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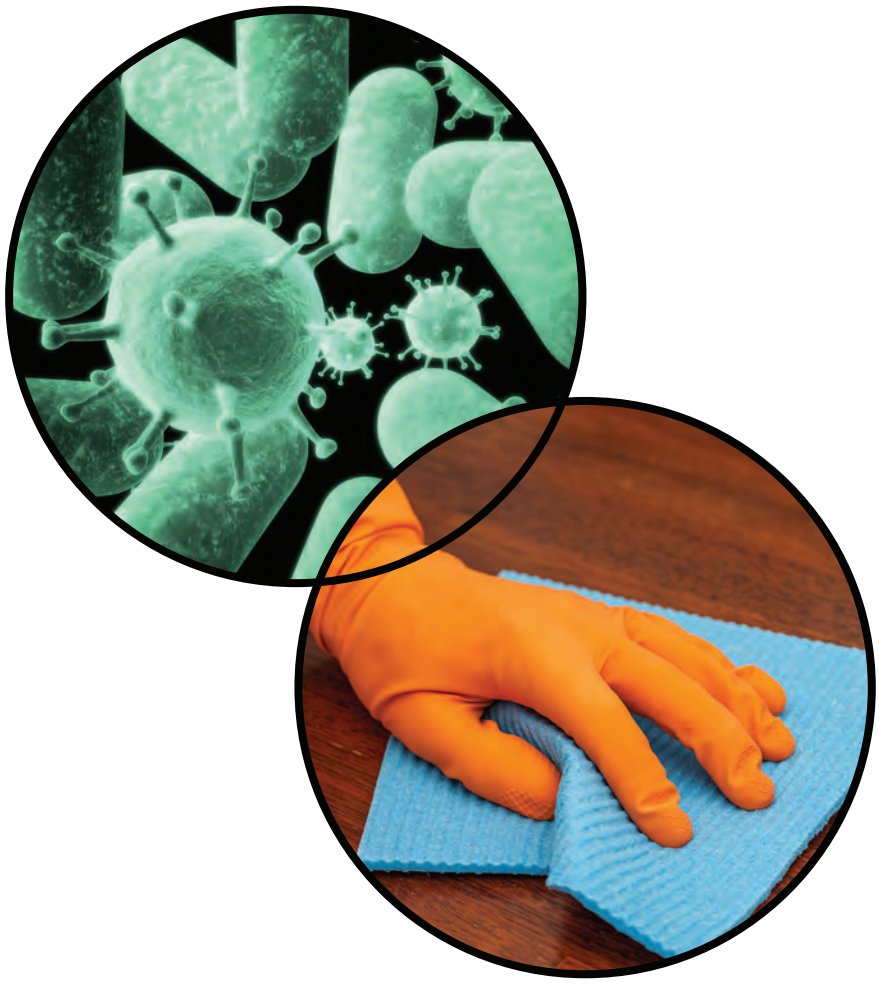

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In the United States, 1 in 25 hospital patients acquire one or more healthcare-associated infections (HAIs) each year (Magill, 2014). Of those who acquire an HAI, approximately 75,000 die and an uncalculated number suffer from long-term complications including paralysis, diminished mental capability, chronic pain, blindness, reduced motor skills, recurring infections, amputated limbs, chronic pain, and lost employment. The Centers for Disease Control and Prevention (CDC) has estimated the financial cost of HAIs to our healthcare system to be between $35.7 and $45 billion each year (Scott 2016).

With an end objective of HAI elimination, the CDC has established tightly defined goals that bring focus on specific HAI infections and gauges their reduction by tracking progress closely in over 5,000 healthcare facilities. The 2020 HAI reduction objectives are summarized in the table below.

