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Guidelines for Reducing Pathogens in Veterinary Hospitals: Disinfectant Selection, Cleaning Protocols, and Hand Hygiene

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Abstract: *Antibiotic resistance is a growing problem in the hospital setting. Organisms that cause hospital-acquired infections are generally highly resistant, requiring expensive antibiotics and further hospitalization. As a result, many owners of infected pets choose euthanasia. Appropriate hospital disinfection and staff hygiene practices can prevent such infections by reducing the pathogen load in a facility in accordance with the "nosocomial prevention triad"—appropriate antibiotic usage, staff and patient hygiene, and hospital maintenance and disinfection. This review outlines the development and implementation of hospital disinfection protocols and hand hygiene practices in small animal veterinary hospitals.*

At a Glance

Hospital-acquired (nosocomial) infections are a growing problem in veterinary and human medicine. Such infections are defined as those that were neither present nor incubating at the time of presentation to the hospital. With veterinary care becoming more sophisticated in both general practice and emergency/referral settings, nosocomial infections are of particular concern because they tend to involve highly infectious, multidrug-resistant bacteria and patients that are less able to survive such a complication because their condition is already compromised. The human medical literature provides conservative worldwide estimates of 15 million nosocomial infections each year (5% of the hospitalized population), leading to 1.5 million deaths per year (10% of affected patients).[1] The most recent data reported an estimated 1.7 million hospital-acquired infections contributing to 99,000 deaths in 2002 in the United States alone.[2] More than 50% of these infections involved the urinary tract or a surgical site. Due to inconsistencies in data collection methods and unavailability of previous rates of infection, comparisons with previous years are very difficult.

The number of hospital-acquired infections in veterinary medicine is unknown. Although it may be lower than that in human medicine, such infections in pets can have a much more profound effect given the lack of pet health insurance coverage and the emotional considerations. Nosocomial infections in veterinary patients often have a broad-spectrum antibiotic resistance pattern that necessitates the use of extremely expensive drugs, adding to the cost of treatment and prolonging hospitalization and patient distress. These variables often lead to higher mortality in the form of euthanasia.

Organisms that can cause hospital-acquired infections may come from health care workers, solutions and liquids present in the hospital, and surfaces such as floors, walls, cages, equipment, and countertops. Surface disinfection is important to reducing the pathogen load of the hospital; if a pathogen from an affected patient contaminates the environment, the colonized surface can in turn contaminate health

TABLE 1 Efficacies of Common Disinfectant Classes

Category	Bacteriocidal or Bacteriostatic	Inactivated by Organic Matter	Activity Against			
			Gram-Positive Bacteria	Gram-Negative Bacteria	Bacterial Spores	Fungi
Alcohols[a] (e.g., ethanol, isopropanol)	Bacteriocidal	Yes	Yes	Yes	No	Low
Biguanides (e.g., chlorhexidine gluconate)	Bacteriocidal	Yes	Yes	Yes	No	Low
Quaternary ammonium compounds[c]	Bacteriostatic	Yes	Yes	Moderate	No	Low
High concentration iodophor compounds (i.e., povidone-iodine)	Bacteriocidal	Yes	Yes	Yes	Moderate	Moderate
Inorganic chlorine solutions (i.e., sodium hypochlorite)	Bacteriocidal	Yes	Yes[d]	Yes	Yes	High
Peroxygen compounds	Bacteriocidal	No	Yes[e]	Yes	Yes	High
Phenolic compounds	Bacteriocidal	No	Yes	Yes	No[f]	Yes
Reducing agents (i.e., glutaraldehyde, dialdehyde, formaldehyde)	Bacteriocidal	No	Yes	Yes	Yes	Yes
Vapor-phase disinfectants (e.g., ethylene oxide, propylene oxide)	Bacteriocidal	Yes	Yes	Yes	Yes	Yes

ENV = activity against enveloped viruses, *N/A* = no information available, *NON* = activity against nonenveloped viruses

[a]Activity in a 70% to 90% solution; ethanol has slightly more activity than isopropanol.

[b]Ethanol is effective against nonenveloped viruses; isopropanol is not.

[c]Virucidal activity varies significantly depending on formulation; some formulations may be more effective than noted here. Not effective against *Mycobacterium* spp. Some manufacturer claims on virucidal activity may be inaccurate.

[d]Studies have shown some strains of *Enterococcus* spp to be resistant to hypochlorite.

[e]Limited efficacy against *Staphylococcus* and *Enterococcus* spp.

[f]Minimal sporicidal activity unless high concentrations are used.

