Microbiologic evaluation of microfiber mops for surface disinfection

William A. Rutala, PhD, MPH,[a,b] Maria F. Gergen, MT (ASCP),[a] and David J. Weber, MD, MPH[a,b]
Chapel Hill, North Carolina

Background: Recently, health care facilities have started to use a microfiber mopping technique rather than a conventional, cotton string mop to clean floors.
Methods: The effectiveness of microfiber mops to reduce microbial levels on floors was investigated. We compared the efficacy of microfiber mops with that of conventional, cotton string mops in 3 test conditions (cotton mop and standard wringer bucket, microfiber mop and standard wringer bucket, microfiber system). Twenty-four rooms were evaluated for each test condition. RODAC plates containing D/E Neutralizing Agar were used to assess ''precleaning'' and ''postcleaning'' microbial levels.
Results: The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner (95% vs 68%, respectively). The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system (95% vs 95%, respectively). However, use of disinfectant did significantly improve microbial removal when a cotton string mop was used (95% vs 68%, respectively).
Conclusion: The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner. The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system. (Am J Infect Control 2007;35:569-73.)

The effective use of disinfectants constitutes an important factor in preventing hospital-associated infections. In 1968, E. H. Spaulding proposed 3 categories of germicidal action to prevent a risk of infection associated with the use of equipment or surfaces.[1] These 3 categories were critical, semicritical, and noncritical. Noncritical surfaces can be divided into noncritical patient care items (eg, blood pressure cuffs) and noncritical environmental surfaces (eg, floors, bedside tables). Contact with noncritical items or surfaces carries little risk of transmitting a pathogen to patients because intact skin is generally a barrier to disease transmission.[2] Thus, the routine use of disinfectants to disinfect hospital floors and other environmental surfaces is controversial.[3,4]

From the Department of Hospital Epidemiology,[a] University of North Carolina Health Care System, and the Division of Infectious Diseases,[b] University of North Carolina School of Medicine, Chapel Hill, NC.

Address correspondence to William A. Rutala, PhD, MPH, Division of Infectious Diseases, Bioinformatics Building, 130 Mason Farm Road, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7030. E-mail: brutala@unch.unc.edu.

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Although noncritical environmental surfaces have not been directly implicated in disease transmission for most nosocomial pathogens, these surfaces may potentially contribute to cross transmission by allowing acquisition of transient hand carriage by health care personnel because of contact with a contaminated surface or by patient contact with a contaminated surface or medical equipment.[2] Using conventional, cotton string mops for wet mopping of patient care areas has long been the standard in floor cleaning in hospitals. Conventional, cotton string mopping requires environmental service staff to change the cleaning solution after mopping 3 patient rooms, which results in the disinfectants (or detergents) and several gallons of water constantly being disposed of and replenished.[5] Recently, health care facilities have started to use a microfiber mopping technique to clean floors. Microfiber products first appeared in Japan more than 30 years ago but emerged in Europe in 1996. In the last several years, microfiber mops have supplanted the conventional, cotton string mop in the commercial and consumer markets. Microfibers are a densely constructed material blended from polyester and polyamide (nylon). These fibers, approximately one sixteenth the size of a human hair, have approximately 40 times more surface area than that of cotton fiber and are advertised to hold dirt, bacteria, and liquid more effectively (Rubbermaid Commercial Products, Winchester, VA). The density of the fiber allows it to hold 6 times its weight in water. The particles are positively charged

Table 1. The effectiveness of microfiber mops in removing microorganisms from floors

Cleaning solution	Test condition	Cleaning system	Solution dry time (min)	Mean % reduction ± SD* (Mean CFU/RODAC pre- and postcleaning)
QUAT	A	Cotton mop/standard bucket with wringer	2:48	94.84 ± 4.8 (101.7-4.5)
QUAT	B	Microfiber mop/standard bucket with wringer	2:13	87.94 ± 17.2 (120.0-17.7)
QUAT	C	Microfiber mop/microfiber bucket	7:04	95.31 ± 5.7 (137.3-5.9)
Detergent cleaner	D	Cotton mop/standard bucket with wringer	2:48	67.75 ± 31.6 (123.0-39.2)
Detergent cleaner	E	Microfiber mop/standard bucket with wringer	2:23	79.74 ± 24.8 (127.1-34.9)
Detergent cleaner	F	Microfiber mop/microfiber bucket	8:03	94.50 ± 4.6 (136.8-7.6)

