CSIRO PUBLISHING

Healthcare Infection, 2013, **18**, 42–44
http://dx.doi.org/10.1071/HI13003

Letter to the Editor

How do we tackle contaminated hospital surfaces?

Jonathan A. Otter PhD

Scientific Director, Healthcare, Bioquell, Andover, Hampshire, UK. Email: jon.otter@bioquell.com

Received 8 January 2013, accepted 8 January 2013, published online 7 February 2013

The role of contaminated environmental surfaces in the transmission of nosocomial pathogens has been debated for many years. Studies published in the 1970s and 1980s indicated that contaminated surfaces contributed negligibly to nosocomial transmission.[1,2] However, more recent data show that bacterial endospores, vegetative bacteria and some viruses are shed into the hospital environment, can survive on dry surfaces for extended periods, usually measured in months, and can be transferred to the hands of healthcare personnel from surfaces.[3–5] The most convincing evidence that contaminated environmental surfaces are important in the transmission of nosocomial pathogens comes from the finding that admission to a room previously occupied by a patient with methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Clostridium difficile* and certain Gram-negative rods such as *Acinetobacter baumannii* increased the chances of acquiring these pathogens by a factor of two or more.[3,6–9] These data indicate that inadequate terminal disinfection is responsible for residual contamination with pathogens that increases the chances of the incoming patient acquiring a nosocomial pathogen. Thus, more needs to be done to disinfect rooms when patients are discharged ('terminal disinfection') in order to mitigate this increased risk.

These are fever studies evaluating daily cleaning and/or disinfection during the stay of a patient. The contribution of contaminated surfaces aside from residual contamination surviving from a prior room occupant is more difficult to quantify. It seems likely that pathogens shed during the stay of a patient infected or colonised with a nosocomial pathogen will have infection control implications some of the time, for example, when acquired on the hands of healthcare personnel during patient care. Therefore, there is strong rationale for improving cleaning and disinfection both during the stay of patients and when they are discharged.

A current controversy surrounds whether to improve conventional disinfection methods or to turn to 'no-touch' automated room disinfection (NTD) systems for terminal disinfection. The use of fluorescent markers or ATP assays to evaluate the cleaning process itself, the adoption of newer, more effective disinfectants or equipment (such a microfibre materials) can all help to improve the effectiveness of conventional methods.[10–13] There is evidence that improving the efficacy of conventional cleaning and disinfection can be effective in reducing the microbial burden and transmission of nosocomial pathogens.[14,15] However, there may be occasions when even optimised conventional methods do not reliably eliminate pathogens.[16,17] On these occasions, an NTD system may be useful.[18] Commonly used NTD systems include hydrogen peroxide vapour (HPV), aerosolised hydrogen peroxide (aHP) and systems based on ultraviolet C or pulsed-xenon UV.[18] There are important differences between these systems and the choice of system will likely depend on the application.[18] The most studied NTD system is HPV, which has been shown to be superior to conventional methods for the elimination of pathogens from surfaces,[16,19] can help to bring outbreaks under control[20,21] and can reduce the spread of pathogens in endemic settings.[22,23] A recently published study from the US showed that HPV successfully mitigated the increased risk from the prior room occupant, with patients admitted to rooms disinfected using HPV being 64% less likely to acquire a multi-drug resistant organism (MDRO), particularly VRE, when the prior room occupant was infected or colonised with an MDRO.[23]

NTD systems are only useful for terminal disinfection, whereas improved conventional methods can be applied both during the stay of patients and when they are discharged. Thus, the most comprehensive environmental strategy would be a program of systematic improvement of conventional methods coupled with NTD disinfection of selected patient rooms. Whilst this approach would likely result in the greatest impact in terms of reduced transmissions, it would not be possible to determine the relative benefit of improved conventional methods and NTD disinfection. The 'ultimate' study would be a large, cluster-randomised, controlled trial to evaluate the impact of improved conventional methods and NTD disinfection individually and combined on the transmission of nosocomial pathogens. Studies of this type are likely to be performed in the future, but in the meantime, hospitals need to decide when their current methods are sufficient, when to implement improved conventional methods and when to turn to NTD systems. I would advocate a scenario-based approach, where the strategy chosen is dictated by the local challenges

and aims. For example, the terminal disinfection strategy for a patient infected with multidrug-resistant *A. baumannii* on an ICU may well be different than for a patient colonised with MRSA on a general ward.

