Efficacy of "Green" Cleaning Products with Respect To Common Respiratory Viruses and Mold Growth

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Abstract

Some disinfectants have been demonstrated to be effective against surface mold growth and viruses responsible for the spread of common respiratory infections. Antimicrobial efficacy of green cleaning products has generally not been established in these areas. A survey of 27 products approved by Green Seal as hard surface cleaners found that 26 do not claim antimicrobial capability. While some contained hydrogen peroxide, a compound potentially contributing limited spectrum disinfection, only one was registered with EPA as antimicrobial. The need for additional research and documentation is discussed.

Introduction

Since the 19th century, the "germ theory of disease" (Pasteur, 1880) has encouraged cleaning practices that minimize the levels of surface pathogens. Introduction of the concept of "green" cleaning represents a major change in philosophy with significant public health ramifications. For example, one organization advocating green cleaning states, "Disinfectants are designed to kill living organisms. They are rarely required." (Healthy Schools Network, 2006). Green cleaning products (GCPs) are marketed as natural materials to replace "highly toxic" disinfectants such as bleach and phenolics without harming health or the environment

(Florida Alliance for Healthy Indoor Environments, n.d.; Hospitals for a Healthy Environment, n.d.). Advantages claimed over traditional surface disinfectants (TSDs) include:

- Reduced emission of harmful volatile organic compounds (VOCs)
- reduction of worker injury (Green Seal, 2006)
- lowered toxicity to aquatic organisms
- improved biodegradability

Concerns have been expressed by cleaning professionals with respect to antimicrobial efficacy of GCPs. For example, the American Hospital Association states, "ASHES warns against blanket support of 'green cleaning' without tested research that it provides an equal or better level of care than current practices . . . and cautions against quick adoption . . . for the sake of being green." (American Society for Healthcare Environmental Services, 2006).

GCPs are certified by the non-profit organization Green Seal (GS) to facilitate their identification and purchasing (Hospitals for a Healthy Environment, n.d.). In recent years, specifications for the purchase of cleaning products have been revised to promote or require the use of GCPs (City of Seattle, n.d.; New York State, 2005; U.S. EPA, n.d.). As a result GCPs now represent a growing proportion of U.S. sales.

General surface sanitation objectives include the control of surface viruses responsible for the transmission of common respiratory infections (CRIs) such as colds and flu. The common cold is often associated with rhinovirus (Gwaltney and Hendley, 1982), while flu is

caused by influenza viruses (Bean, et al., 1982). Cold viruses are non-enveloped, making them more difficult to kill (e.g., resistant to non-bleach disinfectants (Dvorak, 2005)). CRIs are contagious, spreading by either direct contact, sneezing or coughing in close proximity, recirculation of indoor air, or contact with contaminated surfaces (Centers for Disease Control, 2007; Li, et al., 2007). CRIs spread by the latter route are the subject of this review. Droplets containing viruses from a sneeze or cough settle out from the air or are transferred by hand contact to environmental surfaces where they can survive for over a week (Thomas, et al., 2008). Other occupants become infected when they contact a contaminated surface and subsequently touch their nose or mouth before washing their hands (Sattar, Jacobsen, Springthorpe, Cusack, & Rubing, 1993).

While routine cleaning (e.g., applying a surfactant solution) physically removes some surface viruses, effective control against the spread of infection requires application of TSDs (Berry, 1994; Dvorak, 2005; Gwaltney and Hendley, 1982). TSDs are commonly sprayed and/or wiped on hard surfaces. Food contact surfaces must be rinsed following application.

Active ingredients listed on many GCP labels do not include demonstrated antimicrobials Some formulations do include hydrogen peroxide, a compound capable of limited spectrum disinfection. Cleaning products claiming to sanitize surfaces are required to be registered with EPA based on data establishing antimicrobial efficacy (U.S. Environmental Protection Agency, 1982; U.S. Environmental Protection Agency, 2007). Most GCPs are not registered with EPA.

Green cleaning programs often specify exclusive use of products certified by the organization Green Seal (Montgomery County, 2006). Some green cleaning specifications allow for the use of TSDs in areas where contact with broken skin is likely such as medical procedure areas and locker rooms (U.S. Air Force, 2005). The need to sanitize during general surface cleaning is subject to various opinions. For non-critical care areas in hospitals, CDC suggests routine use of TSDs on high-touch surfaces only (Centers for Disease Control, 2003). However, this guidance was limited to control of influenza virus and mold spores in dust, not cold viruses and surface mold growth, which tend to be more resistant to TSDs. In schools where GCPs are required, some custodians and teachers continue to apply TSDs to general use surfaces as a precaution.