[g]Glutaraldehyde has better virucidal activity than formaldehyde.

care personnel or other patients, resulting in pathogen transmission even when there is no direct contact between patients.[3–6]

Patients admitted to the hospital often receive antibiotics. Once antibiotic treatment has been initiated, antimicrobial resistance begins to develop, even in the patient's normal flora (especially in the gastrointestinal tract). The patient becomes a "factory" for resistant bacteria, contaminating the local environment via urine, feces, and vomit. The hands and clothing of health care personnel become contaminated by touching these surfaces and during patient care (especially pilling, other contact with mucous membranes, and bathing). Contaminated hands and clothing can then disperse the bacteria throughout the hospital and to other patients.

To prevent hospital-acquired infections, facilities should implement a "nosocomial prevention triad" aimed at prudent antibiotic usage, adequate staff and patient hygiene, and scrupulous hospital maintenance and disinfection.[7] Recommendations have been published regarding nosocomial prevention strategies in human hospitals, but these are very general and often too vague for practical use, and many are not applicable to veterinary medicine.[4,5] To our knowledge, no comprehensive review of disinfection strategies and staff hygiene practices in veterinary hospitals has yet been published. This article describes the implementation of hospital maintenance strategies, disinfection protocols, and staff hygiene procedures for the prevention of hospital-acquired infections and the application of these strategies for infection control in small animal general practices and referral institutions. We hope to assist veterinarians in evaluating and restructuring protocols to reduce the pathogen load within their hospitals. Although this is a time-consuming venture, careful thought and planning should ensure that once the protocols are in place, hospitals can dramatically reduce the development of antibiotic resistance and consequent nosocomial infection.

TABLE 1 **Efficacies of Common Disinfectant Classes (continued)**

Category	Activity Against					
	Toxocara spp	Viruses	Feline Rhinotracheitis	Feline Calicivirus	Feline Panleukopenia	Canine Parvovirus
Alcohols[a] (e.g., ethanol, isopropanol)	Yes	ENV[b]	Yes	Yes	No	No
Biguanides (e.g., chlorhexidine gluconate)	N/A	Low	Yes	No	No	No
Quaternary ammonium compounds[c]	Yes	Low	Yes	No	No	No
High concentration iodophor compounds (i.e., povidone-iodine)	N/A	ENV	Yes	Yes	No	Yes
Inorganic chlorine solutions (i.e., sodium hypochlorite)	Yes	NON, ENV	Yes	Yes	Yes	Yes
Peroxygen compounds	N/A	NON, ENV	Yes	Yes	Yes	Yes
Phenolic compounds	N/A	ENV	Yes	Yes	No	No
Reducing agents (i.e., glutaraldehyde, dialdehyde, formaldehyde)	N/A	NON, ENV[g]	Yes	Yes	Yes	Yes
Vapor-phase disinfectants (e.g., ethylene oxide, propylene oxide)	N/A	NON, ENV	Yes	Yes	Yes	Yes

ENV = activity against enveloped viruses, *N/A* = no information available, *NON* = activity against nonenveloped viruses
[a]Activity in a 70% to 90% solution; ethanol has slightly more activity than isopropanol.
[b]Ethanol is effective against nonenveloped viruses; isopropanol is not.
[c]Virucidal activity varies significantly depending on formulation; some formulations may be more effective than noted here. Not effective against *Mycobacterium* spp. Some manufacturer claims on virucidal activity may be inaccurate.
[d]Studies have shown some strains of *Enterococcus* spp to be resistant to hypochlorite.
[e]Limited efficacy against *Staphylococcus* and *Enterococcus* spp.
[f]Minimal sporicidal activity unless high concentrations are used.
[g]Glutaraldehyde has better virucidal activity than formaldehyde.

Disinfection

Disinfection is defined as the application of a disinfectant to materials and surfaces to destroy pathogenic organisms. The activities of some common classes of disinfectants are summarized in **TABLE 1**. Classification schemes divide disinfectants into high-, intermediate-, and low-level agents and medical equipment into critical, semicritical, and noncritical devices.[4,5,8,9] Low-level disinfectants are effective against vegetative (active nonsporulated) bacteria, fungi, and influenza viruses. Disinfectants in this category are used on noncritical items that either touch intact skin or do not directly touch the patient. Intermediate-level disinfectants are effective against *Mycobacterium tuberculosis* and enteroviruses and are generally used on semicritical items that touch mucous membranes but do not penetrate body surfaces. High-level disinfectants are effective against bacterial and fungal spores as well as low- and intermediate-level organisms. Sterilization equipment (steam, liquid, or gas sterilizers) or high-level disinfectants are used on critical items that are introduced into the bloodstream or other sterile sites (e.g., urinary tract, body cavity).[9] Although sterilization is considered superior to disinfection, in many cases, high-level disinfection is sufficient for critical items that cannot withstand the sterilization process.

