

Clinical Advantages of Disposable Microfiber Mops

David J. Flynn
Peter K. Kang, Ph.D.
K. Mark Wiencek, Ph.D.

A study of hygiene and effectiveness of disposable versus laundered microfiber products for healthcare cleaning and disinfection

Overview

The need

Environmental surfaces can contribute to the risk of healthcare-associated infections. To improve outcomes, many facilities now use microfiber cloths as part of their cleaning programs. Can the type of microfiber product (disposable vs. re-laundered) make a difference?

The solution

Disposable microfiber mops and wipes offer improved cleaning, compatibility with disinfectants, and consistent quality compared to re-laundered products.

The benefit

Improved compliance, reliability and efficacy of cleaning procedures can reduce the risk of cross-contamination in healthcare environments.

Introduction

For decades, cleaning procedures for healthcare environments have depended on using cotton string mops and cleaning cloths. In the early 2000's, healthcare Environmental Services departments began transitioning from cleaning with cotton products to cleaning with laundered or disposable microfiber floor mopping pads and cloths. While several studies have shown the migration to microfiber textiles has improved cleaning and disinfection techniques and effectiveness (1-4), results of further research summarized below support the additional benefits from using disposable (single-use) microfiber products versus laundered (re-usable) products.

The performance concerns around cleaning with re-laundered microfiber products include:

- 1) Loss of cleaning capacity after repeated laundering due to damage to the fibers.
- 2) Retention and accumulation of microbes, dirt and debris within the microfiber material through repeated use and inadequate laundering.
- 3) Increased risk of cross-contamination and binding/neutralization of disinfectants from contamination during laundering, transport or storage.

This report summarizes the results of several studies that examined the primary concerns with laundered microfiber products used in healthcare applications and how those concerns can be addressed by disposable products.

Study Parameters

- 1) Microfiber mopping pads were examined before and after laundering using microscopy to visualize the impact of laundry processes (mechanical agitation, high temperatures and chemicals) on the delicate microfiber structures that are essential for maximum cleaning performance.
- 2) Levels of organic and inorganic residues/debris trapped in microfiber products after laundering were examined with microscopy and quantified using a simple extraction test.
- 3) The impact of residual organics after laundering on the binding/neutralization of a quaternary ammonia disinfectant was determined for several laundered mops collected from the field.
- 4) Bioburden (bacteria and fungi) on reusable microfiber mops and wipes after laundering was determined using standard microbiological techniques.
- 5) The cleaning efficacy of disposable vs. laundered microfiber products in hospital patient rooms was quantified using ATP analysis.



The laundry facility is faced with a paradox – either launder too aggressively and damage the microfiber, or launder too gently and microbes can survive.

Impact of Laundering Processes on Physical Properties of Microfiber

The properties that make microfiber products such good cleaning tools also make them nearly impossible to be cleaned. The fine filaments and delicate fiber structures are designed to gather and hold dirt, organic matter and microbes; it is extremely challenging to consistently remove those contaminants in each successive laundry cycle. Laundries attempt to clean microfiber textiles with mechanical, thermal and chemical processes during washing and drying. However, these processes can easily damage the microfibers, especially through repeated cycles. Thus, the laundry facility is faced with a paradox – either subject the products to effective laundry conditions that damage the cleaning efficiency of the fibers in the textiles or protect the products from degradation by minimizing the harshness of laundry treatment conditions and then risk incomplete cleaning and disinfection.

Visual Inspection and Analysis with Microscopy

The effects of repeated laundering on microfiber mops can be obvious to the naked eye (Figure 1). A quick exam of a typical storage bin filled with re-laundered mops and wipes reveals the variation in the quality of mops going through the laundering process as mops of different ages are mixed together at the laundry (Figure 2). As stated earlier, the fine nature and delicate structure of synthetic microfibers makes them subject to damage during laundering. The damage can occur from chemicals (e.g. bleach, fabric softeners) in the wash process, or from physical sources (heat, abrasion) in both the washing and drying processes. Upon closer examination, particulate contaminants that become entrapped within microfiber cleaning cloths during use or during the laundering process can be seen. As shown in Figures 3 and 4, it is not unusual to observe contamination such as dirt, hair, sutures and fibers from other cleaning textiles trapped in “clean” laundered mops and wipes. Damaged microfiber and particulate debris also can be seen by examining the mop fibers under a scanning electron microscope. Figures 5 and 6 confirm the dramatic difference between “new” microfiber and microfiber that has been “in the system” for just a few laundry cycles. The laundered fibers appear distorted and melted together. This results in decreased elasticity, sorbency, and capacity to grab and hold dirt, debris and microbes. Particulate contamination not removed by laundering (or introduced during the laundering process) are evident as white specks in Figure 6.