Other approaches to tackling environmental contamination in hospitals warrant consideration. There are several ways to reduce the amount of pathogens that are deposited onto environmental surfaces. For example, converting multi-occupancy bays into a series of individual rooms will likely improve the containment of pathogens.[24] Similarly, daily bathing of patients using chlorhexidine for 'source control' reduces shedding and has been shown to reduce transmission.[25] The introduction of surfaces composed of or impregnated with antimicrobial materials can reduce the microbial burden on surfaces.[26] For example, several studies show that copper surfaces reduce the microbial burden.[27] Several recent studies suggest that contaminated air may be an important factor in the spread of nosocomial pathogens.[28,29] Thus, interventions aimed at reducing the microbial burden in air may help to reduce the burden of pathogens on hospital surfaces.[30] Finally, improved hand hygiene would help to prevent the transmission of pathogens acquired on the hands of healthcare personnel from surfaces. However, a blinkered focus on hand hygiene without paying attention to contaminated surfaces is not the way forward since some transmission will occur directly or indirectly from contaminated surfaces. Equally, improving surface disinfection at the expense of hand hygiene compliance will have a limited impact on transmission since some transmission will occur independently of contaminated surfaces. Thus, a bundled approach considering all possible transmission routes will be most effective for reducing the transmission of nosocomial pathogens.[3]

Further research is required to determinate the best ways to tackle contaminated hospital surfaces. Key questions include:

- How far can conventional methods go in reducing microbial contamination on surfaces?
- When are NTD systems warranted, and which NTD system is suitable for the intended application?
- Is contaminated air key in transmission, and under which circumstances?
- Should 'source control' be implemented universally across the hospital?
- Are antimicrobial surfaces going to be useful in preventing transmission, and, if so, which is the most effective?
- Can the introduction of single rooms in multi-occupancy bays contain pathogens more effectively?

Further research into these and other important questions will give us more guidance as to how to tackle contaminated hospital surfaces. However, controversies will continue and large, randomised controlled trails are likely to remain rare. The problems due to nosocomial pathogens are likely to increase, in particular relating to multidrug-resistant Gram-negative bacteria. As these multidrug-resistant pathogens continue to be transmitted in healthcare facilities worldwide, and treatment options become more limited, the emphasis will move from control to prevention. Thus, the assessment and adoption of cost effective interventions to deliver a clean, safe environment should be high on the agenda of healthcare facilities.

Conflict of interest

I am employed part-time by Bioquell UK Ltd.

Funding

No funding was received in relation to this letter.

References

1. Maki DG, Alvarado CJ, Hassemer CA, Zilz MA. Relation of the inanimate hospital environment to endemic nosocomial infection. *N Engl J Med* 1982; 307: 1562–6. doi:10.1056/NEJM198212163072507
2. Rhame FS. The inanimate environment. In: Bennett JV, Brachmann PS, eds. Hospital Infection. 4th edn. Philadelphia, PA: Lipincott-Raven; 1998: pp. 299–324.
3. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol* 2011; 32: 687–99. doi:10.1086/660363
4. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infect Dis* 2006; 6: 130. doi:10.1186/1471-2334-6-130
5. Hayden MK, Blom DW, Lyle EA, Moore CG, Weinstein RA. Risk of hand or glove contamination after contact with patients colonized with vancomycin-resistant enterococcus or the colonized patients' environment. *Infect Control Hosp Epidemiol* 2008; 29: 149–54. doi:10.1086/524331
6. Drees M, Snydman D, Schmid C, Barefoot L, Hansjosten K, Vue PM, *et al*. Prior environmental contamination increases the risk of acquisition of vancomycin-resistant enterococci. *Clin Infect Dis* 2008; 46: 678–85. doi:10.1086/527394
7. Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. *Arch Intern Med* 2006; 166: 1945–51. doi:10.1001/archinte.166.18.1945
8. Shaughnessy MK, Micielli RL, DePestel DD, Arndt J, Strachan CL, Welch K, *et al*. Evaluation of hospital room assignment and acquisition of *Clostridium difficile* infection. *Infect Control Hosp Epidemiol* 2011; 32: 201–6. doi:10.1086/658669
9. Nseir S, Blazejewski C, Lubret R, Wallet F, Courcol R, Durocher A. Risk of acquiring multidrug-resistant Gram-negative bacilli from prior room occupants in the ICU. *Clin Microbiol Infect* 2011; 17: 1201–8. doi:10.1111/j.1469-0691.2010.03420.x
10. Carling PC, Parry MM, Rupp ME, Po JL, Dick B, Von Beheren S. Improving cleaning of the environment surrounding patients in 36 acute care hospitals. *Infect Control Hosp Epidemiol* 2008; 29: 1035–41. doi:10.1086/591940
11. Mulvey D, Redding P, Robertson C, Woodall C, Kingsmore P, Bedwell D, *et al*. Finding a benchmark for monitoring hospital cleanliness. *J Hosp Infect* 2011; 77: 25–30. doi:10.1016/j.jhin.2010.08.006
12. Moore G, Griffith C. A laboratory evaluation of the decontamination properties of microfibre cloths. *J Hosp Infect* 2006; 64: 379–85. doi:10.1016/j.jhin.2006.08.006
13. Rutala WA, Gergen MF, Weber DJ. Efficacy of improved hydrogen peroxide against important healthcare-associated pathogens. *Infect Control Hosp Epidemiol* 2012; 33: 1159–61. doi:10.1086/668014
14. Datta R, Platt R, Yokoe DS, Huang SS. Environmental cleaning intervention and risk of acquiring multidrug-resistant organisms from prior room occupants. *Arch Intern Med* 2011; 171: 491–4. doi:10.1001/archinternmed.2011.64

15. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. *Clin Infect Dis* 2006; 42: 1552–60. doi:10.1086/503845
16. Manian FA, Griesenauer S, Senkel D, Setzer D, Doll SA, Perry AM, *et al*. Isolation of *Acinetobacter baumannii* complex and methicillin-resistant *Staphylococcus aureus* from hospital rooms following terminal cleaning and disinfection: can we do better? *Infect Control Hosp Epidemiol* 2011; 32: 667–72. doi:10.1086/660357
17. Morter S, Bennet G, Fish J, Richards J, Allen DJ, Nawaz S, *et al*. Norovirus in the hospital setting: virus introduction and spread within the hospital environment. *J Hosp Infect* 2011; 77: 106–12. doi:10.1016/j.jhin.2010.09.035
18. Otter JA, Yezli S, Perl TM, Barbut F, French GL. Is there a role for "no-touch" automated room disinfection systems in infection prevention and control? *J Hosp Infect* 2013; 83: 1–13. doi:10.1016/j.jhin.2012.10.002
19. French GL, Otter JA, Shannon KP, Adams NM, Watling D, Parks MJ. Tackling contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp Infect* 2004; 57: 31–7. doi:10.1016/j.jhin.2004.03.006
20. Jeanes A, Rao G, Osman M, Merrick P. Eradication of persistent environmental MRSA. *J Hosp Infect* 2005; 61: 85–6. doi:10.1016/j.jhin.2005.01.001
21. Snitkin ES, Zelazny AM, Thomas PJ, Stock F, NISC Comparative Sequencing Program, Henderson DK, *et al*. Tracking a hospital outbreak of carbapenem-resistant *Klebsiella pneumoniae* with whole-genome sequencing. *Sci Transl Med* 2012; 4: 148ra116. doi:10.1126/scitranslmed.3004129
22. Boyce JM, Havill NL, Otter JA, McDonald C, Adams NMT, Cooper T, *et al*. Impact of hydrogen peroxide vapor room decontamination on *Clostridium difficile* environmental contamination and transmission in a healthcare setting. *Infect Control Hosp Epidemiol* 2008; 29: 723–9. doi:10.1086/589906
23. Passaretti CL, Otter JA, Reich NG, Myers J, Shepard J, Ross T, *et al*. An evaluation of environmental decontamination with hydrogen peroxide vapor for reducing the risk of patient acquisition of multidrug-resistant organisms. *Clin Infect Dis* 2013; 56: 27–35. doi:10.1093/cid/cis839
24. Moore G, Ali S, FitzGerald G, Muzslay M, Atkinson S, Smith S, *et al*. Ward assessment of SmartIdeas Project: bringing source isolation to the patient. *J Hosp Infect* 2010; 76: 103–7. doi:10.1016/j.jhin.2010.04.017
25. Vernon MO, Hayden MK, Trick WE, Hayes RA, Blom DW, Weinstein RA. Chlorhexidine gluconate to cleanse patients in a medical intensive care unit: the effectiveness of source control to reduce the bioburden of vancomycin-resistant enterococci. *Arch Intern Med* 2006; 166: 306–12. doi:10.1001/archinte.166.3.306
26. Weber DJ, Rutala WA. Self-disinfecting surfaces. *Infect Control Hosp Epidemiol* 2012; 33: 10–3. doi:10.1086/663648
27. O'Gorman J, Humphreys H. Application of copper to prevent and control infection. Where are we now? *J Hosp Infect* 2012; 81: 217–23. doi:10.1016/j.jhin.2012.05.009
28. Best EL, Sandoe JA, Wilcox MH. Potential for aerosolization of *Clostridium difficile* after flushing toilets: the role of toilet lids in reducing environmental contamination risk. *J Hosp Infect* 2012; 80: 1–5. doi:10.1016/j.jhin.2011.08.010
29. Best EL, Fawley WN, Parnell P, Wilcox MH. The potential for airborne dispersal of *Clostridium difficile* from symptomatic patients. *Clin Infect Dis* 2010; 50: 1450–7. doi:10.1086/652648
30. Boswell TC, Fox PC. Reduction in MRSA environmental contamination with a portable HEPA-filtration unit. *J Hosp Infect* 2006; 63: 47–54. doi:10.1016/j.jhin.2005.11.011