Table 1: Expected Infection Reductions for 2020 **Measure**	**Data Source**	**2020 Target (from 2015 baseline)**
Central Line Associated Bloodstream Infection (CLABSI)	(NHSN)	50% reduction
Catheter-Associated Urinary Tract Infection (CAUTI)	(NHSN)	25% reduction
Invasive Methicillin-Resistant *Staphylococcus aureus* (MRSA)	(NHSN/EIP)	50% reduction
Facility-onset MRSA	(NHSN	50% reduction
Clostridium difficile Infection (CDI)	(NHSN)	30% reduction
Surgical Site Infection (SSI)	(NHSN)	30% reduction
CDI hospitalizations (HCUP)	(HCUP)	30% reduction
Table 1: This table lays out expected infection reductions compared to 2015 baseline rates National Healthcare Safety Network (NHSN) tracking is used by over 5,000 healthcare facilities. Emerging Infections Program (EIP) is a CDC program tracking emerging infections and antimicrobial resistance. Healthcare Cost and Utilization Project (HCUP) is a family of healthcare databases and software tools sponsored by the Agency for Healthcare Research and Quality (AHRQ).		

The CDC has focused primarily on acute care facilities. However, increased movement of more procedures into outpatient services requires their inclusion in HAI reduction efforts as well. Such facilities include ambulatory surgical centers (ASCs), dialysis centers, chemotherapy infusion centers, long-term acute care hospitals (LTACHs), and long-term care facilities (LTCF). ASCs are performing more complicated surgeries and many are now allowed to keep patients overnight. Dialysis, infusion centers, LTACH, and LTCFs are expanding largely due to our aging population. As elderly patients are prone to infections and are more often on antibiotic regimens, these facilities can be breeding grounds for antibiotic resistant pathogens. Adding to these concerns, these facilities often do not have the capacity to support strong infection prevention programs. Because patients who acquire infections are transported between these facilities, the CDC recognizes that activities to reduce the spread HAIs and antimicrobial resistance need to be addressed at all healthcare facility levels rather than remain solely focused on acute care hospitals.

Healthcare has entered a time when many factors are contributing to the emergence of the "perfect storm". While we struggle with HAIs in both acute and extended-term care facilities, we do so with an expanding population of the more vulnerable aging patients and new emerging pathogens, all while faced with increasingly ineffective treatments due to antimicrobial resistance. The need for increased infection prevention capability is critical.

One of those capabilities that has been expanding is more effective decontamination of hands, surfaces and items in healthcare facilities. Multiple studies have revealed that hospital surfaces and multi-use devices are readily contaminated with pathogens and opportunistic microorganisms (Hota 2004; Boyce 2007; Weber 2010; Weber 2013; Sexton 2015). These surfaces function as pathogen reservoirs; sources for the spread of HAIs. In fact, Weber, et al stated that, "In some cases, the extent of patient-to-patient transmission has been found to be directly proportional to the level of environmental contamination. Improved cleaning/disinfection of environmental surfaces and hand hygiene have been shown to reduce the spread of all of these pathogens." (Weber 2010).

It has also been shown that pathogens form biofilms on hospital surfaces enabling them to multiply, share antibiotic resistance encoded genes with other bacteria and survive for long periods within their protective biofilm matrix (Vickery 2012; Yezli 2012; Otter 2015). Opportunities for dispersing pathogens are continuous events including microbial spread through touch transfer, droplet aerosols, and contaminated items – fomites. Studies have highlighted contaminated splash droplets from faucets and drains, toilet flushes aerosols, diarrhea, ventilator surfaces, safety rails, IV poles; and onto monitor screens, keyboards, cell phones, iPads, stethoscopes, pressure cuffs, waiting room chairs, etc. These contaminated surfaces and items are then touched or carried by healthcare providers who transport the contamination to other patient environments exposing them to the contaminated devices or hands (Hayden 2008; Huslage 2010; Longtin 2011; Stiefel 2011; Morgan 2012; Russotto 2015). Surface disinfection together with scrupulous hand hygiene (Pittet 2006) are essential if the spread of pathogens in healthcare facilities is ever to be reduced.