Surface disinfection is a two-step process. First, gross contamination with organic debris must be removed by general cleaning. Detergents (soaps) suffice for this task. This step is extremely important because many disinfectants are ineffective in the presence of organic debris, and remaining particulate matter can harbor pathogens. Once gross debris has been removed, surfaces should be disinfected with attention to contact times and types of pathogens suspected (**TABLES 2** through **5**).[4,5,8,9]

The entire hospital must be considered in disinfection strategies, from the floors to the most advanced medical equipment. The sur-

TABLE 2 Chemical Agents and Recommended Dilution Instructions[a]

Agent	Manufacturer	Stock Solution	Disinfectant	Recommended Dilution(s)	mL Needed to Make 1 gal	Stability After Dilution
Alcohols						
Ethanol	Various	70%–90%	Ethanol	As is (70%)	None	Not to be diluted
Isopropanol	Various	70%–90%	Isopropanol	As is (80%)	None	Not to be diluted
Biguanides						
Chlorhexidine gluconate	Various	2%	Chlorhexidine	0.15% 0.50%	30[b] 90[b]	Product expiration[c]
Quaternary Ammonium Compounds[d]						
Roccal-D	Pharmacia and Upjohn	24%	Dimethyl benzyl ammonium chloride	1000 ppm 2000 ppm	15[b] 30[b,e]	2 months
Dual Quat	Vet Solutions	16%	Dimethyl benzyl ammonium chloride	1200 ppm	30[b]	1 day
Benz-all	Xttrium	12.90%	Dimethyl benzyl ammonium chloride	1400 ppm	40[b]	14 days
A-33	Ecolabs	Dry powder	Dimethyl benzyl ammonium chloride	Not applicable	1 packet (0.5 oz)[b]	1 day
Parvosol II RTU	AgriLabs	0.21%	Dimethyl benzyl ammonium chloride	As is	None	Not to be diluted
Zephiran	Sanofi	0.13%	Dimethyl benzyl ammonium chloride	As is	None	Not to be diluted
Iodophors						
Povidone-iodine	Various	Various[f]	Iodine	As is	None	Not to be diluted
Inorganic Chlorine Solutions						
Household bleach	Various	5.25%	Sodium hypochlorite	100 ppm (1:500) 1000 ppm (1:50)	7.2 72	1 day
Peroxygen Compounds						
Virkon-S	DuPont	Dry powder	Potassium peroxymonosulfate	1:100	1.3 oz (37 g)	7 days
Trifectant	Vétoquinol	Dry powder	Potassium peroxymonosulfate	1:100	1.3 oz (37 g)	7 days
Hydrogen peroxide	Various	30%	Hydrogen peroxide	7.50%	950; dilute in distilled water only	No data found; rapid degradation
Phenolic Compounds						
Synphenol-3	Veterinary Products Laboratories	26%	Various phenol derivatives	1% 2%	15[b] 30[b]	7 days
Biophene	DuPont	19.80%	Various phenol derivatives	0.80% 1.50% 2.30%	15[b] 30[b] 45[b]	No data per manufacturer
Matar	Ecolab	21.28%	Various phenol derivatives	1% 2%	18 36	7 days
Lysol Brand Concentrate	Reckitt Benckiser	7.50%	Various phenol derivatives	1% 2%	50 100	Product expiration[c]
Reducing Agents						
Metricide 28	Metrex Research	2.50%	Glutaraldehyde	As is	None	Measure active glutaraldehyde
Cidex OPA	Advanced Sterilization Products	0.55%	Ortho-phthalaldehyde	As is	None	75 days once open
CidexPlus 28	Advanced Sterilization Products	3.40%	Glutaraldehyde	As is	None	Measure active glutaraldehyde

[a]All dilutions are for surface disinfection purposes; further dilution may be needed for skin antisepsis.
[b]Taken from manufacturer's dilution recommendations.
[c]Product remains stable until its expiration date, regardless of dilution.
[d]Active ingredients are combinations of modifications to the dimethyl benzyl ammonium chloride molecule.
[e]Recommended dilution for use in foot baths.
[f]A 10% povidone-iodine solution yields 1% available free iodine (10,000 ppm).

vival of gram-negative bacteria on hospital surfaces and linens for more than 60 days has been reported in some scenarios.[10] **TABLES 3** through **5** summarize reasonable choices and necessary contact times for disinfection of various areas of the hospital and types of equipment.

Disinfectants

Efficacy

Disinfectants are separated into classes based on their chemical properties and mechanisms of action. Bacterial resistance to antibiotic medications does not affect the efficacy of disinfectant solutions.[11] The efficacy of quaternary ammonium compounds varies widely depending on formulation. Examples and dilutions of various agents are listed in **TABLE 2**; this is not an exhaustive list.[8,9,12] Much of this information was obtained directly from product labels or manufacturers' recommendations, which should be consulted for all products. The activities cited against groups of organisms are generalizations, and exceptions exist. When specific organisms are noted in the tables, the efficacy against them is based on published reports; efficacies against organisms not listed are unknown to us. Hard water can reduce the activity of many disinfectants, especially quaternary ammonium compounds and biguanides (chlorhexidine).

