CONCISE COMMUNICATION

Limitations of the Efficacy of Surface Disinfection in the Healthcare Setting

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We examined the efficacy of 2 commercially available wipes to effectively remove, kill, and prevent the transfer of both methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* from contaminated surfaces. Although wipes play a role in decreasing the number of pathogenic bacteria from contaminated surfaces, they can potentially transfer bacteria to other surfaces if they are reused.

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Numerous studies have reported on the ability of pathogens such as *Staphylococcus aureus* to contaminate and survive on surfaces in close proximity to patients.[1] Infection control regimens that include effective cleaning and the use of disinfectants have been encouraged, to minimize the spread of pathogens and prevent their transmission to high-risk patients and, ultimately, to reduce the associated financial burden.[2,3] The measures implemented, however, have to be effective at preventing the survival of potential pathogens in hospitals. Simple cleaning regimens alone might be ineffective at eliminating microbial contamination.[4-6] The use of surface disinfectants as a preventive measure is therefore of prime importance, and the efficacy of these agents needs to be ensured as part of the overall strategy to control healthcare-acquired infection.[3] Disinfection regimens adopted in intensive therapy units (ITUs) and healthcare facilities in Wales include the use of antimicrobial wipes. In the present study, we used a 3-step protocol[7] to examine the ability of 2 types of wipe to effectively remove, kill, and prevent the transfer of methicillin-susceptible and methicillin-resistant *S. aureus* (MSSA and MRSA, respectively) from contaminated surfaces.

METHODS

Genetically distinct bacteremic strains of *S. aureus* (ie, 4 strains of MSSA and 4 strains of MRSA) from ITUs were provided by the University Hospital of Wales (Cardiff, Wales).[8] The MSSA reference strain NCIMB 9518, which is recommended for use in standard antimicrobial susceptibility tests, was also used in the experimental procedures. These strains were cultured, and inocula were prepared to mimic either clean or dirty conditions, as previously described elsewhere.[7]

The 2 types of wipe used in our study were as follows: wipes that contained no alcohol or disinfectants (Sani-Cloth Multi Surface Detergent Wipes; PDI Europe, UK) and wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide (Clinell Universal Sanitising Wipes; Gama Healthcare). The materials used to produce the wipes were also provided by the manufacturers.

A 3-step protocol was used to determine the efficacy of wipes on surfaces contaminated with *S. aureus*.[7] We visited the ITU of a Welsh hospital and observed how wipes were being applied to surfaces proximal to patients (bed rails) as well as other surfaces (monitors, tables, and keypads). Wipes were being applied up to 10 times (for a total of 10 seconds) on the same surface, and they were then used on up to 5 different surfaces before being discarded. These observations enabled us to establish experimental parameters (such as contact time) for subsequent experiments that used the 3-step protocol to determine the efficacy of the wipes used in our study.[7]

Steel disks were inoculated with 20 μL of *S. aureus* test suspension (6.09–6.93 $\log_{10}$ colony-forming units [cfu]), with or without an organic load, and dried. During step 1 of the protocol, wipes were mechanically rotated for 10 seconds at 60 rpm against the surfaces of the steel disks, exerting a weight of 100 $\pm$ 5 g. The steel disks were then transferred to a neutralizer, and the remaining bacteria were resuspended and counted. The neutralizer solution that was used to quench the activity of the wipes has previously been described elsewhere.[7] The number of cells removed from the surface of a steel disk was calculated by subtracting the mean log number of cells recovered from the disk after the application of the wipe from the mean log number of cells originally added to the disk. After the application of wipes to the contaminated surfaces of the steel disks, step 2 of the protocol was that adpression tests were performed on the wipes to assess the bacterial transfer from the steel disks to other surfaces. Eight tryptone soya agar (Oxoid) plates containing 10% v/v of neutralizing solution were consecutively inoculated by pressing the wipe onto their surface, exerting a weight of 100 $\pm$ 5 g.