Figure 1 *New mop vs. re-laundered mop from a hospital housekeeping laundry bin.*



One or more laundry cycles.



Too many laundry cycles.



Figure 2 Typical load of laundered mop pads and other cleaning cloths after laundering.



Figure 3 and 4 Micrographs of a copper-colored and green-colored “clean” laundered floor mop pad showing trapped hair and fibers.

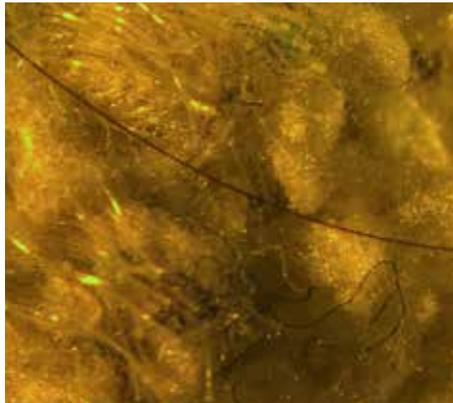


Figure 3

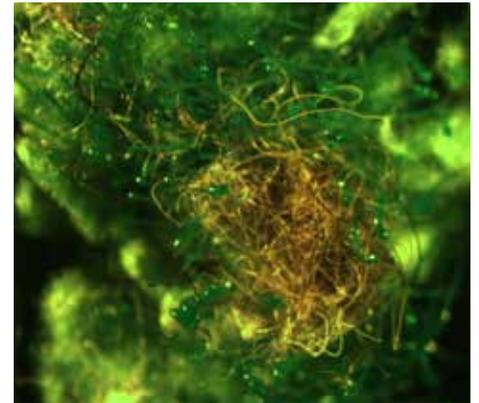


Figure 4

Figure 5 and 6 Scanning electron micrograph of a new, unlaunched microfiber flat mop and a re-laundered flat mop. (mag.=1000x)

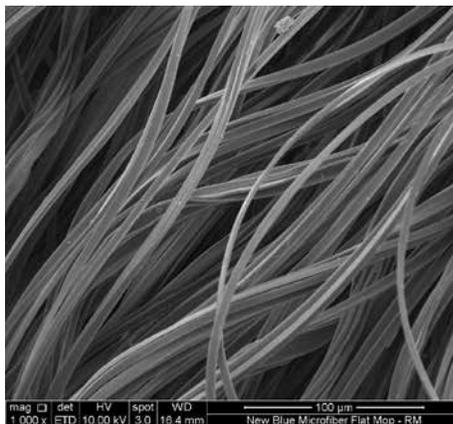


Figure 5

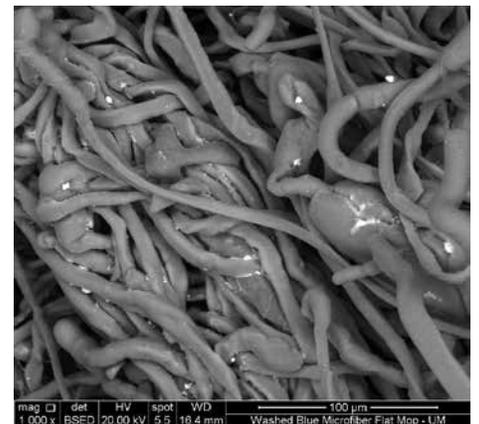


Figure 6



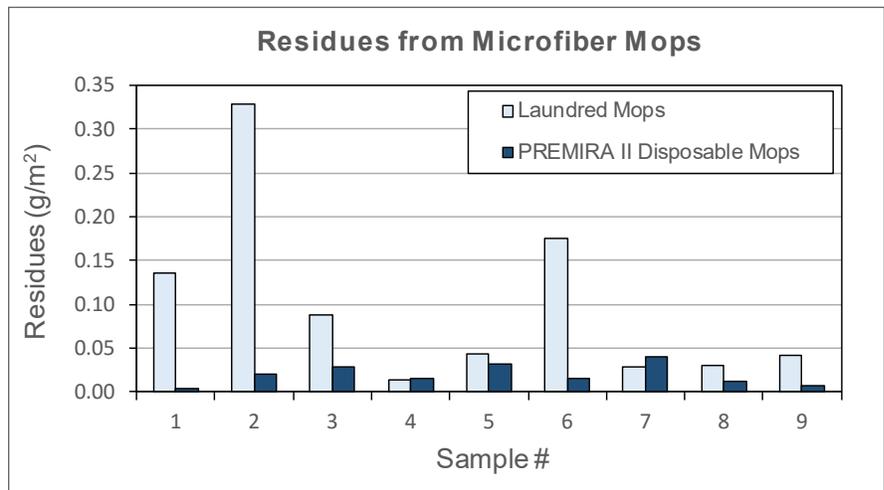
Residue in the Mop – Particles, Detergents and Other Organic Matter

Is your mop or wipe really clean? Soak it in water, then squeeze it into a clean container. If the water clouds or suds, it's not as clean as it should be.