It should be noted that although frequently used in many hospitals, quaternary ammonium compounds may not be reliably effective.[8,12] Research has identified significant deficiencies in the virucidal activity of even some of the newer quaternary ammonium compounds, despite manufacturers' claims; none of the formulas tested in two separate studies[12,13] were effective against canine parvovirus, feline parvovirus, or feline calicivirus, and only some were effective against feline herpesvirus. These compounds are generally bacteriostatic and have poor gram-negative bacterial and viral efficacy, which can result in incomplete removal of organisms from disinfected surfaces and development of resistance to quaternary ammonium compounds. These facts make the use of quaternary ammonium compounds for general cleaning purposes questionable, and the authors of the studies do not recommend disinfection with quaternary ammonium compounds in areas of suspected contamination. Label claims for the antipathogenic activity of any disinfectant may be inaccurate because testing requirements may not reflect clinical conditions.[14]

The efficacy of a disinfectant may be affected by exposure to air, light, or water. It is important to read the manufacturer's recommendations or contact the manufacturer to ensure the appropriate dilution and storage protocols, as well as the duration of efficacy of the diluted solution. **BOX 1** provides the formula to convert parts per million to milliliters per gallon. Appropriate changing of diluted solutions in spray bottles or other containers should be based on these recommendations. Bleach, some quaternary ammonium compounds, and hydrogen peroxide decompose rapidly when diluted and should be changed daily, at minimum (**TABLE 2**).

Preparation and Use

Bacteria and other organisms can colonize most disinfectant solutions under certain conditions directly related to the preparation and duration of use of the solution. The contaminated solution can then act as a source of pathogens to contaminate the hospital.[15–17] Therefore, solutions should be changed frequently, and the containers used to hold them should be sterilized when the solution is changed. In my (J. A. J.) hospital, scrub pots and cold sterile containers are changed and sterilized weekly, a protocol that was initiated in response to the identification of colonies of multidrug-resistant organisms in these containers. Stainless steel scrub containers can be sterilized in the autoclave, and plastic cold sterile items can be gas sterilized with ethylene oxide. Health care workers should use sponge tongs in scrub pots to minimize skin contact with the disinfectant solution. Alternatively, prepackaged individual units that contain antiseptic solution and an applicator designed for single-patient use can eliminate the need for solution containers and thus avoid possible colonization. Mop buckets and mop handles should be periodically scrubbed with an intermediate-level disinfectant solution and allowed to dry thoroughly before reuse. Gloves should be worn when opening stock solutions, and care should be taken when filling solution containers to avoid contamination from hands or the local environment.

QuickNotes

Increasing compliance with hand hygiene practices and other disinfection protocols is fundamental to infection control in the hospital setting.

TABLE 3 Contact Times for Low-Level Disinfection Agents

	70% to 90% Alcohol (ethanol or isopropanol)	Quaternary Ammonium Solutions[a,b]	100 ppm (0.01%) Available Iodine Iodophore[c]	Peroxygen Compounds[a]	0.15% Chlorhexidine	1% Phenolic Solution[a]	Reducing Agents	100 ppm Sodium Hypochlorite (1:500)
Smooth, hard-surfaced objects[d]		10 min	10 min	5 min	10 min	10 min	5 min	5 min
High-touch objects[e]	10 min	10 min	10 min	5 min	10 min	10 min	5 min	5 min
Solution containers and food bowls[f]		10 min	10 min	5 min	10 min	10 min	5 min	5 min
Rubber tubing and catheters		10 min	10 min	5 min	10 min	10 min	5 min	
Polyethylene tubing and catheters		10 min	10 min	5 min	10 min	10 min	5 min	
Lensed instruments		10 min	10 min	10 min	10 min	10 min	5 min	
Thermometers	10 min							
Hinged instruments	15 min	20 min	20 min	10 min	10 min	15 min	10 min	
Inhalation/anesthesia equipment		20 min	20 min	10 min	10 min			
Floors, furniture, walls, doors, etc[g]		Do not use	Suitable for use	Suitable for use		Suitable for use		Suitable for use

[a]Manufacturer recommendations should be followed regarding dilution (**TABLE 2**).
[b]Quaternary ammonium compounds should be used with caution due to the potential for development of resistance; we do not recommend their use in areas of suspected contamination.
[c]Dilution of stock iodophores is not recommended because this practice may alter the free iodine availability. These agents should be purchased based on desired free iodine concentration.
[d]Includes countertops, examination tables, scales, sinks, and cage walls and doors.
[e]Includes telephones, computer keyboards and mice, sink handles, and doorknobs.
[f]Includes gauze/cotton ball jars, scrub pots, cold sterile containers, and mop buckets and handles.
[g]Contact times are not available.

