Disinfectant Use, Best Practices

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Friday, November 4, 2022

OUTLINE

- Systematic Cleaning & Disinfection Practices are key in controlling the spread of pathogens to patient care equipments & surfaces.
- Disinfectants...Definition, Classification, labels and how to select ?
- Rational approach to Disinfection & sterilization based on Spaulding's Classification
- Consideration and assessment for Disinfectants action plan
- Current issues and new technologies in Disinfectants as Hydrogen peroxide & Hypochlorous acid

BACKGROUND

A significant number of hospital-acquired infections occurs due to inefficient disinfection of hospital surfaces, instruments and rooms. The emergence and wide spread of multiresistant forms of several microorganisms has led to a situation where few compounds are able to inhibit or kill the infectious agents.

Several strategies to disinfect both clinical equipment and the environment are available, often involving the use of antimicrobial chemicals. More recently, investigations into gas plasma, antimicrobial surfaces and vapour systems have gained interest as promising alternatives to conventional disinfectants.

Decontamination

Use of physical or chemical means to remove, inactivate, or destroy pathogens on a surface or item so that they are no longer capable of transmitting infectious particles.

Cleaning

A process that removes foreign material (e.g. soil organic material, micro-organisms) from an object

Disinfection

- The removal or destruction of all microbes except bacterial spores
- Precleaning IS A MUST
- Disinfecting agents are registered by the Environmental Protection Agency (EPA) as "antimicrobial pesticides".

Sterilization

A controlled process that destroys all microorganisms including bacterial spores

Disinfection of Patient care Equipments

Miscellaneous Inactivating Agents

1. Flushing- and washer-disinfectors
2. Pasteurization
3. Ultraviolet radiation
4. Metals as microbicides
5. Other germicides

Chemical Disinfectants

1. Acids (eg acetic acid, citric acid)
2. Alcohols (eg Ethanol, Isopropanol)
3. Aldehydes (eg Formaldehyde, gluteraldehyde)
4. Alkalies (eg sodium or ammonium hydroxide)
5. Biguanides (eg chlorhexidine)
6. Halogens (eg chlorine , iodine compounds)
7. Oxidizing Agents (eg Hydrogen Peroxide, Paracetic acid)
8. Phenols
9. Quaternary Ammonium compounds

TABLE 4. Summary of Advantages and Disadvantages of Disinfectants Used as Low-Level Disinfectants

Disinfectant active	Advantages	Disadvantages
Alcohol	Bactericidal, tuberculocidal, fungicidal, virucidal Fast acting Noncorrosive Nonstaining Used to disinfect small surfaces, such as rubber stoppers on medication vials No toxic residue	Not sporicidal Affected by organic matter Slow acting against nonenveloped viruses (eg, norovirus) No detergent or cleaning properties Not EPA registered Damages some instruments (eg, harden rubber, deteriorate glue) Flammable (large amounts require special storage) Evaporates rapidly, making contact time compliance difficult Not recommended for use on large surfaces Outbreaks ascribed to contaminated alcohol[41]
Sodium hypochlorite	Bactericidal, tuberculocidal, fungicidal, virucidal Sporicidal Fast acting Inexpensive (in dilutable form) Not flammable Unaffected by water hardness Reduces biofilms on surfaces Relatively stable (eg, 50% reduction in chlorine concentration in 30 days)[42] Used as the disinfectant in water treatment EPA registered	Reaction hazard with acids and ammonias Leaves salt residue Corrosive to metals (some ready-to-use products may be formulated with corrosion inhibitors) Unstable active (some ready-to-use products may be formulated with stabilizers to achieve longer shelf life) Affected by organic matter Discolors/stains fabrics Potential hazard is production of trihalomethane Unpleasant odor (some ready-to-use products may be formulated with odor inhibitors); irritating at high concentrations
Improved hydrogen peroxide	Bactericidal, tuberculocidal, fungicidal, virucidal Fast efficacy Easy compliance with wet-contact times Safe for workers (lowest EPA toxicity category, IV) Benign for the environment Surface compatible Nonstaining EPA registered Not flammable	More expensive than most other disinfecting actives Not sporicidal at low concentrations