To keep up with this continuous microbial deposition and accumulation, more and more facilities are turning to much more frequent decontamination efforts than the traditional "once every 24 hours" or once a day, for frequently touched surfaces. This is where canisters with disinfectant or cleaner disinfectant saturated wipes are so practical and beneficial. Killing infection-causing pathogens before they settle-in and potentially share resistance encoded instructions, and are transferred to the next patient is technology we have today. However, with so many brands and formulations of disinfectant wipes available, how can you tell which disinfection products are right your facility? The good news is, every disinfectant or cleaner disinfectant used in any healthcare facilities must be registered by the Environmental Protection Agency (EPA):

> "to be registered for use in a hospital or medical setting (such as a nursing home, day care center, doctors office), the product must be approved as a broad spectrum disinfectant and also must be proven through efficacy testing to be effective against the nosocomial bacterial pathogen Pseudomonas aeruginosa. Additional claims may be made if testing against other specified microorganisms demonstrates that the product is efficacious. Information on efficacy testing for such products can be found in the Subdivision G testing guidelines and at Disinfectants for Use on Hard Surfaces." (EPA)

There are so many more questions that need to be asked and answered when researching the best disinfectant to meet your needs. For example, focusing on your facility, here are thirteen questions to consider:

1. Will the disinfectant be effective against the pathogens that seem to show-up and spread sporadically?
2. What are the active ingredients in the disinfectant?
3. How much wet contact time (dwell time) is required for killing/inactivating the types of organisms you are fighting? Is it 10 minutes? Can you wait that long? Will it stay wet on the surface that long? Or would it be better to use a 1 or 2 minute required dwell time to kill your targeted pathogens? It can make a huge difference in probability of actually complying with the IFU requirements, the percentage of pathogens killed, liability exposure, and in time expended.
4. Is the wiper sufficiently saturated to cover disinfect a reasonable surface area with enough disinfectant to meet the required dwell time?
5. Does the wiper have a sufficiently coarse surface to disrupt dried organic residue and attached biofilms?
6. Is the disinfectant an effective cleaner? A surface needs to be cleaned before it can be disinfected.
7. Does product leave a sticky residue? Are you required to rinse the surface after disinfection to prevent stickiness or dulling build-up?
8. Are you sure it is safe for use in the nursery?
9. Can you use the product for more than flat environmental surfaces? For example, is it safe to use on a stethoscope diaphragm or on the surface of a glucose monitor; or to disinfect safety glasses or to wipe the frequently touched areas of your facility's privacy curtains?
10. Is it safe for mattresses, or does repeated use create cracks that can protect pathogens and enable their transfer to the next patients occupying the bed?
11. Is the odor too strong? Does it trigger reactions in asthmatics?
12. Does the canister design facilitate easy opening and closing? Does the lid and dispenser design enable the next unused wipe to be sufficiently presented for easy removal, while keeping the wipe moist and protected between uses?
13. Can the disinfectant be used safely on the following surfaces in your facility without making them become cloudy, brittle, degraded, corroded, stained, sticky, or ruined? See Table 2.

Table 2. Surface Type Compatibility to Be Considered When Selecting Disinfectants	
• Acrylic	• Plexiglas®
• Brass	• Powder painted coated surfaces
• Chrome	• Leather
• Copper	• Stainless steel
• Painted surfaces	• Varnished surfaces
• Plastics (e.g., polycarbonate, polypropylene, polyvinylchloride, polystyrene)	

Yet, you may not know the material of construction or their finishes. Another way to assess whether or not a disinfectant is "surface-safe" is to refer to the item's "Instructions for Care" (IFU). For example, the instructions may say 'do not use bleach on the surface as it will oxidize and degrade the waterproof covering' on an examination table, dentist chair, surgery table or mattress cover for example (Hicks 2012). Not following the IFU will usually void the warrantee. Examples of medical equipment and surfaces that are often contaminated and need more frequent disinfection, but may have IFU restrictions, are listed in Table 3. Check the item's IFU for cleaning restrictions or research the EPA website for specific disinfectant compatibility as described later in this article.