Resistance

Resistance to disinfectants is another problem. The knowledge base in the literature regarding this topic is increasing, although few recommendations exist for prevention at this time. Most of the current data on disinfectant resistance come from microbial exposure to disinfectants at sublethal concentrations or disinfectants with low bactericidal activity (i.e., quaternary ammonium compounds).[18,19] Genetic mechanisms for development of resistance to quaternary ammonium compounds have also been identified and suggest a higher rate of resistance to these compounds than to other disinfectants.[20] In light of this information, quaternary ammonium compounds should be used with caution, and all disinfectant solutions should be diluted appropriately and changed according to manufacturers' recommendations (**TABLE 2**). We have not identified any references regarding the benefits or consequences of rotation of disinfectants as a preventive strategy for the development of resistance to a particular disinfectant solution, and future studies on this topic should be considered.

Protocols by Hospital Area

Noncritical Surfaces

Noncritical surfaces (e.g., floors, walls, countertops) in veterinary facilities are more likely to be contaminated by pathogens than those in human facilities, as veterinary patients frequently pass body fluids onto environmental surfaces. Furthermore, veterinary patients share equipment (e.g., thermometers, clippers, bandage/suture scissors) and examination tables and are not separated into private or semiprivate rooms or distanced from the floor by a bed. Floors, walls, and tabletops should be cleaned when soiled and disinfected when contamination is suspected. We recommend that mop heads and the disinfectant solution in mop buckets be changed a minimum of twice daily: at the beginning of the day and immediately before the final mopping of the day. Mop heads and cleaning solutions should also be changed whenever visibly soiled and after cleaning large spills.[5] In 24-hour facilities, where there is no end of the day, the mop head and solution should be changed before mopping the floor between shifts. At least once a day, the mop bucket itself should be emptied,

disinfected with a fresh solution, and allowed to dry before refilling. For high-volume or 24-hour facilities where large body-fluid spills are likely to occur frequently, changing the mop head and disinfectant solution after every large spill becomes impractical; we recommend cleaning large spills primarily with disposable materials (e.g., absorbent pads, paper towels) followed by mopping of the local area. Cleaning solutions should contain an appropriate disinfectant, as simple detergents (soaps) are frequently contaminated with pathogens that are then spread throughout the hospital.[21] **TABLES 3** through **5** list appropriate choices for disinfectants. It should be noted that quaternary ammonium compounds have been found to be inadequate for cleaning furniture, bathrooms, toilets, and floors.[21] Carpeting and other cloth furnishings should be deep-cleaned on a regular basis, although we have not identified specific recommendations for appropriate time frames.[5] Cages and other patient housing should be thoroughly disinfected and allowed sufficient contact time before housing another patient. Care should be taken to disinfect all parts of the cage: floor, walls, ceiling, door, and latches.

Floor Drains

We have been unable to identify any literature on the disinfection and maintenance of floor drains in patient care areas.[a] The moist environment and frequent introduction of water contaminated with pathogens create a risk for colonization in floor drains. Liberal flushing of the drain with clean water should follow cleaning of a contaminated area. Intermediate-level disinfectants should be poured into the drain regularly, with attention to contact times before rinsing. We recommend weekly disinfection with a 1:50 bleach solution, but further studies are necessary to assess the risks posed by the use of floor drains. Routine disinfection of sink and tub drains is also recommended, especially in tubs used for wound flushing or patient bathing. If drains are used infrequently, water should be flushed into the drain to ensure appropriate water levels in the plumbing trap; failure to ensure a full trap will allow sewage odors to permeate the hospital area. Caps should be considered for floor drains that are used infrequently.

[a]The decision to place floor drains in the hospital is discussed in "Guidelines for Reduction of Veterinary Hospital Pathogens: Hospital Design and Special Considerations," also available on Vetlearn.com.

High-Touch Surfaces

"High-touch" surfaces—such as door handles and keyboards—should be cleaned and disinfected more often than other surfaces. Several studies have identified bacteria and viruses surviving on numerous fomites in the hospital setting, including computer mice and keyboards; telephones (especially handsets and keypad buttons); sink faucets; door, drawer, cabinet, and procedure light handles; light switches; and cage latches. Plastic covers for keyboards and telephone keypads can aid in cleaning these surfaces and prevent colonization of the crevices between the keys.[22–26] Contamination of high-touch surfaces can be reduced through appropriate hand hygiene protocols, but because hand hygiene compliance is never 100%, surface disinfection is still necessary.

