Disinfection of Surfaces and Equipment

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Chemical disinfection of surfaces and instruments is an important aspect of infection control as routinely practised in dental units and elsewhere. The timing and method of chemical disinfection, the factors affecting the efficacy of germicides and the hazards posed by their use are important considerations in selecting disinfectants. The terminology used for such chemicals is often confusing, and many of the common synonyms (such as biocide, microbiocide, germicide and disinfectant) imply a broad spectrum of efficacy against a range of microbial pathogens. However, a given product may actually carry claims for activity against only one class of microorganisms, usually vegetative bacteria. Therefore, the user is urged to closely examine a product's label claims before purchase to assess its potential for surface disinfection or decontamination.

The main reason for practising disinfection is to interrupt transmission of pathogens from an infected individual to a susceptible host. Disinfection of air is impractical, potentially hazardous and usually ineffective in preventing transmission of airborne microorganisms, so disinfection is usually confined to the use of liquid chemical germicides on environmental surfaces and equipment. When a pathogen is shed into the environment it contaminates surfaces either directly or through settled aerosols. Depending on the nature of the pathogen and its suspending medium, as well as environmental factors such as temperature and relative humidity, organisms can survive for periods from a few minutes to several weeks or even months. The initial drying period affects pathogen viability to varying degrees, but fractional amounts of most pathogens can be detected up to several hours on contaminated surfaces. During that time, contact with the contaminated item may result in direct inoculation of a susceptible host or, more likely, contamination of another vehicle, such as the hands, by means of which indirect inoculation occurs. Disinfectants can be effective in limiting the survival of pathogens and their transfer to susceptible hosts or secondary vehicles.

Heat sterilization, when possible, is always preferred to chemical disinfection. However, high-level chemical disinfection of instruments after each use may be necessary in some situations. The determination of the need to disinfect environmental surfaces is usually a matter of assessing the relative risks to patients and staff from exposure to frequently contacted surfaces that may be at risk of contamination, either directly or from settled aerosols.

Efficient disinfection depends on 3 principles, which are equally important in achieving a successful result. The *product* is important because a poor disinfectant will not work even when applied properly and regularly. The *protocol* by which the selected product is applied is important because even a good product, regularly used, will not work if the method of application does not result in good contact with the contaminated surface or surfaces. *Regular compliance*, using an appropriate protocol and a good product, is essential because if the product is not applied regularly or properly, disinfection will not occur. What product is to be applied, and when and how the application is to take place, should be defined in documented protocols and procedures for disinfection of all important surfaces and equipment, especially when disassembly is required. In addition, chemical disinfection should be performed in conjunction with handwashing or antisepsis, because transfer of pathogens between hands and objects occurs readily when either is contaminated.

The major factors affecting the efficacy of disinfection are presented in Table 1.

A wide range of disinfectants is available for purchase, including halogen compounds such as sodium hypochlorite, alcohols, peroxygen compounds such as hydrogen peroxide, and aldehydes such as glutaraldehyde, all of which generally have a broad efficacy spectrum when used appropriately. Other types of disinfectants such as phenols, quaternary ammonium compounds and biguanides (including chlorhexidine) are relatively ineffective against nonenveloped viruses and bacterial spores, and many have limited ability to kill mycobacteria.

The ideal disinfectant has the following properties: it has a broad spectrum of activity, acts rapidly, is not readily neutralized, is noncorrosive, is environmentally friendly, is free of volatile organic compounds, is nontoxic and nonstaining, and lacks hormone-disrupting components. In addition, the product should have a clear label, with instructions for use