Indoor mold growth is considered unacceptable due to possibility of allergic reactions (atopic individuals only) and opportunistic infections (immunocompromised patients only), material damage, and malodor (U.S. Environmental Protection Agency, 2001). Where moldy material cannot be removed and replaced, recommended response measures include damp wiping. Although many TSDs are recognized to be fungicidal (Krause, Geer, Swenson, Fallah, & Robbins, 2006), green cleaning programs generally advise against their use due to concerns for chemical exposure and a belief that allergenic proteins remain intact after killing mold (U.S. Environmental Protection Agency, 2001). This latter concern was addressed by a recent study which demonstrated that TSD application can also denature mold proteins responsible for allergic reactions (Martyny, et al., 2005). While surface growth can be effectively treated in this manner, mold may also extend into porous materials such as wood. Although subsurface mold growth is not a demonstrated exposure hazard, it can be sealed with a primer as a precaution

(American Industrial Hygiene Association, 2005). Risk of opportunistic infection can thus be minimized by treatment with halogenated or phenolic disinfectants while mold allergens can be controlled with bleach. Such treatments remain effective as long as surfaces do not become wet again.

Methods

Characteristics of multi-purpose cleaners were documented based on EPA registration, product labels, and marketing literature. Twenty-seven products certified by Green Seal (Green Seal, 2007) were compared to five EPA-registered disinfectants. Active ingredients listed on Material Safety Data Sheets were evaluated for virucidal and fungicidal efficacy. In addition to considering available literature, discussion also reflects the author's experience overseeing the use of surface cleaning products as a consultant.

Results

Traditional Surface Disinfectants

The most commonly used products for disinfecting hard surfaces generally fall into the category of halogen-based (e.g., bleach), phenolics (e.g., Lysol, Sporicidin), or quaternary ammonium compounds (e.g., DiQuat, Zepharin) (Dvorak, 2005; University of Colorado, 2005). Relative efficacy against respiratory viruses and surface mold growth is summarized in Table 1.

Product labels provide guidance related to limitations, potential impacts, and precautionary measures. Applicator safety concerns primarily involve irritation of the eyes and skin. Although there is some risk of dermal and ocular effects from direct contact with most cleaning products, eye protection and gloves are typically required to avoid such problems. Product exposure is a common source of janitorial injury but cleaning is not cited as a major contributor (U.S. Environmental Protection Agency Region IX, 2001). Potential occupant health effects depend not only on product toxicity but also volatility, timing of application (e.g., occupied vs. after-hours), ventilation, half-life (e.g., quickly dissipate vs. long-lasting), the presence of susceptible individuals, and application procedures. Occupant impacts can generally be avoided by following label requirements, treating areas while unoccupied, and providing adequate ventilation. Potential damage to treated surfaces (e.g., corrosion) is another concern. This can be avoided by following label directions and pretreating a test patch.

Green Cleaning Products

Cleaning products certified by Green Seal claim to minimize health impacts associated with application and to promote protection of the general environment. Criteria for approval are based on soil removal, toxicity of the undiluted product, combustibility, VOC content, aquatic toxicity, biodegradability, and packaging (Green Seal, 2006). Antimicrobial properties are not considered. Some GCP labels specify that they include naturally-derived products such as citrus oils while others do not list active ingredients.

GCPs can be classified into two groups with respect to inclusion of hydrogen peroxide (a limited spectrum disinfectant under some conditions). Review of 27 products certified by GS as general-purpose cleaners indicated that 12 contained hydrogen peroxide. Only one of these products is registered with EPA as a disinfectant. The other eleven products containing hydrogen peroxide presented no specific claims regarding the control of surface pathogens (one product claimed to "leave surfaces sanitary"). One vendor marketed a similar, non-GS product which was registered with EPA as effective against flu viruses (but not cold viruses or fungi).

Typical hydrogen peroxide concentrations in GCPs are around 4%. In general, hydrogen peroxide applied at 5-20% may be effective against enveloped viruses (e.g., influenza) but is limited with respect to control of non-enveloped viruses such as those associated with colds (Dvorak, 2005). Fungicidal properties are also rated as "limited" (Dvorak, 2005).

Other GCP Claims

VOCs are normally present in indoor air at the parts per billion level, emitted from a variety of sources (cleaning is generally a minor contributor) (Air Quality Sciences, 2007). Concentrations are orders of magnitude below established thresholds for human health effects and are commonly considered normal background constituents of indoor air. Human toxicity of disinfectant residue following recommended application procedures has not been established.