Medical Equipment

Specialized medical equipment (e.g., endoscopes, dental units) must also be considered in disinfection protocols. After use, endoscopes and dental units should be cleaned and scrubbed with an enzymatic cleaner to ensure removal of all organic debris, flushed well with water and air, and disinfected. After equipment has been soaked for the required disinfection time, all parts should be dried thoroughly, preferably with pressurized air to remove any water droplets left in the channels.[4,9,27–31] Specific disinfection recommendations can be obtained from the equipment manufacturer. Ultrasound probes have been shown to pose minimal risk as fomites when wiped clean with a dry towel, but coupling gel can act as a medium for bacterial growth. Therefore, probes should be cleaned at the end of each day to remove any remaining coupling gel, using a low-level disinfectant that will not damage the equipment.[32] We recommend using ethanol or isopropyl alcohol for this task. Stethoscopes have also been identified as sources of nosocomial infections. Isopropyl alcohol is considered the most effective disinfectant for decontamination of the diaphragm compared with plain soap and water, sodium hypochlorite, and quaternary ammonium solu-

*Quick***Notes**

Understaffing contributes to hospital-acquired infections because overworked health care workers do not have time to disinfect the hospital appropriately or observe proper hand hygiene practices.

TABLE 4 Contact Times for Intermediate-Level Disinfection Agents

	70% to 80% Ethanol	500 ppm (0.05%) Available Iodine Iodophore[a]	Peroxygen Compounds[b]	0.5% Chlorhexidine	2% Phenolic Solution[b]	Reducing Agents	1000 ppm Sodium Hypochlorite[c] (1:50)
Smooth, hard-surfaced objects[d]	15 min	20 min	10 min	10 min	20 min	15 min	10 min
High-touch objects[e]	15 min	20 min	10 min	10 min	20 min	15 min	10 min
Solution containers and food bowls[f]	15 min	20 min	10 min	10 min	20 min	15 min	
Rubber tubing and catheters		20 min	10 min	10 min	20 min	15 min	
Polyethylene tubing and catheters		20 min	10 min	10 min	20 min	15 min	
Lensed instruments			15 min	10 min		15 min	
Thermometers	15 min						
Hinged instruments	20 min	30 min	15 min	10 min	20 min	20 min	
Inhalation/anesthesia equipment	20 min	30 min		10 min		20 min	
Floors, furniture, walls, doors, etc[g]		Suitable for use	Suitable for use		Suitable for use		Suitable for use

[a]Dilution of stock iodophores is not recommended because this practice may alter the free iodine availability. These agents should be purchased based on desired free iodine concentration.
[b]Manufacturer recommendations should be followed regarding dilution (Table 2).
[c]1000 ppm bleach solutions can be corrosive to some surfaces.
[d]Includes countertops, examination tables, scales, sinks, and cage walls and doors.
[e]Includes telephones, computer keyboards and mice, sink handles, and doorknobs.
[f]Includes gauze/cotton ball jars, scrub pots, cold sterile containers, and mop buckets and handles.
[g]Contact times are not available.

tions.[33] Pulse oximeter probes are frequently contaminated because of their sites of use; they can be cleaned with alcohol between patients. The controls of any medical device or piece of monitoring equipment should be wiped down at least once daily with alcohol to remove pathogens, and the housings of handheld devices should also be disinfected. Alcohols disinfect by protein denaturation and desiccation; when used for cleaning, alcohol should be applied for the appropriate contact time and allowed to evaporate completely before reuse. The use of probiotic bacteria and biosurfactants to prevent the colonization of pathogenic bacteria on inanimate surfaces is an emerging strategy that may provide another method for protecting medical equipment and devices in the future.[34]

Laundry

Cage bedding, surgical laundry, and other linens pose special disinfection problems. Laundry areas should have appropriate handwashing stations, and other protective equipment (e.g., gloves) should be readily accessible; gloves should be used when processing dirty laundry.[5] Soiled laundry should be contained in leak-resistant containers or bags at the point of use, although covers are not necessary on laundry receptacles. Presorting and prerinsing at the point of use should be avoided.[5] The laundry should be sorted and cleaned of gross debris in the laundry area, then washed in a hot water cycle (>70°C [160°F] for 25 minutes) with an appropriate disinfectant.[4,5,9,35] A 1% bleach dilution is likely to be effective,[35] although one study found that a phenolic compound (Microbac-II; Ecolab, St. Paul, MN) and a dialdehyde (Metricide; Metrex Corp, Parker, CO) were the only products that removed feline calicivirus from 100% polyester fabric (the type of fabric most resistant to disinfection).[36] If the hot water system cannot attain the necessary temperature, successful decontamination has been achieved using a copper-based disinfectant at low temperature settings.[37] Surgical linens (e.g., quarter drapes, surgical pack material) should be washed separately from general hospital linens.