Iodophors	Bactericidal, mycobactericidal, virucidal Not flammable Used for disinfecting blood culture bottles	Not sporicidal Shown to degrade silicone catheters Requires prolonged contact to kill fungi Stains surfaces Used mainly as an antiseptic rather than disinfectant
Phenolics	Bactericidal, tuberculocidal, fungicidal, virucidal Inexpensive (in dilutable form) Nonstaining Not flammable EPA registered	Not sporicidal Absorbed by porous materials and irritate tissue Depigmentation of skin caused by certain phenolics Hyperbilirubinemia in infants when phenolic not prepared as recommended
Quaternary ammonium compounds (eg, didecyl dimethyl ammonium bromide, dioctyl dimethyl ammonium bromide)	Bactericidal, fungicidal, virucidal against enveloped viruses (eg, HIV) Good cleaning agents EPA registered Surface compatible Persistent antimicrobial activity when undisturbed Inexpensive (in dilutable form)	Not sporicidal In general, not tuberculocidal and virucidal against nonenveloped viruses High water hardness and cotton/gauze can make less microbicidal A few reports documented asthma as result of exposure to benzalkonium chloride Affected by organic matter Multiple outbreaks ascribed to contaminated benzalkonium chloride[41]

NOTE. Modified from Rutala and Weber.[43] EPA, Environmental Protection Agency; HIV, human immunodeficiency virus.

A RATIONAL APPROACH TO DISINFECTION AND STERILIZATION

Background:

Dr. **Earle Spaulding** – Microbiologist - of Temple University (Philadelphia) in 1939 proposed "a strategy for sterilization/disinfection" based on a classification of medical reusable devices. **The Spaulding classification was originally proposed in 1957.**

Nowadays this classifications is recognized in National and International Guidelines.

More than 45 years ago, Earle H. Spaulding devised a rational approach to disinfection and sterilization of patient care items or equipment. This classification scheme is so clear and logical that it has been retained, refined, and successfully used by infection control professionals and others when planning methods for disinfection or sterilization.

Spaulding believed that the nature of disinfection could be understood more readily if instruments and items for patient care were divided into three categories based on the degree of risk of infection involved in the use of the items (Risk Assessment of patient care equipment).

Classification of patient care equipment or environment according to Risk Assessment

Items of high risk (critical items)

- **Sterile tissues** body cavities and the vascular system.
- Surgical instruments, vascular catheters.
- **Sterile**
  - Single use and disposable
  - Reusable after thorough cleaning followed by sterilization.

Items of Intermediate risk (Semi-critical items)

- In contact with intact mucous membranes or non-intact skin.
- Respiratory equipment, gastrointestinal endoscopes, vaginal instruments
- Cleaning followed by disinfection is usually adequate

Items of low risk (Non critical items)

- In contact with normal and intact skin or the inanimate environment
- Bedpans, blood pressure cuffs, bedside tables and floors.
- Decontaminated by low level disinfectants.

How are we going to select the Ideal Disinfectant whether for the reprocessing of patient care equipment or environmental disinfection?

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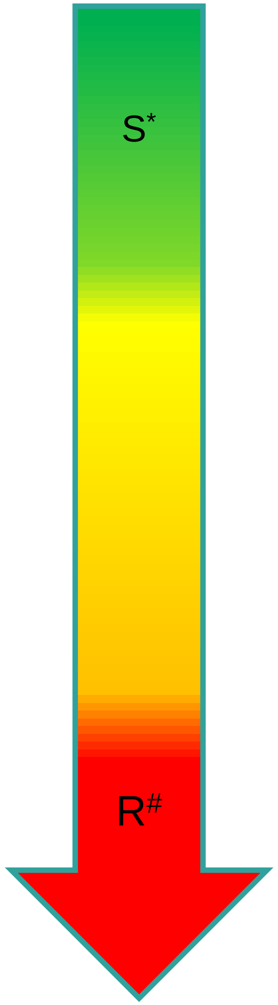
Consideration and Assessment for a Disinfectant Action Plan