Beyond what can be observed with microscopes, the level of particulates and residue in re-usable microfiber products after use and laundering can be measured by soaking a microfiber wipe or mop in clean water and then squeezing the extract into a clear beaker. If the resulting water is dirty, cloudy, or contains suds, then the laundering process has failed to sufficiently remove the trapped residues from laundry detergents, floor and surface cleaners or disinfectants.

To compare residuals from laundered re-usable mops versus disposable mop pads, an extraction test was conducted on 18 samples (9 laundered re-usable microfiber mops and 9 new PREMIRA® II Microfiber pads) using the recommended practice published by the Institute of Environmental Sciences and Technology (5). Samples of each mop were taken only from the microfiber fabric portion (which is the “effective” cleaning part) of a typical microfiber floor mop. Results of the analysis for residues are shown in Figure 7. The laundered microfiber mops had an average residual level of $0.099 \pm 0.102 \text{ g/m}^2$ whereas the average residues from disposable microfiber mops (PREMIRA II) were nearly five times lower ($0.020 \pm 0.012 \text{ g/m}^2$) and exhibited much lower variability among the nine samples.

Figure 7 Levels of residue extracted from re-laundered vs. PREMIRA® disposable mops using the method described in IEST-RP-CC 004.3 Section 7.1.2.





If the cleaning tool is contaminated with residual detergents or organic debris left over after laundering, the cleaning tool itself can bind and inactivate the disinfectant chemistry before it ever touches the surfaces to be disinfected.

Impact of Trapped Residues on Binding and Inactivation of Disinfectants

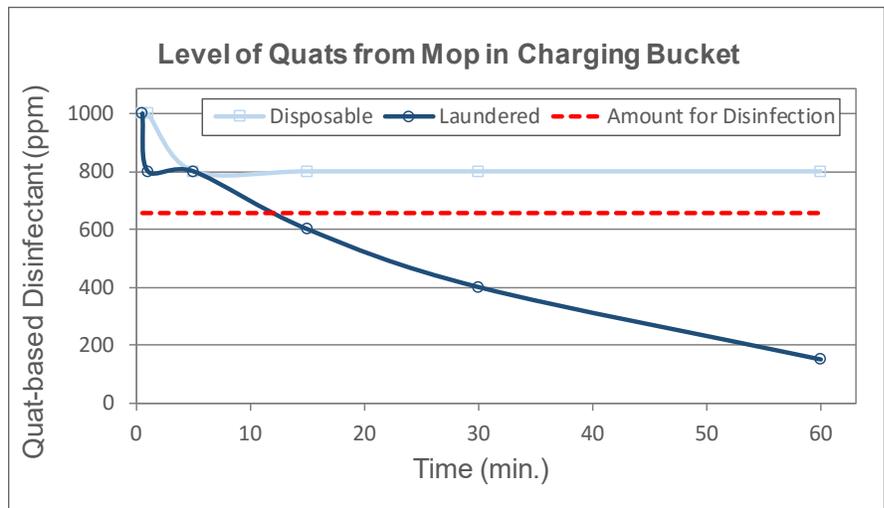
The retention of organic particulates and residues in laundered mops can cause serious issues when the mops are returned to service. Chemicals used to disinfect surfaces are very reactive – the chemicals readily bind to organic materials whether they are living or not. If the cleaning tool is contaminated with residual detergents or organic debris left over after laundering, the cleaning tool itself can bind and inactivate the disinfectant chemistry before it ever touches the surfaces to be disinfected. Examples of a similar reaction have been demonstrated in previous studies where quaternary ammonium disinfectants (“quats”) readily bind to cotton (cellulose) based cleaning wipes and mops, even before the textiles have been used or laundered (6-8). This type of reaction also can occur with residual organics in laundered synthetic cleaning tools.

To quantify this binding effect, a study using laundered mops vs. disposable PREMIRA® II advanced microfiber mops with a common quaternary-based disinfectant was conducted. Test coupons (304 stainless steel) were treated with a high-level disinfectant (PeridoxRTU® Sporocidal Disinfectant and Cleaner), followed by rinsing with sterile isopropyl alcohol (IPA) to reduce any initial bioburden or organic material on the coupons. Then, two separate batches of a quat-based disinfectant (VIREX® II 256 Quaternary) were prepared to achieve a dose of 1000 ppm of the active ingredients in each batch. Per the EPA label, disinfection with this product requires at least 660 ppm be maintained on a surface for 10 minutes. The mops were immersed in their respective solutions of the quat disinfectant for 0.5, 1, 5, 10, 15, 30 and 60 minutes. After removing the mops, residual active disinfectant on the mops was measured using Hydrion® Quat Check (1000) Test Paper (Micro Essential Laboratory, Inc.) and the mop was then used to wipe the surface of a stainless steel coupon. Test paper was used to measure the level of residual active disinfectant on the coupon. The interim treatment with PeridoxRTU® and IPA was repeated in between each application of VIREX® II 256 (except between the 0.5 and 1 minute time points).