Step 3 of the protocol was the measurement of the bactericidal activity of wipes. A test sample of wipes with the detergent or disinfectant formulation and a control sample of wipes without either formulation were directly inoculated with 20 μL of the test suspension (with 6.2–6.66 $\log_{10}$ cfu of *S. aureus*). After 10 seconds of exposure, the wipes were transferred to the neutralizer, and surviving bacteria were counted. The bactericidal effect was calculated by subtracting the mean log number of surviving bacteria on the test wipes from the mean number of surviving bacteria on the control wipes. A 1-way analysis of variance was used at the 95% confidence

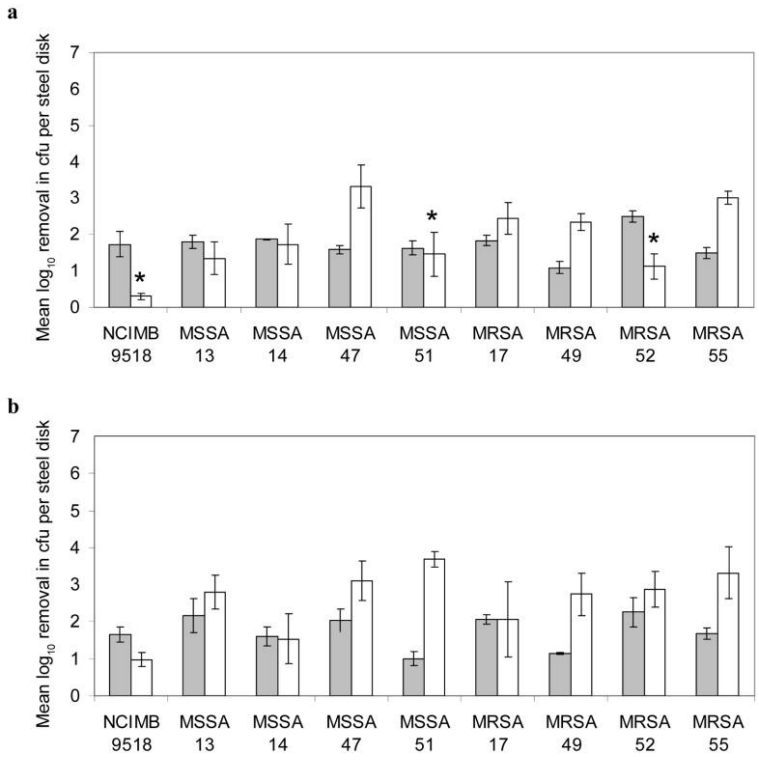

FIGURE 1. Bar graph of the mean $\log_{10}$ number of methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* (MRSA and MSSA, respectively) cells removed from dirty *(a)* and clean *(b)* surfaces (ie, steel disks) after the 10-second application of wipes that contained no alcohol or disinfectants (Sani-Cloth Multi Surface Detergent Wipes; PDI Europe, UK) and wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide (Clinell Universal Sanitising Wipes; Gama Healthcare). The mean values (± standard errors) from 3 replicated experimental procedures are presented. *Gray bars,* PDI wipes; *white bars,* Clinell wipes; *whiskers,* standard errors. The Clinell wipes removed a significantly fewer number cells of 3 strains (marked with an asterisk) from dirty surfaces, compared with those from clean surfaces ($P < .05$). Cfu, colony-forming units

level of significance to test differences between the mean values of the data sets.

RESULTS

We measured the efficacy of surface wipes on surfaces contaminated with *S. aureus.* During step 1 of the protocol, we found that the wipes that contained no alcohol or disinfectants removed 1.09–2.49 $\log_{10}$ cfu per steel disk of *S. aureus* from dirty surfaces and 1–2.26 $\log_{10}$ cfu per steel disk of *S. aureus* from clean surfaces (Figure 1). The wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide removed 0.3–3.31 $\log_{10}$ cfu per steel disk of *S. aureus* from dirty surfaces and 0.97–3.31 $\log_{10}$ cfu per steel disk of *S. aureus* from clean surfaces. When the results for each strain were examined individually, no significant difference was found in the efficiency of removal for wipes that contained no alcohol or disinfectants, in the presence or absence of an organic load ($P > .05$). This was largely true when the wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide were applied. However, significantly fewer cells of 3 strains (MSSA reference strain NCIMB 9518, MSSA strain 51, and MRSA strain 52) were removed from dirty surfaces than they were from clean surfaces ($P < .05$).