Micro-organism consideration

Disinfectant consideration

Environmental consideration

Microorganism Consideration



Organism	Type	
Virus (enveloped)	Virus	Influenza, HIV, HBV, HCV
Gram-positive bacteria	Bacteria	Staphylococcus including MRSA Enterococcus including VRE
Large Virus (non-enveloped)	Virus	Adenovirus Rotavirus
Gram-negative bacteria	Bacteria	*Acinetobacter* *Klebsiella* including CRE
Fungi		Aspergillus
Small Virus (non-enveloped)	Virus	Polio, Norovirus
Mycobacteria	Bacteria	*M. tuberculosis*
Bacterial Spores	Bacteria	*Bacillus, C. difficile*

Effect of Disinfectants on Microorganism

Resistant

* Sensitive

Disinfectant Consideration

- **Disinfectant concentration**
- **Application method.**
- **Contact time**
- **Stability and storage.**
- **Instructions for use**
- **Safety precautions.**
- **Expense.**
- **Economic considerations “**costs should always be calculated on a per gallon of use/dilution rather than the cost of concentrate”

Environmental Consideration

- Purpose of disinfection protocol.
- Organic load
- Surface topography
- Temprature
- Relative Humidity
- Water hardness
- pH
- Presence of other chemicals
- Value of the item to be decontaminated
- Health, safety and the environment

Implementing a Disinfection Action Plan

- Assessment
- Cleaning (washing/sanitizing)
- Disinfection
- Evaluation

Implementing a Disinfection Action Plan

Assessment

A thorough assessment of the problem by evaluating the infectious agent suspected, its mode of transmission, potential areas affected and selection of the proper chemical disinfectant.

Cleaning

It has been estimated that cleaning alone may remove over 90% of bacteria from surfaces.

Washing/sanitizing

This is the most crucial step in the disinfection process and will most likely eliminate the majority of remaining microorganisms, if performed correctly.

Disinfection

Always read the entire product label and follow dilution instructions explicitly to ensure that the safest, most effective concentration is applied.

Evaluation

While visual inspection of cleanliness is important, bacteriological samples should be obtained to determine the effectiveness of the cleaning and disinfection protocol. The best time to sample is 2-3 days after disinfection.

Key Considerations for Selecting the Optimal Disinfectant

Consideration	Questions to ask	Score (1–10)
Kill claims	Does the product kill the most prevalent healthcare pathogens, including those that • Cause most HAIs? • Cause most outbreaks? • Are of concern in your facility?	
Kill and wet-contact times	How quickly does the product kill the prevalent healthcare pathogens? Does the product keep surfaces visibly wet for the kill times listed on its label?	
Safety	Does the product have an acceptable toxicity rating? Does the product have an acceptable flammability rating? Is a minimum level of personal protective equipment required? Is the product compatible with the common surfaces in your facility?	
Ease of use	Is the product odor considered acceptable? Does the product have an acceptable shelf life? Does the product come in convenient forms to meet your facility's needs (eg, liquids, sprays, refills, multiple wipe sizes)? Does the product work in the presence of organic matter? Is the product water soluble? Does the product clean and disinfect in a single step? Are the directions for use simple and clear?	
Other factors	Does the supplier offer comprehensive training and ongoing education, both in person and virtual? Does the supplier offer 24-7 customer support? Is the overall cost of the product acceptable (considering product capabilities, costs of infections that may be prevented, and costs per compliant use)? Can the product help standardize disinfectants used in your facility?	

When determining the optimal disinfecting product for surface disinfection in your facility, consider the 5 components shown, give each product a score (1 is worst and 10 is best) in each of the 5 categories, and select the product with the highest score as the optimal product choice (maximum score is 50).

Disinfectant Labels

Product labels contain important information on the proper use and hazards of a chemical. This information may often be overlooked, however **it is a violation of federal law to use a product in a manner inconsistent with its labeling.**

Disinfectants may have a range of uses and label claims, such as cleaner, deodorizer, sanitizer, disinfectant, fungicide, virucide or 'for hospital, institutional and industrial use'.

1. **product Identification**
2. **Name (brand and generic) , category of compound**
3. **Listing of ingredients by percentage of chemical composition**
4. **Registration Date (National, EPA, FDA)**
5. **Use characteristics (Dilution, activation)**
6. **Germicidal activity (spectrum for use)**
7. **Safety information(MSDS)**

CURRENT ISSUES AND NEW TECHNOLOGIES IN DISINFECTION AND STERILIZATION

New disinfectants that are currently available or under development include improved hydrogen peroxide liquid disinfectants, peracetic acid-hydrogen peroxide combination, electrolyzed water (hypochlorous acid), cold atmospheric pressure plasma, and polymeric guanidine.