QUAT, quaternary ammonium compound; *SD*, standard deviation.
*Each test condition evaluated 24 rooms and 5 samples per room; thus, mean percentage reduction summarizes the 24 rooms and 5 samples per room or 120 RODAC samples per condition tested.

and attract negatively charged particles such as dirt and microorganisms.[5] In addition, some grades of microfiber are split to create gripping "hooks" that trap dust and microorganisms (Rubbermaid Commercial Products, Winchester, VA). Because we could find no studies that evaluated the effectiveness of microfiber mops in removing bacteria from environmental surfaces, we compared the ability of the microfiber and the conventional, cotton string mop to remove microorganisms from an environmental surface.

METHODS

In comparing the efficacy of microfiber mops with that of conventional, cotton string mops, we investigated 3 test conditions: (1) a conventional, cotton string mop in combination with a standard wringer bucket; (2) a microfiber mop (ie, 18-inch blue wet pads; Rubbermaid Commercial Products, Winchester, VA) in combination with a standard wringer bucket; and (3) a microfiber cleaning system consisting of a microfiber mop and its customized "rinsing system" (Press Wring Bucket; Rubbermaid Commercial Products).

When the cotton string mops were tested (Table 1, test conditions A and D), they were wetted with the cleaning solution, placed in the wringer to remove excess solution, and the floors were wet mopped in their entirety and allowed to dry. The conventional, cotton string mop was soaked in fresh solution and used for only 3 rooms. New solution was used for each test condition.

When the microfiber mop was used in conjunction with a standard wringer bucket (Table 1, test conditions B and E), microfiber mops were allowed to soak in the cleaning solution. Immediately prior to use, one microfiber mop was taken out of the cleaning solutions and folded into quarters and placed into the wringer over a towel dampened with the solution to give the mop the additional height required for the wringer to function. A downward pressure was applied to the handle for 10 seconds to express the excess germicide. When the microfiber system was tested (Table 1, test conditions C and F), the system consisted of a specialized bucket (eg, Press Wring Bucket) and a microfiber mop. The Press Wring Bucket was filled with the desired volume of cleaning solution, and the microfiber mops were allowed to soak in the solution. The microfiber mop was secured to the hook-and-loop fastening system at the base of the mop handle. Per manufacturer's recommendation, to remove excess solution, the mop was lifted onto the bucket sieve, and, holding the handle upright (perpendicular to the floor), the mop was pressed straight down firmly over the sieve of the bucket. The application of pressure onto the sieve to remove excess solution was repeated 3 times. All mopping was performed by the same trained individual to avoid introducing technique bias (eg, equivalent pressure applied to both the cotton string mop and the microfiber mop was employed). Each microfiber mop was used and then laundered. The microfiber mops were laundered per manufacturer's recommendations and, postlaundering, were found devoid of microbial contamination using sheep blood agar (≤1 colony *Bacillus* species or coagulase-negative staphylococcus per plate).

Twelve rooms from a general surgery ward were used to conduct the study. All of the rooms used in our study were measured, and the average square footage was 140.6 (range, 103.4-193.2 sq ft). Each room was cleaned with a dry dust mop prior to sampling. The room was then divided into quadrants. Each of the 4 quadrants, along with the center of the room, was cultured using a RODAC plate containing D/E Neutralizing Agar (Becton Dickinson & Company, Sparks, MD). After collecting these "precleaning" samples,

