Editorial

Antiseptics and Disinfectants—Safe and Effective?

In his presentation before the British Medical Association in 1867, Joseph Lister referred to the positive influence that antiseptic treatment has " . . . upon the general healthiness of a hospital."[1] Now, 117 years later, we have innumerable chemical disinfectants and antiseptics to help us achieve that state of healthiness by reducing microbial contamination of the animate and inanimate environment to a level unlikely to allow transmission of infection. For this reason the germicidal activity of disinfectants (used to decontaminate patient care supplies or equipment) and antiseptics, may be the most important criterion for selecting a particular germicide. While neither disinfectants nor antiseptics are required to sterilize treated objects, they should not support bacterial growth in stock or recommended use-dilutions. Such, however, is not always the case as two articles in this issue of *Infection Control* emphasize. Newman et al detail persistent contamination of a disinfectant system which pipes phenol into each laminar air flow room to the toilet and to a spray faucet which is available for cleaning surfaces.[2] Ironically, this piped disinfectant system which was designed to help reduce potential pathogens in the environment of critically ill oncology patients contributed to environmental contamination with *Pseudomonas sp.* Sautter et al report a case of *Serratia marcescens* meningitis associated with skin preparation with benzalkonium chloride before a subarachnoid injection of an anti-inflammatory agent.[3] This study demonstrates again the means whereby organisms persist in benzalkonium chloride and cause serious nosocomial infections.

Contaminated disinfectants and antiseptics have been occasional vehicles of hospital infections for more than a quarter of a century.[4-33] Has there been an increase in reported infections secondary to the use of contaminated antiseptic or disinfectant solutions? If so, what control measures could be instituted to prevent recurrence of these products as the source of nosocomial infections? Are newer chemical formulations of germicides more resistant to contamination or are multiply antibiotic-resistant nosocomial pathogens more resistant to the germicides? These are a few of the questions that will be briefly addressed in this editorial.

Disinfection is an intermediate process between cleaning and sterilization. The objective of disinfection is to prevent infection by reducing microbial contamination on inanimate objects to a level unlikely to be hazardous. The factors that affect the efficacy of chemical disinfectants and the categories of disinfection based upon the degree of infection risk are well-described.[34-36] When examining the reports of disinfectants found contaminated with microorganisms there are several noteworthy observations. Perhaps most importantly, members of the genus *Pseudomonas* (eg, *P. aeruginosa*) are the most frequent isolates from contaminated disinfectants, being the agents recovered from 80% of the contaminated products. Their ability to remain viable or grow in use-dilutions of disinfectants is unparalleled. This survival advantage for *Pseudomonas* is presumably due to their nutritional versatility[37-41] and/or their unique outer membrane which constitutes an effective barrier to the passage of germicides.[34] While the concentrated solutions of the disinfectants have not been demonstrated to be contaminated at the point of manufacture, Newman et al found that an undiluted phenolic may be contaminated by a *Pseudomonas sp.* during use. Additionally, about half of the reports in the Table discuss illness associated with the contaminated disinfectants. In fact, most of the reports that describe illness associated with contaminated disinfectants, used the products to disinfect patient-care supplies

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TABLE
CONTAMINATED GERMICIDES

Antiseptics	Organisms Isolated
Benzalkonium chloride	*Pseudomonas-Achromobacteriaceae,*[9] *Pseudomonas sp.,*[5,17] *Enterobacter agglomerans,*[19] *Enterobacter cloacae,*[7,19] *Serratia marcescens,*[3,19] *Pseudomonas cepacia*[13,19,20]
Benzalkonium chloride/picloxydine	*Pseudomonas cepacia*[21,23]
Cetrimide	*Pseudomonas aeruginosa*[4]
Chlorhexidine	*Serratia marcescens,*[29] *Flavobacterium meningosepticum,*[16] *Flavobacterium sp.,*[29] *Pseudomonas aeruginosa,*[32] *Pseudomonas cepacia,*[15,31] *Pseudomonas sp.*[10,29]
Chlorhexidine/Cetrimide	*Pseudomonas cepacia,*[14] *Pseudomonas maltophilia,*[24] *Pseudomonas sp.*[10]
Hexachlorophene	*Pseudomonas aeruginosa*[33]
Poloxamer-iodine	*Pseudomonas aeruginosa*[30]
Povidone-iodine	*Pseudomonas cepacia*[27,28]
Propamidine	*Pseudomonas cepacia*[22]
Disinfectants	**Organisms Isolated**
Chlorhexidine	*Flavobacterium meningosepticum,*[16] *Pseudomonas sp.*[9]
Quaternary ammonium	*Serratia marcescens,*[26] *Pseudomonas aeruginosa,*[6] *Pseudomonas cepacia*[17]
Phenolic	*Alcaligenes faecalis,*[12] *Pseudomonas aeruginosa,*[12,18] *Pseudomonas sp.*[2,11,25]
Pine	*Pseudomonas aeruginosa*[18]

or equipment such as cystoscopes, cardiac catheters, and thermometers.

Antiseptics are substances that reduce microbial contamination when applied to skin and other superficial tissues. Again, *Pseudomonas sp.* (especially *P. cepacia*) are the most frequent isolates (88%) from contaminated antiseptics. Further, nosocomial infections were commonly associated with the contaminated antiseptics presumably because they were used for direct patient care activities, such as wound and skin care or as a skin preparation before invasive procedures. The several outbreaks of infection associated with in-use contamination of quaternary ammonium products (QUATS), eg, benzalkonium chloride, provide strong support for the Centers for Disease Control (CDC) elimination of such solutions as antiseptics on skin and tissue.[36] The safer and more effective antimicrobial agents preferred by experts for handwashing are 4% chlorhexidine, 3% hexachlorophene, iodophors and alcohol. While there are reports of in-use contamination of hexachlorophene, iodophors and chlorhexidine, with the exception of the iodophors, these reports describe a more diluted form of the antiseptic than is recommended.