Adpression tests (performed during step 2 of the protocol) revealed that the surviving cells of each strain were transferred from the wipes that contained no alcohol or disinfectants in numbers too numerous to count (ie, more than 100 cfu) onto 8 consecutive agar plates. During the series of adpression tests, the wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide consecutively transferred the strains up to 8 times; in some instances, they transferred more than 100 cfu of *S. aureus,* and in others, they transferred numbers of colony-forming units that decreased during the course of testing (data not shown).

During step 3 of the protocol, when wipes that contained no alcohol or disinfectants were directly inoculated to assess bactericidal activity, they did not produce any reduction in cell number (data not shown). After 10 seconds of exposure to *S. aureus,* wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide produced

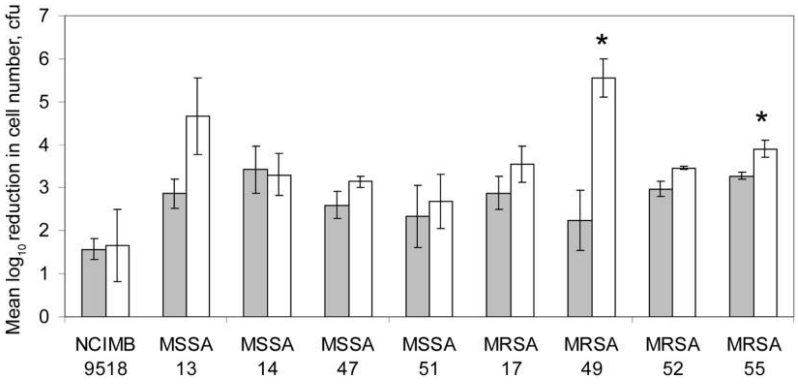

FIGURE 2. Bar graph of the bactericidal effect of 10 seconds of exposure to disinfectant wipes containing a mixture of quaternary ammonium compounds and a polymeric biguanide on strains of methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* (MRSA and MSSA, respectively). The mean values (± standard errors) from 3 replicated experimental procedures are presented. *Gray bars,* inocula prepared to simulate dirty conditions; *white bars,* inocula prepared to simulate clean conditions; *whiskers,* standard errors. The wipes were significantly more active against MRSA strains 49 and 55 (marked with an asterisk) in the absence of an organic load than in the presence of an organic load ($P < .05$).

$\log_{10}$ reductions of 1.57–3.42 and 1.66–5.55 in the presence and absence of an organic load, respectively (Figure 2). There was no significant difference in $\log_{10}$ reduction when all the strains exposed in the presence of an organic load ($P > .05$). The wipes were significantly more active against MRSA strains 49 and 55 when they were exposed in the absence of an organic load ($P < .05$).

DISCUSSION

When either wipes that contained no alcohol or disinfectants or wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide were applied to surfaces contaminated with *S. aureus,* they removed similarly low levels of bacteria from surfaces in the presence or absence of an organic load (Figure 1). The detergent formulation used in the wipes that contained no alcohol or disinfectants does not contain any antimicrobial agents and thus had no antimicrobial activity when they were directly inoculated with bacteria. As a result, after their use on contaminated surfaces, high numbers of each strain were consecutively transferred from the wipes onto agar plates. The wipes that contained a mixture of quaternary ammonium compounds and a polymeric biguanide were chosen as a potential candidate because the formulation applied to the wipe material contains several common disinfectants. These wipes exhibited antimicrobial activity when they were directly inoculated with MSSA or MRSA (Figure 2). They could not, however, prevent the transfer of *S. aureus* onto different surfaces when adpression tests were performed.

It is clear that if either of these wipes encountered similarly high contamination levels in practice, the subsequent survival of bacteria on the wipe material could potentially lead to cross-contamination if used on more than 1 surface. Other studies have also shown that cleaning implements treated with detergents or disinfectant solutions can become contaminated with pathogenic microbes during the cleaning process and thus have the potential to redistribute the microorganisms throughout the patients' environment.[4-6] Finally, some reports have suggested that MRSA might be more resilient than MSSA to disinfection (eg, to chlorhexidine-based solutions).[9,10] In our study, we found no difference in susceptibility or resistance between MSSA and MRSA with regard to surface disinfection.

Our observations, in the present study and in previous studies,[7] have highlighted particular concerns over the use of wipes in hospitals. We recommend that a wipe not be used on more than 1 surface, that it be used only on a small area, and that it be discarded immediately after use, to reduce the risk of microbial spread—a 1 wipe, 1 application per surface policy.

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