Hand Hygiene

Organisms are most commonly transmitted between patients on the hands of health care workers. As a result, hand hygiene protocols are a major part of nosocomial control strategies. Pathogens contaminate the hands either directly from a colonized pet or from a colonized fomite. If hand hygiene is not performed or is inadequate, pathogens can be spread across the hospital to other patients

TABLE 5 Contact Times for High-Level Disinfection/Sterilization Agents

	Ethylene Oxide Gas	Hydrogen Peroxide Gas Plasma	Hydrogen Peroxide 7.5%[a]	2% Glutaraldehyde Solution (high-level disinfection)	2% Activated Glutaraldehyde (sterilization)	Steam (sterilization; autoclave at 121°F)
Smooth, hard-surfaced objects[b]				30 min		
High-touch objects[c]				30 min		
Solution containers and food bowls[d]	3–12 hr	1–2 hr	6 hr	30 min	10 hr	15–30 min
Rubber tubing and catheters	3–12 hr	1–2 hr	6 hr	30 min	10 hr	
Polyethylene tubing and catheters	3–12 hr	1–2 hr	6 hr	30 min	10 hr	
Lensed instruments	3–12 hr	1–2 hr	6 hr	30 min	10 hr	15–30 min
Hinged instruments	3–12 hr	1–2 hr	6 hr	60 min	10 hr	15–30 min
Inhalation/anesthesia equipment	3–12 hr	1–2 hr	6 hr		10 hr	

[a]7.5% hydrogen peroxide can be corrosive to some metals.
[b]Includes countertops, examination tables, scales, sinks, and cage walls and doors.
[c]Includes telephones, computer keyboards and mice, sink handles, and doorknobs.
[d]Includes gauze/cotton ball jars, scrub pots, cold sterile containers, and mop buckets and handles.

and fomites (e.g., high-touch surfaces).[4,15,38] Contact with patients and their surroundings is unavoidable, and the behavior of pathogens in the environment cannot be controlled; therefore, hand hygiene is the most effective way to prevent the transmission of pathogens within the hospital setting. A multifaceted approach, beginning with staff education, must be used. Staff members must understand the risks to their patients, the hospital, and themselves.

Ideally, gloves would be used for every patient and hand disinfection would immediately follow glove removal. However, this can be costly and associated with poor compliance from health care workers, making it an unrealistic goal in many hospital settings. Therefore, hand hygiene protocols and staff education programs should be implemented. We recommend glove use when handling patients with infections known to be highly transmissible or highly resistant. Immunocompromised patients, such as those undergoing chemotherapy, neonates, or those with low white blood cell counts secondary to disease processes, must also be handled using gloves. Staff members should be trained to disinfect their hands immediately before reaching into a multiunit glove box to prevent contamination of the box and again immediately following removal of the gloves.

Compliance with hand hygiene protocols is likely the greatest obstacle to reducing pathogen transfer from patient to patient. Inevitably, hand hygiene compliance is <100% in any practice. Contamination of the inanimate environment then leads to contamination of all workers, including those following appropriate hand hygiene practices. Compliance rates in many human hospitals are frequently reported to be between 25% and 50%.[39–41] Numerous factors affect compliance among health care workers, including easy access to antiseptic solutions, hand cleaning lotions, and alcohol-based hand rubs, especially in high-demand situations. One of the most important factors is staff education. In some studies, compliance rates were 25% to 50% before implementation of staff education programs; afterward, they were 65% to 80%.[4,5,39,40,42–44] Educational efforts should be examined at the level of the individuals, supervisors, and administrators (including those responsible for product ordering and hospital monitoring).

Product selection is an important aspect of hand disinfection compliance among health care workers. The product used must be efficacious, hypoallergenic, nonirritating, nondrying, and easily accessible.[15,40,42,43] Alcohol-based hand rubs are desirable because of the short time associated with proper antisepsis, tolerability by health care workers, ease of setup for multiple hand hygiene stations, and lack of plumbing requirements. Alcohol-based hand antiseptic solutions and rubs appear to be the most effective at reducing pathogen loads on the hands of health care workers.[15,45,46] Although multiple references suggest superior antisepsis

BOX 1

Formula to Convert Parts per Million to Milliliters per Gallon

Description	Example: Making a 100-ppm solution using household bleach (5.25%)
1. Multiply the percent concentration of the stock solution by 10,000.	1. 5.25 × 10,000 = 52,500
2. Divide the result by the desired concentration in ppm.	2. 52,500 ÷ 100 = 525
3. Divide 3,785 by this result.	3. 3785 ÷ 525 = 7.21
4. Add this many milliliters and fill container with water to a total of 1 gal.	4. Add 7.2 mL of bleach and bring solution to 1 gal with water.