As shown in Figure 8, the level of active disinfectant available to kill microbes decreased by 20% within the first minute of exposure to a laundered microfiber mop. More importantly, the concentrations in solution continued to decrease with longer exposure times. Within 15 minutes, the levels in solution contacting the mop had dropped below the level required for disinfection. At that point, the intended process of disinfecting surfaces is likely just spreading contamination throughout the environment. With disposable microfiber mops, the level of active quat in solution also decreased during initial exposure to the mop. However, unlike with the laundered product, the concentration of active disinfectant stabilized after 1 minute and remained at effective levels throughout the duration of the study. The levels of active quat recovered from the stainless steel coupons were lower than the levels from the mops, but the same trends were observed between disposable and laundered mops. These results indicate that residual organic matter can impact the efficacy of disinfectants when applied with re-laundered microfiber mops.

Figure 8 Levels of quat disinfectant in residual solution sampled from the mop when applied using a laundered versus disposable microfiber mop.





The delicate structures of microfiber can be damaged by elevated temperatures, bleach-based chemicals and abrasion through mechanical action during the washing and drying process.

Effectiveness of Laundering Process for Cleaning and Disinfecting Microfiber Mops and Wipes

Results of the studies described above indicate laundered microfiber cleaning tools can trap particulates and residues during use and laundering. A related issue is the reliability of the laundered cleaning products to clean and disinfect microbial contamination and how to protect laundered items from further contamination. Healthcare facilities that utilize laundered cleaning products must effectively manage the storage of used products destined for the laundry, as well as receipt and storage of laundered items. As described earlier in this article, facilities that launder healthcare and hospitality textiles must attempt to juggle multiple priorities regarding the receipt, sorting, washing, drying, re-sorting and delivery of textiles. The considerations include:

- 1) Adherence to CDC/ANSI/AAMI guidelines regarding washing and drying conditions that can effectively and consistently disinfect potential microbial pathogens in the laundry.
- 2) Recognition and implementation of specific laundry conditions and care labels from manufactures of reusable products.
- 3) Minimizing the negative impact that high temperatures and harsh chemical treatments can have on delicate textiles such as microfiber-based cleaning products.
- 4) Operational logistics like proper segregation of dirty versus laundered products.
- 5) Financial issues like turnaround time and energy costs.

To kill several of the most dangerous bacterial contaminants in the healthcare environment (*e.g.* spores of *C. difficile*), the laundry must use extended exposure to high temperatures and/or 50-150 ppm bleach. For example, the minimum conditions for disinfection of healthcare textiles requires a temperature of 160°F (71°C) for at least 25 minutes (9). We have discussed previously that the delicate structures of microfiber can be damaged by elevated temperatures, bleach-based chemicals and abrasion through mechanical action during the washing and drying process.

How Do Laundries Wash Microfiber Products?

Both the CDC (9) and OSHA (10) indicate that laundries should follow manufacturers' recommendations for cleaning fabric products. However, laundry recommendations from manufacturers of microfiber cleaning products cover a surprisingly wide range of options considering all microfiber is composed of either polyester or nylon fibers. Care labels from actual commercial products suggest microfiber can be washed anywhere from 140 to 200°F and dried from 130 to 140°F. Some labels provide few specific instructions, whereas others appear to provide contradictory advice on the same label (Figure 9).

Laundry Care Symbols

-  Washer Temperature

-  Bleach

-  Do Not Bleach

-  Tumble Dryer Temperature

-  Tumble Dry on Low Heat

-  Do Not Iron



Figure 9 Images of actual hang-tags of laundry care instructions for laundered microfiber mops.

The confusing guidance regarding how to properly wash, disinfect, and dry microfibers without causing damage to the delicate fibers can lead to variability in the hygiene and/or cleaning quality of these laundered products. Unfortunately, both microbial and particle contamination as well as damage to the fibers can be difficult to observe without microbiological or microscopic examination. However, since the damage to the product is cumulative, eventually the mop or cloth will show visible signs that it should be discarded and replaced (Figure 1). To add to these complexities, laundries find that consistent adherence to these guidelines is often impractical given the variety of different products being laundered, as well as issues like water and energy costs and the time constraints for turnaround (receipt, cleaning, and delivery) to a facility. Operators of healthcare laundries (both in-house and contract facilities) undoubtedly do the best they can, but they face many challenges to provide consistently clean and effective products. Alternatively, there are no laundry care tags on disposable products.