Table 2. Comparison of the microfiber and conventional, cotton string mop

Microfiber mop	Conventional, cotton string mop
No water changing; solution remains clean	Water changed every 3 or 4 patient rooms; solution becomes dirty
One mop pad per patient room	Mop changed regularly
Reduced or no chemicals	Chemical (disinfectant or detergent) changed every 3 or 4 patient rooms
Lightweight mop (~2 lb)	Heavier mop (~10 lb)
Possibly better cleaning performance (penetrates microscopic crevices of most surfaces)	Cleaning efficacy may be less
Withstands approximately 300 laundry cycles	Withstands approximately 75 laundry cycles
May be more cost efficient (per reduced cleaning times, staff injuries, chemical usage, and others; although microfiber mop is approximately 3× times more expensive)	May be more costly

Modified from Rubbermaid Commercial Products (Winchester, VA) and Environmental Protection Agency,[5] Polonsky and Roill,[6] and Lehman.[14]

the room was mopped with a cleaning solution. Once the floor had dried, ''postcleaning'' samples were obtained in the same manner as that described above.

The cleaning solution for test conditions A, B, and C was a quaternary ammonium solution that was used at the recommended use dilution of 1:128 (5.15% didecyl dimethyl ammonium chloride, n-alkyl [50% C14, 40% C12, 10% C16]; 3.43% dimethyl benzyl ammonium chloride; A-428-N EcoLab, Airkem Professional Products, Division of Ecolab, St. Paul, MN) and allowed to air-dry. The quaternary ammonium compound was prepared fresh daily by making a 1:128 dilution with sterile distilled water. The cleaning solution for test conditions D, E, and F was a Neutral Cleaner (EcoLab; Airkem Professional Products). This cleaner did not have any germicidal properties and was prepared by dissolving 1 packet in 7.5 L of sterile distilled water.

Statistical comparisons were performed by a 1-way ANOVA analysis. To adjust for multiple comparisons, statistical significance was defined as $P < .01$.

RESULTS

The results are shown in Table 1. When the conventional mop and bucket were used, the level of microbial reduction was significantly improved with the quaternary ammonium compound versus the detergent cleaner (94.84% vs 67.75%, respectively, $P < .0001$). However, when the microfiber mop was used with the quaternary ammonium compound compared with the detergent cleaner and either the routine bucket (87.94% vs 79.74%, respectively, $P > .05$) or the special microfiber bucket (95.31% vs 94.50%, respectively, $P > .05$), there was no significant difference in bacterial reduction. The microbial load prior to cleaning ranged from a mean of 102 to 137 colony-forming units (CFU)/RODAC plate and, following cleaning, decreased to 4 to 35 CFU/RODAC plate.

The microfiber system we used in this study employed a microfiber mop and a system bucket with a grid to express excess fluid. The microfiber system we used applied more water/disinfectant or detergent to the floor as indicated by the increased dry time.

DISCUSSION

Microfiber fabrics have been introduced into health care facilities to improve cleaning. A comparison between the microfiber and conventional, cotton string mop is shown in Table 2. A positive component of the microfiber system is the use of 1 cleaning mop per room instead of changing mops every 3 rooms. The microfiber mops are placed in the basin or bucket of disinfectant (or detergent) and removed one at a time for use. No redipping would occur because, after use, it is placed in a container for laundering. The special laundering process of the microfiber excludes the use of bleach, which degrades the microfiber, and fabric softeners. In addition, the washing temperature cannot exceed 200°F, and the drying temperature cannot exceed 140°F (Rubbermaid Commercial Products). Cleaning is achieved as per manufacturer's directions. The microfiber system is currently replacing the traditional 1- or 2-bucket conventional, cotton string mop process in many health care facilities.

The microfiber mops can withstand over 300 launderings. Although we evaluated only the microfiber mops used to clean floors, microfiber cloths are also available for bathroom, glass, and general purpose cleaning. The lighter weight microfiber mops should improve productivity and decrease worker injury costs because the traditional mop weighs approximately 10 lb and the microfiber mop approximately 2 lb. Additionally, the microfiber mop does not require employees to wring out the cotton mops, which occurs more than 75 times per shift with conventional, cotton string mops.[6]

Although extraordinary cleaning and decontamination of floors in health care facilities is not warranted, when blood and other potentially infectious materials are present on floors, a disinfectant is recommended.[7]