Table 3. Are these items "contact safe" after disinfection?		
Anesthesia equipment	Laboratory surfaces and equipment	Privacy curtains
Bassinets	Microscopes, including lenses	Pulmonary function equipment
Biological safety hoods	Monitor screens: LCD thin plastic film*	Reusable pressure cuffs
Cardiac catheterization labs	Monitor screen: glass**	Respirators (elastomeric full/half)
Dialysis machine (external)	Neonatal critical care units	Respiratory care units
Endoscope exterior surface (pre-cleaning after use)	Nurse call button; bed positioning control	Stethoscope diaphragms
Glucose monitors	Nursery surfaces generally	Surgical microscopes; Loupes
Goggles, safety glasses	Nursing station surfaces	Toys
Infant incubator (unoccupied)	Oxygen tent	TV remotes
Keyboards, mouse	Plastic/rubber coated cords/leads	Urinary or IV bag exterior
*LCD touch screens have two very thin plastic films with liquid crystal between **Older Cathode Tube monitor screens possess glass screens with or without an outer thin plastic film		

Breeding grounds: Surface compatibility is much more important than one might realize. It is not just that a disinfectant may make something look old or unkempt. If the disinfectant starts to corrode a surface like a stainless steel counter, handrail, IV pole, medical device or instrument, initially the damage is often not visible. However, any damage invites bacteria to enter even the slightly pitted or damaged areas, find shelter, and initiate biofilm formation (Vickery). For example, this type of damage can occur when using strong acids, ammonia, or hypochlorite-based disinfectants (bleach) on items composed of stainless steel. The corrosive damage increases with repeated use of an inappropriate disinfectant expanding the area affected and the depth of the corrosion providing more shelters to serve as pathogen reservoirs.

There are additional concerns. If the stainless steel item is thin, corrosion will weaken the metal. If it has a sharp blade, the edge will be dulled and microscopically jagged. Not only will the instrument function sub-optimally, but the chemical reactions on the now oxygen-exposed sub-surfaces with mounting rust particles could injure the patient.

LCD touch screens can easily be ruined by incompatible chemicals. It is best to check with the manufacturer as mistakes can be costly. It is important when using a compatible cleaner or disinfectant on any monitor or television screen that you do not spray directly on to the screen as the droplets could penetrate poor seals and short the circuitry, or drip down and seep into the space between the screen and the protective cover.

Accessing the EPA information: Answers to the many questions asked above and many more that are important to be asked, are available to the public. To obtain substantiated, unbiased information, the Environmental Protection Agency (EPA) has posted the validated microbial kill times, surface compatibility details, the disinfectant's active and inert ingredients, stability requirements, and many more details for every EPA approved disinfectant and cleaner disinfectant. However, the EPA does not have a specific list of disinfectants approved for use in healthcare facilities. Because of the diverse surfaces and patient populations that exist, EPA instead reviews test parameters and results regarding each disinfectant's claim for compatibility on hospital surfaces, its potential toxicity, the specific microbial kill test data on which

required dwell time is based for organism-specific inactivation. It also evaluates the cleaning instructions and efficacy of the cleaner in the "all-in-one" cleaner disinfectants.

To access the EPA multipage document on any approved disinfectant at any time, visit:

https://www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants

There you can find any EPA registered disinfectant information by entering:

1. **The 6 digit EPA number** *(EPA Reg. No.)* on the product label (include the dash)
2. **The product's name** (gets you to the same place as the registration number)
3. **The microorganism of specific concern** such as when dealing with an outbreak (e.g. Mycobacterium, Influenza)

Print out the pdf for your research into the best disinfectant(s) for your facility's needs. It is also good to have a copy available to present to an inspector should the disinfectant you selected ever be questioned.