Two separate instances of rare fungal infections, one from cutaneous mucormycosis (14) and the other from invasive zygomycosis (15), were traced back to contaminated linen from laundry facilities, resulting in the death of several patients.

High levels of bacteria and fungi can be recovered from the very textiles that are supposed to clean and deliver disinfectants to critical surfaces in healthcare environments.

Ramifications and Risks of Laundered Microfiber

The implications of using mops and cloths with damaged microfiber have been discussed in detail. What are the ramifications that laundering may not completely disinfect contaminated cleaning products? What are the risks that the complicated process of sorting, washing, drying, re-sorting, delivery and storage of textiles can contaminate otherwise clean textiles? Results of several studies in peer-reviewed scientific publications indicate that viable bacteria and fungi can be recovered from laundered healthcare textiles. One often-cited study conducted at ten hospitals in Arizona found that 93% of re-laundered cloth towels (both cotton and microfiber) contained viable bacteria (11). That same study also found that re-laundered microfiber towels contained significantly more microbial contaminants than cotton towels, presumably due to their enhanced ability to trap and retain contaminants. Further review of the literature reveals other instances where microbes that can cause serious infections have been isolated from clinical laundry facilities or from re-laundered products. A study conducted during 2015 in a large consolidated laundry facility found that although the “dirty” area was significantly more contaminated than the “clean area”, 8% (2/25) of the samples that were positive before laundering were contaminated with *C. difficile* isolates after laundering (12). Fijan, *et. al.* (13) reported evidence of rotavirus on healthcare textiles after laundering and drying procedures. Rotaviral RNA also was detected on environmental surfaces and on the hands of laundry workers. Two separate instances of rare fungal infections, one from cutaneous mucormycosis (14) and the other from invasive zygomycosis (15), were traced back to contaminated linen from laundry facilities, resulting in the death of several patients. According to the review article authored by Dr. Schulster in 2015 (16), while a majority of outbreaks (58%) related to laundered textiles were linked to deficiencies in laundry processes, issues such as improper transport and storage also were implicated in contamination events leading to infected patients. An unknown number of additional occurrences of laundered healthcare textiles contaminated with bacteria, virus or fungi may have gone unnoticed or unreported.

To further understand the potential for laundered textiles as a fomite (inanimate object that can act as a reservoir or vector for cross-contamination), random samples of re-laundered mops were collected from several different healthcare facilities and sent to an independent lab to determine the level of bioburden (bacteria and fungi) on the mop pads. As shown in Figure 10, results indicate that bioburden on laundered products is variable, but that high levels of bacteria and fungi can be recovered from the very textiles that are supposed to clean and deliver disinfectants to critical surfaces in healthcare environments. In stark contrast, no microbes were recovered from disposable cleaning products prior to use (Figure 11). The bioburden levels shown below are for the entire mop pads. To understand how these levels compare to the bioburden limits allowed for laundries participating in the voluntary “Hygienically Clean Healthcare certification” managed by the Textile Rental Services Association (TRSA), the results per pad were converted to CFU per 100 square centimeters (equal to 1 dm² or about 4”x4”). Of the 36 samples tested, 20 mop pads (56%) exceeded the TRSA limit for total aerobic microbial counts and 6 pads (17%) exceeded the limit for total yeast and mold counts. Although it is not known if any of products tested were laundered in TRSA-certified laundries, these results reiterate and confirm the common theme discussed throughout this publication: the processes for supplying laundered cleaning textiles like mops and wipes yields products with variable quality and require oversight from infection control practitioners to minimize the potential impacts on patients and healthcare workers.



Figure 10 Levels of bacteria and fungi recovered from 36 laundered microfiber mop pads taken from EVS departments in several different hospitals from 2015-2017.