In fact, the Centers for Diseases Control and Prevention (CDC) guidelines advises that facilities may wish to use a 1-step process and an Environmental Protection Agency (EPA)-registered hospital disinfectant designed for housekeeping purposes in patient care areas in which (1) uncertainty exists as to the nature of the soil on the surfaces (eg, blood or body fluid contamination vs routine dust or dirt) or (2) uncertainty exists regarding the presence of multidrug-resistant organisms on such surfaces.[2,8] This may present a problem to environmental service workers because it may not always be obvious when patient care surfaces are contaminated with multidrug-resistant organisms or blood and it may not be convenient to maintain 2 products on the environmental services cart: a neutral detergent cleaner and a disinfectant. Whatever a health care facility decides to do regarding the use of a disinfectant or detergent with a microfiber or conventional cotton mop, the importance of complete and consistent cleaning is critical. Our data suggest the health care facilities that use conventional, cotton string mops could use a disinfectant for 2 reasons: (1) to improve microbial elimination on floors and (2) to prevent microorganisms being carried from room to room because mops are only changed every 3 rooms.[9] Our data further suggest that, if the microfiber system is used, the use of a disinfectant does not significantly improve removal of microorganisms compared with the use of a detergent cleaner. It is unclear whether the type of cloth (ie, cotton fiber mop or microfiber) used to apply the quaternary ammonium compound to the surface affected the concentration of the quaternary ammonium compound delivered to the surface. It has been shown in one study[10] that cotton and cellulose-based wipers significantly absorb the quaternary ammonium compounds and do not release them to the surface; however, microfiber was not studied. Prior to recommending the widespread use of microfiber cloths or mops without disinfectants, our results need to be validated in other studies. Because microorganisms are entrapped (but not inactivated) within the microfiber weave, effective laundering is essential to mitigate contamination risk of the reusable microfiber cloths.[11] Our preliminary assessment of our routine laundering cycle showed that no microorganism were recoverable on blood agar plates when an impression method was used. Furthermore, the microbial removal of microfiber cloths used on other surfaces (eg, plastic laminate, tile, stainless steel) needs to be investigated.

It is essential that cleaning be thorough and consistent and that all surfaces be wiped regardless of whether cleaning is done with a detergent or disinfectant. From studies we have conducted for surface disinfection, we believe that successful surface disinfection is dependent on ''practice not product.'' That is, when vancomycin-resistant enterococci or methicillin-resistant *Staphylococcus aureus* are recovered from surfaces cleaned with a disinfectant, it is not due to a failure of the disinfectant to inactivate the pathogen[12,13] but rather that a failure to wipe all surfaces leads to continued microbial contamination of nonwiped surfaces (Rutala WA, unpublished data, November 2006). Obviously, effective cleaning with a nongermicidal detergent is also dependent on wiping all surfaces because removal requires that there be physical contact.

The increased exposure time observed with the microfiber system using the microfiber system bucket occurred because the microfiber pad contained excess cleaning solution that was not removed by applying pressure to the sieve. The longer dry times could increase the risk of slips and falls. The manufacturer now markets a microfiber pad system that has a bucket with a wringer for expressing excess cleaning solution (Pedal Wring Bucket; Rubbermaid Commercial Products). The dry times for the Pedal Wring Bucket (10.36 minutes, n = 3) and the Press Wring Bucket (7.04 minutes, n = 24) were longer than the routine bucket wringer (2.13 minutes, n = 24) or a ''twist of the wrist'' of the microfiber mop (2.15 minutes, n = 3). If a health care facility changes to microfiber mops and cloths, training is an essential part of implementing the new cleaning method. Some health care facilities that have implemented the use of microfiber mops decided not to use them in areas possibly contaminated with high amounts of blood (eg, operating room, emergency department) or in greasy, high-traffic kitchen areas.[5,14]

In conclusion, the microfiber system tested demonstrated superior microbial removal compared with conventional, cotton string mops when used with a detergent cleaner. The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system. However, use of disinfectant did significantly improve microbial removal when a conventional, string mop was used. The microfiber system also prevents the possibility of transferring microbes from room to room via a contaminated mop or cloth because a new microfiber cloth is used in each room.

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