Relatively low toxicity ratings for GCPs may be misleading since routine precautions and realistic use scenarios are not considered. For example, GS certification is based on the

undiluted product despite the lack of ingestion during normal use. Potential dermal and eye irritation are highlighted without consideration of required avoidance measures (e.g., gloves and eye protection). Similarly, potential inhalation toxicity of the undiluted product is rated without considering compliance with OSHA standards and the availability of application strategies to protect sensitive occupants. Concerns for aquatic toxicity and general environmental protection are also theoretical, lacking evidence of impacts.

While the term "green" implies the use of natural substances with a low "carbon footprint," these factors are not specifically addressed by Green Seal. Both GCPs and TSDs vary widely in relation to manufacturing process and energy consumption. Hydrogen peroxide, sometimes implied to be a natural ingredient, is synthesized in chemical manufacturing plants.

Conclusions

1. Green Cleaning Products have been introduced in recent years based on claims of improved safety and protection of the environment.

2. Control of surface viruses associated with common respiratory infections such as influenza and colds is often recognized as an important objective for general cleaning. However, efficacy in this area is not addressed in certification of Green Cleaning Products.

3. Although surface disinfectants such as halogen-based and phenolic compounds are virucidal, their use is discouraged by green cleaning advocates due to safety concerns.

4. Some surface disinfectants are effective fungicides while one (bleach) has been shown to denature allergenic proteins associated with mold growth. Use of these products is discouraged by green cleaning programs.

5. Green cleaning products promote physical removal of dirt but have generally not been established as antimicrobial. Of the 27 products surveyed, only one was registered with EPA as antimicrobial. Some of the products surveyed did contain hydrogen peroxide, a compound with limited spectrum disinfecting ability. Under some conditions, hydrogen peroxide provides disinfection of flu virus, but it is generally ineffective with respect to cold viruses and mold growth.

6. Claims that green cleaning products are less toxic than disinfectants and less damaging to the environment do not take into account label safety precautions and have not been demonstrated under realistic use scenarios.

Recommendations

Surface hygiene is an important factor in public health. Selection of cleaning products should consider pathogen control along with precautions for minimizing impacts on applicators, sensitive occupants, and the environment. Although the scope of this review is limited to efficacy with respect to common respiratory viruses and mold growth, enhanced surface sanitation can also be expected to provide benefits with respect to control of other pathogens such as food-borne illness, SARS, and Avian Flu.

1. Selection of cleaning products for general surfaces should consider control of common respiratory viruses. EPA registration with respect to both enveloped and non-enveloped viruses provides the only assurance that this objective can be achieved.

2. Treatment of surface mold growth should, at a minimum, utilize EPA-registered fungicides. Demonstrated effectiveness in denaturing allergenic proteins should also be considered. Based on currently available data, only bleach has been established to denature allergenic proteins.

3. Potential injury to applicators can generally be avoided by following product label safety requirements.

4. Exposure of sensitive individuals can be minimized by after-hours application and ventilation.

5. In the future, green cleaning products should be evaluated for efficacy against pathogens with data made available to the public to allow for evidence-based decisions.

6. Evaluation of cleaning products for human safety and environmental impact should address realistic use scenarios including recommended safety procedures and use dilutions.

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Table 1. Relative Effectiveness of TSDs

Category	Flu Virus	Cold Virus	Fungi	Allergens
Bleach	effective[1]	effective[2]	effective[3]	effective[4]
Phenolics	limited[5] to effective[1]	ineffective[6] to limited[5]	effective[3]	no data
Quats	limited[5] to effective[1]	ineffective[6] to limited[5]	limited[5]	no data

1. Disinfection generally established with respect to enveloped viruses (Dvorak, 2005; University of Colorado, 2005).
2. Disinfection generally established with respect to non-enveloped viruses (Sattar, 1993; University of Colorado, 2005)
3. Disinfection generally established with respect to fungal spores (Dvorak, 2005; Gupta, 2002).
4. Allergenic proteins denatured (Martyny, 2005).
5. Partially effective under some conditions (Dvorak, 2005; University of Colorado, 2005).
6. Low antimicrobial activity (Dvorak, 2005).

Note: Effectiveness is dependent on pre-cleaning of soiled surfaces, using specified dilution and application techniques, maintaining a minimum contact time, and changing bucket solutions/mop heads frequently. Disinfection may be less on surfaces which are porous or uneven.