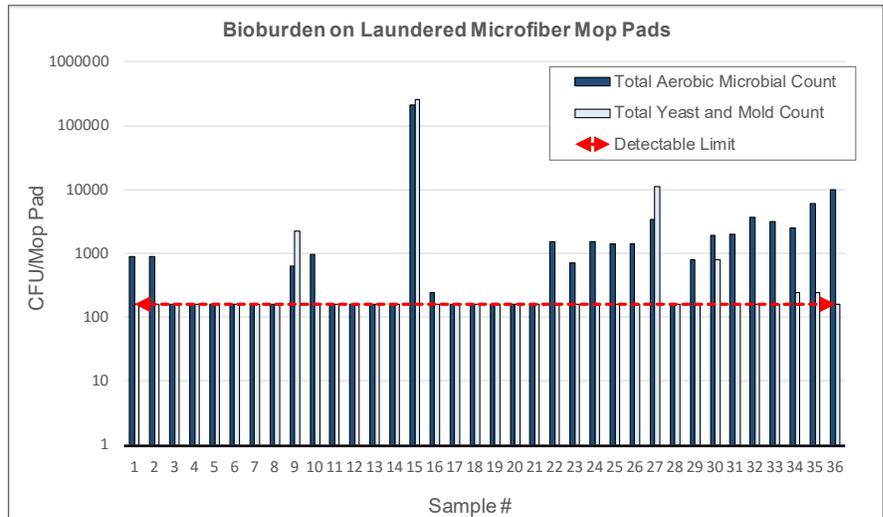
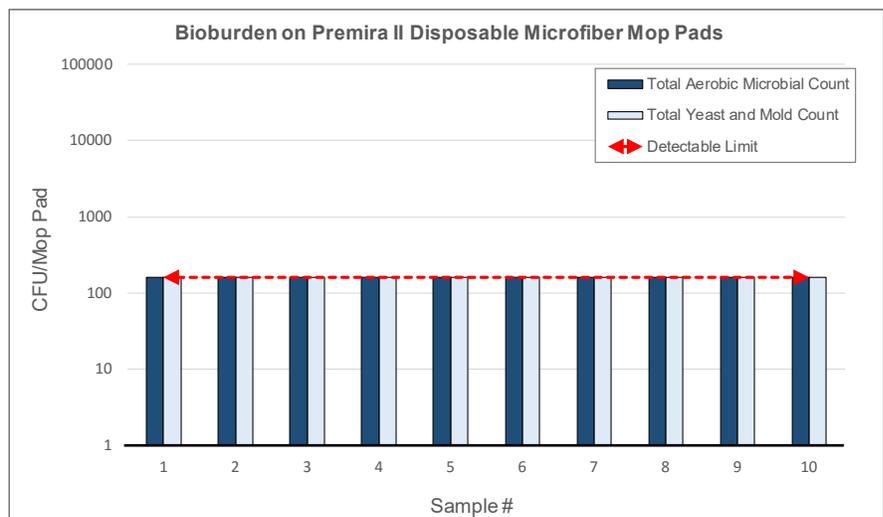


Figure 11 Levels of bacteria and fungi recovered from 10 disposable microfiber mop pads manufactured in 2015.



The relationship between bioburden on laundered healthcare textiles and actual HAIs is a matter of ongoing debate and epidemiological research. While the reported number of infections or outbreaks due to microbial contamination on laundered healthcare textiles was reported to be twelve in 2015 (16), it has since continued to increase (15). Also, it is likely that some incidents are not reported because of litigation through the court systems. Although it can be challenging to determine the specific source of a single or even clustered hospital acquired infections and the role of laundered textiles like mops or wipes, it is proposed that the safest and most reliable option for cleaning products is to use disposable microfiber textiles.

One response from proponents of re-laundered products is that any bioburden that might be retained or introduced onto a mop or wipe will be killed when the cleaning tool is exposed to disinfectant. However, this is a dangerous proposition – the intent of the disinfectant is to kill microbes on non-porous surfaces in the healthcare environment, not to disinfect the cleaning tool itself. The disinfectants registered with the EPA are not approved for disinfection of porous materials like textiles. In addition, data shown earlier indicate that disinfectants can be degraded by reactions with bioburden or debris in the laundered products and is no longer available to disinfect the target surfaces. The best way to avoid these issues is to start the cleaning and disinfection process with a fresh, disposable tool.



Cleaning and Disinfection of Floors in Hospital Patient Rooms Using Laundered vs. Disposable Microfiber Mops.