*Quick***Notes**

Compliance with hand hygiene depends on staff education and acceptance of cleaning products and allowing sufficient time for proper hand cleaning.

with alcohol-based hand rubs, hand washing cannot be completely eliminated.[40,44–46] Staff should be educated on the importance of hand washing in the presence of visible soiling. For hand washing liquids and waterless hand rubs, we recommend a perfume-free 60% to 70% ethanol–based formulation that contains 1% to 3% glycerol (an emollient).[b]

The association between workload and hospital-acquired infections is often overlooked. Adequate staffing must be ensured to allow sufficient time not only for patient and client care but also for hand hygiene. The time available for hand hygiene and other preventive strategies is significantly reduced when too few personnel are responsible for too many patients, resulting in increased rates of nosocomial infection.[4,47]

Conclusion

Disinfection strategies for the hospital should include a regular cleaning schedule with attention to appropriate disinfection agents and their necessary contact times for the surface or equipment in question. Cleaning tools, disinfection agents, and hand hygiene stations should be readily available, easily accessible, and well tolerated by staff (especially hand hygiene products). Setting up a comprehensive disinfection program is an intimidating and tedious project, but once it is in place, such a program can dramatically reduce the hospital's pathogen load.

Staff education is imperative to increase compliance with hospital disinfection strategies. Often, health care workers may not realize the potential risks to patients and increase in workload associated with repercussions of nosocomial infections. Instructions should be repeated periodically for redundancy and in training of new staff. The hospital should be adequately staffed to allow enough time for employees to follow the protocols established for hospital maintenance and appropriate hand hygiene practices.

A team approach to the care of the hospital and its patients can dramatically improve the standard of care. Administrators, veterinarians, technicians, and assistants must all participate and communicate in the development, education, implementation, and reinforcement of hospital disinfection and staff hygiene protocols. Increased awareness of the environment as a source of infection can help save lives, improve patient comfort, and significantly reduce hospital costs associated with nosocomial infections. C

[b]Appropriate hand antisepsis in presurgical scrubs is discussed in "Guidelines for Reduction of Veterinary Hospital Pathogens: Hospital Design and Special Considerations," also available on Vetlearn.com.

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3 CE CREDITS

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1. **Mop water and mop heads should be changed**
   - **a.** whenever visibly soiled.
   - **b.** at the start of each day (or between shifts for 24-hour facilities).
   - **c.** before the final mopping at the end of the day.
   - **d.** all of the above

2. **What type of cleaning solution is appropriate for disinfection of thermometers?**
   - **a.** quaternary ammonium compounds
   - **b.** sodium hypochlorite (bleach)
   - **c.** alcohol-based solutions
   - **d.** peroxygen compounds

3. **Prudent management of floor drains involves**
   - **a.** placing drains in as many areas as possible throughout the hospital.
   - **b.** permanently covering all drains.
   - **c.** daily scrubbing with a 1:50 bleach solution.
   - **d.** weekly scrubbing followed by disinfection using a 1:50 bleach solution.

4. **Good hand hygiene compliance**
   - **a.** requires the use of gloves at all times.
   - **b.** requires periodic staff education.
   - **c.** decreases the need to clean high-touch surfaces frequently.
   - **d.** necessitates the use of antibacterial soap for all hand washing.

5. **Which is considered a critical device with regard to disinfection?**
   - **a.** stethoscope
   - **b.** ultrasound probe
   - **c.** endoscope
   - **d.** laparoscope

6. **Which statement regarding disinfection of hospital linens is false?**
   - **a.** All laundry should be cleaned in a hot-water cycle (>160°F) for at least 25 minutes.
   - **b.** Surgical laundry should be washed separately from other linens.
   - **c.** An appropriate disinfectant should be used in the wash cycle.
   - **d.** Dirty laundry should be collected in leakproof containers at the point of use and stored in a covered container until transport to the laundry area.

7. **Before implementation of staff education and training procedures, the rate of hand hygiene compliance in many human facilities is often**
   - **a.** <50%.
   - **b.** 50% to 65%.
   - **c.** 65% to 80%.
   - **d.** 80% to 90%.

8. **After implementation of staff education and training procedures regarding hand hygiene importance, compliance rates often improve to**
   - **a.** <50%.
   - **b.** 50% to 65%.
   - **c.** 65% to 80%.
   - **d.** 80% to 90%.

9. **Which characteristic is not ideal for hand antiseptic solutions?**
   - **a.** nonirritating
   - **b.** pleasant fragrance
   - **c.** efficacious against a wide variety of organisms
   - **d.** nondrying

10. **When cleaning medical equipment that uses water (e.g., endoscopes, dental units), which of the following steps is necessary?**
    - **a.** thorough cleaning, flushing, and scrubbing of all surfaces and channels
    - **b.** use of an appropriate disinfectant with adequate contact time
    - **c.** thorough and complete drying after disinfection
    - **d.** all of the above