Boyce *Antimicrobial Resistance and Infection Control* (2016) 5:10
DOI 10.1186/s13756-016-0111-x

Antimicrobial Resistance and Infection Control

REVIEW **Open Access**

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Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals

John M. Boyce

Abstract

Experts agree that careful cleaning and disinfection of environmental surfaces are essential elements of effective infection prevention programs. However, traditional manual cleaning and disinfection practices in hospitals are often suboptimal. This is often due in part to a variety of personnel issues that many Environmental Services departments encounter. Failure to follow manufacturer's recommendations for disinfectant use and lack of antimicrobial activity of some disinfectants against healthcare-associated pathogens may also affect the efficacy of disinfection practices.

Abstract

Experts agree that careful cleaning and disinfection of environmental surfaces are essential elements of effective infection prevention programs. However, traditional manual cleaning and disinfection practices in hospitals are often suboptimal. This is often due in part to a variety of personnel issues that many Environmental Services departments encounter. Failure to follow manufacturer's recommendations for disinfectant use and lack of antimicrobial activity of some disinfectants against healthcare-associated pathogens may also affect the efficacy of disinfection practices.

Improved hydrogen peroxide-based liquid surface disinfectants and a combination product containing peracetic acid and hydrogen peroxide are effective alternatives to disinfectants currently in widespread use, and electrolyzed water (hypochlorous acid) and cold atmospheric pressure plasma show potential for use in hospitals. Creating "self-disinfecting" surfaces by coating medical equipment with metals such as copper or silver, or applying liquid compounds that have persistent antimicrobial activity surfaces are additional strategies that require further investigation.

Newer "no-touch" (automated) decontamination technologies include aerosol and vaporized hydrogen peroxide, mobile devices that emit continuous ultraviolet (UV-C) light, a pulsed-xenon UV light system, and use of high-intensity narrow-spectrum (405 nm) light. These "no-touch" technologies have been shown to reduce bacterial contamination of surfaces. A micro-condensation hydrogen peroxide system has been associated in multiple studies with reductions in healthcare-associated colonization or infection, while there is more limited evidence of infection reduction by the pulsed-xenon system. A recently completed prospective, randomized controlled trial of continuous UV-C light should help determine the extent to which this technology can reduce healthcare-associated colonization and infections.

In conclusion, continued efforts to improve traditional manual disinfection of surfaces are needed. In addition, Environmental Services departments should consider the use of newer disinfectants and no-touch decontamination technologies to improve disinfection of surfaces in healthcare.

Keywords: Disinfection, Disinfectants, Cleaning, Ultraviolet light, UV-C, Hydrogen peroxide vapor

Improved Hydrogen Peroxide

- **Effective Microbicidal Activity** very low levels of anionic and/or nonionic surfactants in an acidic product that act with hydrogen peroxide

- **Safe** for humans and equipment, and **benign** for the environment

- **The lowest EPA toxicity category (category IV)** based on its oral, inhalation, and dermal toxicity... **nontoxic and is not an irritant**.

- **Various concentrations (e.g., 0.5 to 7 percent)** Lower concentrations (i.e., 0.5 percent, 1.4 percent) and higher concentrations (e.g., 2 percent) are designed for the low level and the high level disinfection respectively.

- Different products may use different terminology **“accelerated” or “activated”**

Improved Hydrogen Peroxide

Cont.

- The improved hydrogen peroxide-based environmental surface disinfectants proved to be more effective (> 6log10 reduction) and fast-acting (1 minute) microbicides in the presence of a soil load (to simulate the presence of body fluids) than commercially available hydrogen peroxide.

- The activated hydrogen peroxide completely eliminated contamination with methicillin-resistant *Staphylococcus aureus (MRSA) and vancomycin-resistant* enterococci (VRE) and resulted in a 98.5 percent reduction in microbes (only *Bacillus spp. recoverable). Thus, at UNC Health Care privacy* curtains are being disinfected at the grab area by spraying the grab area of the curtain three times with activated hydrogen peroxide at discharge cleaning.