Has there been an increase in reported infections secondary to the use of contaminated antiseptic or disinfectant solutions? So far, there are 32 published reports describing contaminated disinfectant and antiseptic solutions, and the frequency of contaminated germicides and infections secondary to their use has increased. For example, examining these reports in five-year periods from the first report in 1951 to the present, one realizes that the frequency of contaminated disinfectant and antiseptic publications has peaked in the last decade with ten in 1975-1979 and nine in 1980-1984. About half of the reports in each period describe infections secondary to the use of the contaminated products. So while there were three less reports of contaminated quaternary ammonium compounds in 1980-1984 than in the preceding five-year period, chlorhexidine and phenol were observed contaminated at a similar frequency in both periods and the iodophors were observed contaminated for the first time in 1980. How *Pseudomonas cepacia* survived in a 10% solution of povidone-iodine (1% iodine) and undiluted poloxamer-iodine is inexplicable. Several hypotheses were formulated by Berkelman et al including intrinsic resistance of *P. cepacia* to iodine or perhaps protection of the bacteria by organic or inorganic debris.[27] A more definitive answer as to why *Pseudomonas* has a survival advantage in the antiseptics and disinfectants listed in the Table will not be available until investigators clarify the mechanism of microbiocidal activity of germicides and evaluate the unique characteristics of *Pseudomonas sp.* that permit their tolerance to or utilization of these compounds. Are multiply antibiotic-resistant strains of nosocomial pathogens innately more resistant to the germicides? Available data suggest that antibiotic-resistant strains of nosocomial pathogens are not discernibly more resistant to germicides than are antibiotic-sensitive strains.[42] For example, when antibiotic-resistant and -sensitive hospital strains of bacteria (*Staphylococcus aureus, P. aeruginosa, Klebsiella pneumoniae, Escherichia coli, Staphylococcus epidermidis*) were tested using the Association of Official Ana-

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lytical Chemists (AOAC) Use-Dilution method, the antibiotic-sensitive and antibiotic-resistant strains showed a similar susceptibility to a phenolic and a QUAT. Further, when ten commonly used hospital disinfectants (five phenolics and five QUATS) were tested against the three AOAC test bacteria, the data showed that most disinfectants were effective (disinfectant killed the test organism in 59/60 replicates) against *S. aureus* and *Salmonella choleraesuis* but were generally ineffective against *P. aeruginosa* (unpublished results, Rutala). One explanation for these data is that *P. aeruginosa* has an innate resistance to disinfectants and antibiotic-resistant and -sensitive strains of nosocomial pathogens are similarly affected by disinfectants. There are also no data that suggest the transfer of genetic material carrying antibiotic resistance also carries resistance to germicides commonly used in hospitals. Can we expect our newer chemical formulations of germicides to be more resistant to contamination? This question cannot be confidently answered without additional information; however, for reasons already discussed it appears that germicides used in hospitals today are not more resistant to contamination with the principal contaminant, *Pseudomonas*.

What control measures should be instituted to reduce the frequency of contaminated antiseptics and disinfectants and the threat of serious nosocomial infections related to their use? First, some germicides are not meant to be diluted and those that are must be prepared correctly to achieve the manufacturer's recommended use-dilution. We must also learn from the literature what inappropriate activities result in extrinsic contamination (at the point of use) of our antiseptics and disinfectants and prevent their recurrence. Common sources of extrinsic contamination in the reviewed literature are the water used to make working dilutions, contaminated containers, or general contamination of the hospital areas where the antiseptics or disinfectants are prepared and/or used. Success in overcoming these contamination problems can only be made by educating hospital personnel to the potential risk of infection associated with these inappropriate practices. Second, until we can depend on germicides being self-sterilizing there must be federal regulations which establish sterility standards for manufacturers. This will necessitate developing an accurate and simple assay for determining microbial contamination of different germicides. Third, manufacturers should be encouraged by the infection control community to develop germicides that demonstrate efficacy against *P. aeruginosa* and *P. cepacia*. Fourth, manufacturers' efficacy claims against microorganisms should be verified by independent laboratories or preferably by the appropriate federal agency (Environmental Protection Agency—EPA—for disinfectants and Food and Drug Administration—FDA—for antiseptics) using a standardized test. The EPA recently stopped intramural pre- and post-registration efficacy testing of chemical disinfectants and presently manufacturers do not need verification of claims by the EPA or an independent testing laboratory. Additionally, the AOAC Use-Dilution method used for testing disinfectants has several presumed deficiencies and there is no standardized protocol required by the FDA for efficacy testing of antiseptics. The FDA also does not require manufacturers' efficacy data if the antiseptic contains an active ingredient that is already on the market in that concentration. These problems should be eliminated by standardized protocols for testing disinfectants and antiseptics as well as pre- and post-registration efficacy testing by the appropriate federal agency or independent laboratories. This would provide assurance that products that meet the requirements are capable of achieving a certain level of antimicrobial activity when used as directed. Unless control measures are instituted, we can confidently predict that additional reports will emerge that describe contaminated antiseptics and disinfectants and nosocomial infections secondary to their use.

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