/chem_search/pls/070299-00019-20120706.pdf
	SaniDate Ready to Use RTU: 0.108% Hydrogen Peroxide (H ₂ O ₂) 5-minute dwell time <i>According to the manufacturer, this product also contains PAA below reporting requirements.</i>	Biosafe Systems; LLC EPA Reg. No. 70299-9; Label: www.epa.gov/pesticides/chem_search/pls/070299-00009-20130621.pdf
Pine Oil	None of the pine oil products evaluated are registered as sanitizers. They are only registered as disinfectants.	
Quaternary Ammonium Chloride Compounds ("Quats")	Clorox Disinfecting Wipes RTU: Contain 0.29% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 0.145% alkyl dimethyl benzyl ammonium chloride (ADBAC) • 0.145% didecyl dimethyl ammonium chloride (ADBAC) 30-second dwell time for non-food-contact surface sanitizing <i>MSDS also lists isopropanol</i>	The Clorox Company EPA Reg. No. 5813-58; Label: www.epa.gov/pesticides/chem_search/pls/005813-00058-20111201.pdf
	Enviro Care Neutral Disinfectant Concentrate: 4.23% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 2.54% Didecyl dimethyl ammonium chloride (DDAC) • 1.69 Alkyl dimethyl benzyl ammonium chloride (ADBAC) Sanitizing dilution 1:64 (2 oz., per gallon) 1-minute dwell time for non-food-contact surface sanitizing	Rochester Midland Corporation/Lonza Corporation EPA Reg. No. 47371-131-ZA-527; Label: www.epa.gov/pesticides/chem_search/pls/047371-00131-20130702.pdf
	Professional Lysol Brand Disinfectant Antibacterial Kitchen Cleaner RTU: 0.1076% alkyl dimethyl benzyl ammonium chloride (ADBAC) 30-second dwell time for non-food-contact surface sanitizing	Reckitt Benckiser, Inc. EPA Reg. No. 777-66-ZG-675; Label: www.epa.gov/pesticides/chem_search/pls/000777-00066-20120719.pdf
	Virex II/ 256 Concentrate: 16.894% quaternary ammonium chloride compounds, including: <ul style="list-style-type: none"> • 8.704% Didecyl dimethyl ammonium chloride (DDAC) • 8.190% Alkyl dimethyl benzyl ammonium chloride (ADBAC) Sanitizing dilution: 1:256 (1/2 oz. per gallon) 1-minute dwell time for non-food-contact surface sanitizing (which includes sanitizing efficacy against MRSA)	Diversey, Inc. (Sealed Air) EPA Registration No.70627-24; Label: www.epa.gov/pesticides/chem_search/pls/070627-00024-20111216.pdf

Table 9 (Cont'd)

Active Ingredient	Sample Non-Food-Contact Surface Sanitizing Products Evaluated	Company Name EPA Registration No.
PRODUCTS NOT RECOMMENDED DUE TO HEALTH AND ENVIRONMENTAL CONCERNS		
Sodium Hypochlorite (Chlorine Bleach)	Clorox Commercial Solutions Anywhere Hard Surface Sanitizing Spray RTU: 0.0095% sodium hypochlorite 1-minute dwell time for non-food-contact surface sanitizing	Clorox Professional Products Company EPA Reg. No. 67619-14; Label: www.epa.gov/pesticides/chem_search/pls/067619-00014-20111006.pdf
	Clorox Concentrated Regular Bleach 1 Concentrate: 8.25% sodium hypochlorite Sanitizing dilution: 1:32 (½ cup per gallon) 30-second dwell time for non-food-contact surface sanitizing <i>Food-contact surface must be rinsed with potable water after sanitizing with bleach at this concentration.</i>	The Clorox Company EPA Registration No. 5813-100; Label: www.epa.gov/pesticides/chem_search/pls/005813-00100-20130801.pdf
Thymol	Antibac Antibacterial Kitchen Cleaner (also called Seventh Generation Bathroom Cleaner) RTU: 0.05% thymol 30-second dwell time for non-food-contact surface sanitizing	Method Products, Inc. EPA Reg. No. 84683-3-AA-75277 (This product is registered under <i>Benefect Botanical Daily Cleaner Disinfectant</i> by OhSo Clean (84683-3); Label: www.epa.gov/pesticides/chem_search/pls/084683-00003-20130829.pdf

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