Food Research 4 (Suppl. 4) : 65 - 72

Journal homepage: http://www.myfoodresearch.com

FOOD RESEARCH

Effective microbial disinfection in food industry with hydroxyl radical fumigation

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Article history:

Received: 27 May 2020

Received in revised form: 23 September 2020

Accepted: 7 December 2020

Available Online: 20 December 2020

Keywords:

Abstract

Hydrogen peroxide (H_2O_2) fumigation has recently been explored and tested to be a good fumigant replacement of formaldehyde. This technique has been proven safer, less irritating and requires shorter exposure times. Surface disinfection has long been implemented with toxic formaldehyde or 35% hydrogen peroxide (H_2O_2). The results showed that they could be replaced with a safer and stronger oxidizing agent, activated

Article history:
Received: 27 May 2020
Received in revised form: 23 September 2020
Accepted: 7 December 2020
Available Online: 20 December 2020

Keywords:
Surface disinfection,
Hydrogen peroxide,
Fumigation,
Ozone,
Ultraviolet

DOI:
https://doi.org/10.26656/fr.2017.4(S4).010

Abstract

Hydrogen peroxide (H_2O_2) fumigation has recently been explored and tested to be a good fumigant replacement of formaldehyde. This technique has been proven safer, less irritating and requires shorter exposure times. Surface disinfection has long been implemented with toxic formaldehyde or 35% hydrogen peroxide (H_2O_2). The results showed that they could be replaced with a safer and stronger oxidizing agent, activated H_2O_2 in a vaporized form. Aerosolization by aerosol generators has been used to produce aerosols containing hydroxyl radicals of hydrogen peroxide. The dispersal of this highly oxidizing mist of micron-size droplets destroyed *Escherichia coli* and *Aspergillus niger* colonies that have been artificially spiked on surfaces. The experiments demonstrated efficient disinfection by integrating 1 to 5% H_2O_2 fumigation with ozone (O_3) and ultraviolet light (UV-C). Studies with *E. coli* and *A. niger* showed some disinfection with either O_3 or UV-C. Combining H_2O_2 fumigation with both O_3 and UV-C exposure considerably accelerated the microbial inactivation. This approach allowed fast disinfection with 1 to 5% H_2O_2 while offering cheaper and safer disinfection for healthcare settings.

5. Conclusion

In this research, the results presented the successful methodology for surface disinfection using hydrogen peroxide (H_2O_2) fumigation in couple with ozonation and UV photolysis. Oxidizing agents have been widely used in food industry, hospitals and clinics for cleaning, yet existing methods have some disadvantages. For example, vaporized hydrogen peroxide (VHP) requires high concentration of H_2O_2. In this work, a system that produces aerosols of H_2O_2 solution to inactivate the microorganisms was developed. Exposure of the fumes to either ozone or UV light has found to enhance the rate of disinfection. When combining both ozone and UV effects to the fumigation system, the disinfection was the most efficient, making it possible to clean the surface totally within a very short time and with a low concentration of H_2O_2.

Aerosolized Hydrogen Peroxide Decontamination of N95 Respirators, with Fit-Testing and Viral Inactivation, Demonstrates Feasibility for Reuse during the COVID-19 Pandemic