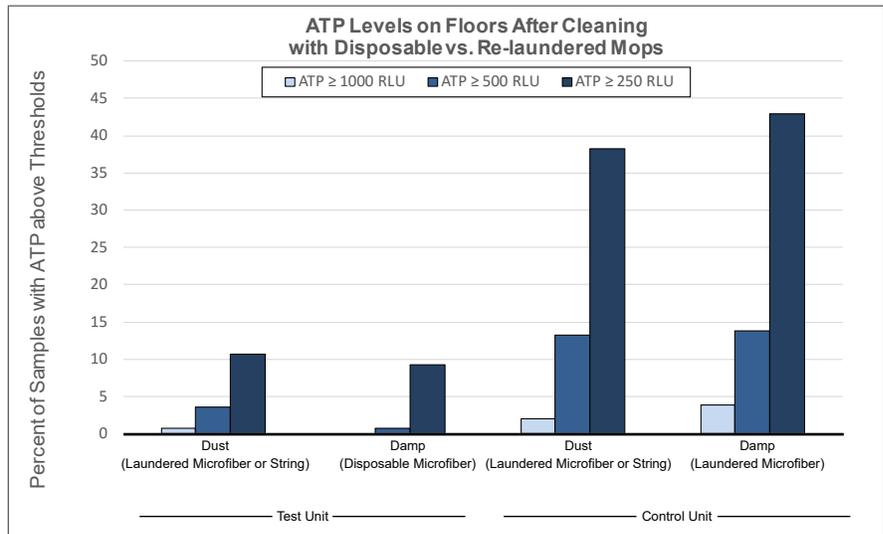
Results of the studies described above indicate that laundered healthcare textiles such as microfiber mops and wipes are difficult to clean and disinfect through multiple laundry cycles, resulting in damage to the physical structure of the textiles and retention of organic residues and debris, including viable bacteria and fungi. In contrast, the use of properly designed and manufactured disposable microfiber products ensures that the textile fibers are optimized for cleaning, without the risk of contamination by debris or microbes.

To better understand how the use of disposable vs. laundered microfiber mops to clean surfaces in critical environments can impact hygiene, a daily-cleaning field trial was conducted in two 20-bed units of a hospital during 2014-15. Floors in the test unit were cleaned using either laundered microfiber or string mops for dusting, followed by disposable PREMIRA® II Advanced Microfiber mop pads dampened with a neutral floor cleaning detergent (no disinfectant). The control unit continued to use their existing standard procedures for cleaning floors: laundered microfiber mop pads for both dusting and damp mopping. The typical room size in each unit was 320 sq. ft. With both the test and control units, a total of four mop pads were used in each room: two for dusting, then damp mopping the patient room and two for dusting, then damp mopping the bathroom. The flooring in the patient rooms was no-finish sheet vinyl; the bathrooms had troweled epoxy floors. After dusting or damp mopping, the hygiene of several areas on the floors was assessed using a common ATP test kit. Overall, 140 ATP measurements were taken in the test unit and 128 measurements were taken in the control unit over a period of approximately 6 weeks.

The data were analyzed by calculating the percentage of the total readings that exceeded various thresholds often utilized in ATP testing of surfaces to delineate clean from dirty surfaces. Several guidelines indicate that 250-500 Relative Light Units (RLUs) is a reasonable threshold range to assess the efficacy of cleaning surfaces. As shown in Figure 12, the frequencies of “dirty” samples were substantially higher in patient rooms that were exposed to laundered microfiber mops dampened with detergent cleaner compared to rooms cleaned with disposable microfiber mops. Interestingly, results after dusting in the test unit that used disposable mops for damp cleaning also showed dramatically lower frequencies of dirty samples even though the dust mops themselves were not disposable. As expected, the percentage of samples exceeding the established thresholds increased as the thresholds were lowered from 1000 to 250 RLUs. However, regardless of which RLU threshold was utilized, substituting disposable mops for re-laundered products yielded cleaner floors. During this field trial, the re-laundered mops themselves were not assessed for ATP or bioburden. Therefore, it is unknown if the higher frequency of dirty samples was caused by contaminated cleaning tools spreading organic material across the floor or if the laundering process had damaged the cleaning performance of the wetted mops. The results showing that the ATP values in the test unit remained low even though re-laundered string mops and microfiber pads were used for dusting suggests the predominant effect for poor results in the control unit was due to damaged fibers in the laundered products.



Figure 12 Results of field trial comparing ATP measurements on floors after damp mopping with disposable vs. re-laundered microfiber mops. RLU = Relative Light Units.



Conclusions

While the transition from cotton to microfiber cleaning tools has improved cleaning effectiveness and efficiency, evidence from published studies and experiments conducted by Contec, Inc. indicate that the relatively complicated process of using laundered mops and wipes can result in products with unreliable quality. Disposable microfiber cleaning products used with appropriate detergents and disinfectants provide superior and consistent results without the risk of cross-contamination in the healthcare environment. To summarize the evidence presented in this report:

- 1) The laundry process can cause irreversible damage to the delicate microfiber structures that are essential for cleaning.
- 2) Retention and accumulation of microbes, dirt and debris can occur during repeated use, washing, drying, transport and storage of healthcare cleaning textiles.
- 3) The combination of damaged microfiber and contaminated textiles may lead to poor outcomes after cleaning as measured by conventional methods like surface ATP.

Some may claim that use of disposable products is only a matter of convenience and a “nice to have”. The performance and ease-of-use of disposable cleaning textiles is convenient. But convenience leads to compliance and compliance has been shown time and time again to generate improved outcomes.