It is important for healthcare professionals and staff alike to understand how long microorganisms remain viable on surfaces and textiles. Sharing the survival chart in Table 4 with fellow professionals, staff, visitors and patients, can help highlight the importance of both surface disinfection and hand hygiene for everyone's protection.

Table 4. Pathogen Survival on Dry Inanimate Surfaces

Bacteria	**Survival**
• **Acinetobacter**	3d to 5mo
• **Clostridium difficile (spores)**	≥5mo
• **Escherichia coli**	1.5h to 16mo
• **Enterococcus Including VRE**	5d to 4mo
• **Haemophilus influenza**	12d
• **Klebsiella spp.**	2h to >30mo
• **Mycobacterium tuberculosis**	1d to 4mo
• **Pseudomonas aeruginosa**	6h to 16mo; 5wk on dry floors
• **Staphylococcus aureus (including MRSA)**	7d to 7mo
• **Streptococcus pneumoniae**	1-20d
• **Streptococcus pyogenes**	3d to 6.5mo
Fungi & Yeast	
• **Aspergillus conidia (spores)**	several mo to >yr
• **Candida albicans**	1-120d
Viruses	
• **Adenovirus**	7d to 3mo
• **Coronavirus (SARS, GI infections, cold)**	3-28d
• **Coxsackie virus**	>2wk
• **Cytomegalovirus**	8h
• **HBV**	2h to 60d
• **HIV**	>7d
• **Influenza virus**	1-2d
• **Norovirus**	CDC: Stable in environment
• **Papillomavirus 16**	>7d
• **Respiratory syncytial virus (RSV)**	Up to 6h
• **Rotavirus**	2d to 2mo
h=hour(s); d=day(s); wk=weeks; mo=month(s). adapted from Kramer 2006 & Casanova 2010	

Emphasize the importance of frequent disinfection by highlighting the fact that cracks, crevices, and corrosion-pitted surface areas missed during cleaning and disinfection are all places that provide added opportunity for extended survival and biofilm formation. A blood smear on the bed rail, a used tissue on the side table, cough droplets landing anywhere, crumbs from a meal on the over table, or just dead skin cells, provide a variety of food sources for bacteria. In addition to heavily contaminated droplets dispersed from the respiratory tract, each person (patient, visitor, or healthcare professional) sheds skin cells at the rate of about 1,000,000,000 cells every day, and that about 10% of these dead skin cells each carry an average of 4 bacteria (Whyte 1988; White 1981). That calculates out to the dispersal rate of approximately 400,000,000 microorganisms every day by every person in addition to those dispersed from the respiratory tract.

With a little shelter and food, bacteria can multiply rapidly. Table 5 displays the exponential growth of Escherichia coli over a 7-hour period. This organism divides quickly, producing a new generation every 20 minutes. It is only logical that the linked practices of surface cleaning, disinfection, and conscientious compliance with hand hygiene requirements provide a formidable defense against cross-contamination and the spread of pathogens.

Table 4. E. coli Multiplication

Time	Number of Bacteria
0	1
20 minutes	2
40 minutes	4
1 hour	8
2 hours	64
3 hours	512
4 hours	4,096
5 hours	32,768
6 hours	262,144
7 hours	2,097,152

Conclusion: Surface disinfection coupled with hand hygiene compliance must be essential parts of every Infection Preventionist's pathogen-fighting plan. The wise choice of an appropriate disinfectant must take into account the facility's history of infections, time required for the disinfectant to kill or inactivate the targeted pathogens, the compatibility of the disinfectant with the wide variety of surfaces upon which it is to be used, and any safety concerns it may present for patients and staff. This article presented many questions to be asked before making final purchasing decisions and described how to find substantiated, unbiased answers to most of those questions on the EPA website. Healthcare facilities are unique environments occupied by very vulnerable individuals who depend on healthcare's stewardship their protection.

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