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Affiliations + expand

PMID: 36040048 PMCID: PMC9599425 DOI: 10.1128/msphere.00303-22

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PAGE NAVIGATION

Title & authors

Abstract

Conflict of interest statement

Figures

Abstract

In response to the demand for N95 respirators by health care workers during the COVID-19 pandemic, we evaluated decontamination of N95 respirators using an aerosolized hydrogen peroxide (aHP) system. This system is designed to dispense a consistent atomized spray of aerosolized, 7% hydrogen peroxide (H_2O_2) solution over a treatment cycle. Multiple N95 respirator models were subjected to 10 or more cycles of respirator decontamination, with a select number periodically assessed for qualitative and quantitative fit testing. In parallel, we assessed the ability of aHP treatment to inactivate multiple viruses absorbed onto respirators, including phi6 bacteriophage, herpes simplex virus 1 (HSV-1), coxsackievirus B3 (CVB3), and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). For pathogens transmitted via respiratory droplets and aerosols, it is scenario. **IMPORTANCE** The COVID-19 pandemic led to unprecedented pressure on health care and research facilities to provide personal protective equipment. The respiratory nature of the SARS-CoV2 pathogen makes respirator facepieces a critical protective measure to limit inhalation of this virus. While respirator facepieces were designed for single use and disposal, the pandemic increased overall demand for N95 respirators, and corresponding manufacturing and supply chain limitations necessitated the safe reuse of respirators when necessary. In this study, we repurposed an aerosolized hydrogen peroxide (aHP) system that is regularly utilized to decontaminate materials in a biosafety level 3 (BSL3) facility, to develop a method for decontamination of N95 respirators. Results from viral inactivation, biological indicators, respirator fit testing, and filtration efficiency testing all indicated that the process was effective at rendering N95 respirators safe for reuse. This proof-of-concept study establishes baseline data for future testing of aHP in crisis-capacity respirator-reuse scenarios.

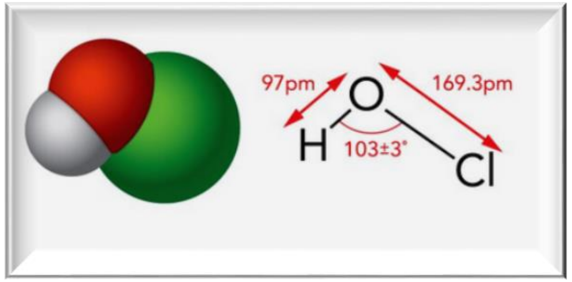
Keywords: COVID-19; CURIS; N95 respirators; SARS-CoV2; aerosolized hydrogen peroxide; decontamination; disinfection; filtering facepiece (FFP) respirators (FFR); fit-testing; sterilization; virologic testing; virus.

Related information

Grant support

LinkOut - more resources

Hypochlorous Acid



- Not all chlorine species are the same – or as effective. Studies exploring the mechanism of chlorine disinfection can't precisely identify how each particular chlorine species works, but it's a mix of:
Rapid oxidation reactions with cell walls or other vital cell components including proteins, nucleic acids and key enzymes rendering them non-functional, and the rate of diffusion through the cell wall – so how quickly it penetrates into pathogen Cells.

- Hypochlorous works on both levels and that's why it's widely regarded as being 100 times more effective than more commonly used disinfectants in the chlorine family, such as bleach.

- Most disinfectants kill by penetrating the cell wall and killing the RNA or DNA, but this can take 1, 5 or 10 minutes or longer. As hypochlorous acid has high oxidation values it oxidises cell walls very quickly, penetrating the cell and killing them within seconds.

Uses

- **In medicine,** hypochlorous acid water has been used as a disinfectant and sanitiser.

- In wound care, and as of early 2016 the U.S. Food and Drug Administration has approved products whose main active ingredient is hypochlorous acid for use in treating wounds and various infections in humans and pets. It is also FDA-approved as a preservative for saline solutions.

- **In disinfection,** it has been used in the form of liquid spray, wet wipes and aerosolised application. Recent studies have shown hypochlorous acid water to be suitable for fog and aerosolised application for disinfection chambers and suitable for disinfecting indoor settings such as offices, hospitals and healthcare clinics.

Uses

Cont.

- **In food service and water distribution**, specialized equipment to generate weak solutions of HClO from water and salt is sometimes used to generate adequate quantities of safe (unstable) disinfectant to treat food preparation surfaces and water supplies. It is also commonly used in restaurants due to its non-flammable and nontoxic characteristics.

- **In water treatment,** hypochlorous acid is the active sanitizer in hypochlorite-based products (e.g. used in swimming pools).

- **In deodorization**, hypochlorous acid has been tested to remove up to 99% of foul odours including garbage, rotten meat, toilet, stool, and urine odours.

TAKE HOME MESSAGE

- **When properly used, disinfection and sterilization can ensure the safe use of invasive and noninvasive medical devices.**
- **Cleaning should always precede high level disinfection and sterilization.**
- **Strict adherence to current disinfection and sterilization guidelines is essential to prevent patient infections and exposures to infectious agents.**

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f you' willing

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- John Maxwell

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Thank You

For your attention