References

1. Environmental Protection Agency. (2002). Environmental Best Practices for Health Care Facilities. Using Microfiber Mops in Hospitals. Available at: www.epa.gov/region09/waste/p2/projects/hospital/mops.pdf.
2. Rutala, W. A., Gergen, M. F., & Weber, D. J. (2007). Microbiologic evaluation of microfiber mops for surface disinfection. *American Journal of Infection Control*, 35(9), 569-573.
3. Wren, M. W. D., Rollins, M. S. M., Jeanes, A., Hall, T. J., Coen, P. G., & Gant, V. A. (2008). Removing bacteria from hospital surfaces: a laboratory comparison of ultramicrofibre and standard cloths. *Journal of Hospital Infection*, 70(3), 265-271.
4. Trajtman, A. N., Manickam, K., & Alfa, M. J. (2015). Microfiber cloths reduce the transfer of *Clostridium difficile* spores to environmental surfaces compared with cotton cloths. *American Journal of Infection Control*, 43(7), 686-689.
5. Institute of Environmental Sciences and Technology (IEST). Evaluating Wiping Materials Used in Cleanrooms and Other Controlled Environments. *Recommended Practice (RP)*, IEST-RP-CC 004.3 Section 7.1.2.
6. MacDougall, K. D., & Morris, C. (2006). Optimizing disinfectant application in healthcare facilities. *Infection Control Today*, 10, 62-67.
7. Engelbrecht, K., Ambrose, D., Sifuentes, L., Gerba, C., Weart, I., & Koenig, D. (2013). Decreased activity of commercially available disinfectants containing quaternary ammonium compounds when exposed to cotton towels. *American Journal of Infection Control*, 41(10), 908-911.
8. Boyce, J., Sullivan, L., Booker, A., & Baker, J. (2016). Quaternary Ammonium Disinfectant Issues Encountered in an Environmental Services Department. *Infection Control & Hospital Epidemiology*, 37(3), 340-342.
9. Centers for Disease Control and Prevention (CDC). (original: 2003). Environmental Infection Control Guidelines, G. Laundry and Bedding. Updated version available at: www.cdc.gov/infectioncontrol/guidelines/environmental/index.html.
10. OSHA regulations (29 CFR 1910.1030)
11. Sifuentes, L. Y., Gerba, C. P., Weart, I., Engelbrecht, K., & Koenig, D. W. (2013). Microbial contamination of hospital reusable cleaning towels. *American Journal of Infection Control*, 41(10), 912-915.
12. Michael, K., No, D., Dankoff, J., Lee, K., Lara-Crawford, E., & Roberts, M. C. (2016). *Clostridium difficile* environmental contamination within a clinical laundry facility in the USA. *FEMS Microbiology Letters*, 363(21), fnw236.
13. Fijan, S., Steyer, A., Poljšak-Prijatelj, M., Cencic, A., Šostar-Turk, S., & Koren, S. (2008). Rotaviral RNA found on various surfaces in a hospital laundry. *Journal of Virological Methods*, 148(1), 66-73.
14. Duffy, J., Harris, J., Gade, L., Schulster, L., Newhouse, E., O'Connell, H., Noble-Wang, C., Rao, C., Balajee, S., & Chiller, T. (2014). Mucormycosis outbreak associated with hospital linens. *The Pediatric Infectious Disease Journal*, 33(5), 472-476.
15. Cheng, V. C., et. al. (2015). Hospital outbreak of pulmonary and cutaneous zygomycosis due to contaminated linen items from substandard laundry. *Clinical Infectious Diseases*, 62(6), 714-721.
16. Schulster, L. M. (2015). Healthcare laundry and textiles in the United States: Review and commentary on contemporary infection prevention issues. *Infection Control & Hospital Epidemiology*, 36(9), 1073-1088.

About Contec, Inc.

For three decades, Contec has been developing innovative products to meet the demanding standards of cleanroom environments in the pharmaceutical, biotech, medical device, and microelectronics industries. With the healthcare market developing increasingly sensitive processes which demand effective cleaning, Contec has designed a truly unique line of products rooted in best practices to provide solutions for Pharmacy, Operating Room Turnover and Terminal Cleaning, Ambulatory Surgery Centers, Procedure Rooms, Isolation Rooms, Central Sterile and other critical patient areas.

Our experienced R&D and Technical Services teams understand the challenges of cleaning and disinfecting critical and controlled environments in a variety of industries. We are bringing that wealth of knowledge to healthcare environments.

Learn More

For more information about Contec and our products for OR turnover and terminal cleaning, please visit www.contechealthcare.com.



Contec, Inc.
Spartanburg, SC 29304 USA
Toll Free: 1-800-289-5762 • +1-864-503-8333
healthcare@contecinc.com
www.contechealthcare.com