Table 1 Factors Affecting Efficacy of Disinfection

Factor	Comments
Concentration of disinfectant	Each disinfectant has a minimum concentration for potency against particular pathogens in suspension; when contaminants are dried onto a surface, the concentration required is invariably higher
Formulation of disinfectant	Even if 2 products have the same nominal concentrations of active ingredients, other components of the formulations may affect relative efficacy
Target organism(s)*	Pathogens have different degrees of resistance to germicides; although there is definite overlap between classes depending on organism and product, the order of resistance is generally considered to be as follows: bacterial spores > non enveloped viruses = mycobacteria > fungi > enveloped viruses = vegetative bacteria
Contact time	Disinfectants should be applied for at least the time specified on the product label as this has been validated by the manufacturer
Temperature	Efficacy of disinfection generally increases with temperature; therefore, it is important to observe the minimum temperatures given on label instructions
Water hardness	Hard water can diminish product efficacy; consult product label or the manufacturer
Soil load	Inorganic or organic soil remaining on surfaces can partially neutralize applied disinfectants by interaction and can help to shield microbial contaminants from contact with the disinfectant
Biofilm presence	Surfaces that are continuously or frequently wet or damp develop microbial biofilms, which can be very resistant to disinfection
Surface microtopography	Even apparently flat surfaces have many scopic irregularities, which can shield microorganisms from proper contact with the disinfectant; formulations often contain wetting agents to facilitate such contact
Precleaning	The compatibility of precleaners and disinfectants must be verified, especially for quaternary ammonium compounds
pH	Disinfectants are usually designed to work optimally at a specified pH
Relative humidity	Relative humidity of the room affects penetration of the disinfectant into dried material
Compatibility	Some surfaces are incompatible with certain types of disinfectants
Application method	The amount of disinfectant delivered to the target depends on whether it is applied by immersion, flooding, brushing or wiping; moreover, the nature of the applicator should be compatible with the type of disinfectant and the applicator must be clean, so as not to neutralize the applied disinfectant
Application rate	The ratio between the target contamination and the applied disinfectant is important, especially when soiling is present: the amount to be applied per unit area is not usually specified by the manufacturer
Storage	Disinfectant should always be stored according to the manufacturer's directions
Product age	Disinfectant should always be used within the manufacturer's specified shelf life

**In practice, the contaminating microorganisms are not usually known.*

that are unambiguous and easy to follow. Unfortunately, some labels are extremely confusing and difficult to understand, even for the infection control professional. In Canada, disinfectants for use in dental practice have a drug identification number (DIN) issued by Health Canada, which is shown on the label. The product label also presents the main set of information that the manufacturer is legally required to provide, and the label contents are monitored before issuance of the DIN. Nonetheless, the disinfectant user *must* read the label carefully before selecting and using a product.

Disinfection is a double-edged sword. By their very nature, disinfectants are potent chemicals designed to kill; therefore, they can present hazards, especially if used frequently or improperly. Some disinfectants can be carcinogenic, toxic to humans or the environment, and can act as hormone disrupters. Not all types of disinfectants present the same safety risks: some can be readily neutralized by dilution or are readily biodegradable, whereas others may leave toxic and environmentally harmful residues or may persist for prolonged periods in the environment. Thorough rinsing of instruments with sterile water is desirable to avoid exposing patients to residual disinfectant. Exposure to certain disinfectants can lead to skin reactions and sometimes extreme sensitization. Caution must also be exercised with disinfectant products that may be flammable or corrosive.

Disinfectants for use on environmental surfaces are frequently diluted. Proper storage and labeling of disinfectants is essential, even after dilution, to avoid the possibility of accidental ingestion. Extreme caution should be exercised in the storage and control of such solutions because certain bacteria, in particular mycobacteria and pseudomonads, can persist and grow in improperly diluted disinfectants or those that have been stored improperly or for too long. To avoid problems, such diluted disinfectants should be made up in limited quantities and renewed regularly in properly cleaned containers. Containers of diluted disinfectants and handwashing agents should be cleaned properly before being refilled. Although extreme resistance to germicides is rare, there is currently significant interest in the possibility that some mechanisms of bacterial resistance overlap between antibiotics and germicides, both of which are bacterial toxins. Therefore, exposure to sublethal concentrations of germicides may trigger antibiotic resistance by a common mechanism.

Users should be aware that accepted methods for testing disinfectants are flawed and under review. Very different assessments of efficacy may be obtained by different laboratories examining the same batch of the same product. Some products may therefore carry label claims that cannot be substantiated by more stringent testing. Moreover, salespersons often exaggerate the capabilities of the products they are marketing. In general, microbial biofilms are more difficult to disinfect than microorganisms dried on surfaces, which in turn are more difficult to destroy than bacteria in suspension; this progression is especially important for mycobacteria. However, it must be remembered that disinfection is only a tool — a helpful tool when used properly, but one that cannot be relied upon to solve infection control problems. Ideally, disinfection forms just one component of an overall infection control strategy. While it is difficult to make specific recommendations on brand-name products, oxidative chemicals such as the peroxides, peracids and halogen compounds are recognized for their broad spectrum of activity when formulated and used properly, and hydrogen peroxide itself has the added benefit of being relatively safe for personnel and the environment when properly handled. ✥

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