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Short report

Use of a door handle disinfection system to reduce the risks associated with microbial loads on fomites in a healthcare setting

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SUMMARY

Background: Pathogenic organisms, including those that are multidrug resistant, can survive for extended periods of time on surfaces. Numerous studies show that contaminated hand-touch sites, such as door handles, pose a serious risk for onward transfer to patients.
Aim: To compare microbial levels on the handles of ten frequently used door locations, with and without a door handle disinfection system in place, in a busy rehabilitation unit consisting of two wards at the National Orthopaedic Hospital, Dublin.
Methods: A door handle disinfection system (Handle Hygiene®), utilizing an atomizing pump (non-aerosol), automatically delivered a pulse of disinfectant to a door handle each time the door was used. Microbial levels on the handles of frequently used door locations were monitored over a 16-week period, to compare microbial loads with and without a door handle disinfection system in place. Samples of two disinfectant types, Steri-7 (broad-spectrum disinfectant) and Dew (hypochlorous acid), were used in the study.
Findings: Levels of $\leq$2.5 cfu/cm^2 were recorded on 93% of samples collected where a door handle disinfection system was in use, with 66% of samples showing no microbes recovered. Where a level of $>$2.5 cfu/cm^2 was recorded, the door handle disinfection system reduced this to a negligible level by the time the next sample was taken, compared with several days where no system was in place.
Conclusion: Door handle disinfection systems offer an effective solution to reducing microbial levels on frequently touched door handles, as an automated solution with minimal additional costs.

Introduction

Frequently touched surfaces, such as door handles, are known fomites [1]. The more frequently surfaces are touched, the greater the number and variety of organisms they are likely to harbour, some of which may be pathogenic [2]. Shared

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toilets in hospitals are frequently used many times a day by a wide variety of people, making the exit door handle a critical contact point [3].

Until recently, environmental surfaces were considered inconsequential in the spread of nosocomial infections [4]. However, studies now show that pathogenic organisms can survive on surfaces for extended periods of time, especially in warm humid environments such as washrooms, where they can proliferate, creating a potential risk for onward transfer to patients [5]. The World Health Organization states in its 2016 Guidelines on core components of infection prevention and control programmes: 'Special attention should be given to sanitation or toilet facilities as these are often areas that are heavily contaminated and reservoirs for HAIs' [6]. Microbiological standards for a cleaner hospital environment have been proposed at a desired level of <1 colony-forming unit (cfu)/cm^2 of indicator micro-organisms and a maximum of 2.5–5 cfu/cm^2 of micro-organisms in total post cleaning, for frequent hand-touch surfaces [7,8].

Many shared washrooms in hospitals are used several hundred times a day, making it difficult for normal systematic cleaning procedures alone to maintain the desired safe level on their exit door handles [9]. To date, numerous efforts have been made to address this problem without any real success. Attempts have ranged from special handle covers, handles that emit hand gel, doors operated by foot, to doors which engage aerosols – something considered unacceptable in healthcare. Others include antimicrobial surfaces such as copper, which, though effective in certain areas, do not have the contact kill times needed for frequently and commonly touched surfaces such as washroom door handles.

The aim of this study was to assess a door handle disinfection system delivering a pulse of disinfectant via an atomizing pump (non-aerosol) directly on to the handle, each time the door was used, so that the disinfectant became active immediately.

Methods

This study examined microbial levels on the handles of ten frequently used door locations, in a busy rehabilitation unit, consisting of two wards, at the National Orthopaedic Hospital, Dublin. The study was undertaken over a 16-week period between September 2019 and February 2020. Figure 1 shows the layout of the rehabilitation unit, highlighting the doors involved and their various locations. Doors were selected for inclusion in the study due to their location and regular frequency of use. They included the exit door handles from various patients' shower/WC facilities, the exit door from staff and public washrooms, the door from a patient side-room, and the ARU gym. Three of the doors (1, 4, and 6) were substituted after week 3, for doors more compatible with the door handle disinfection system (11, 12, and 13). Each door had similar sized lever-style handles, made from hospital grade stainless steel.

The door handle disinfection system, developed by Handle Hygiene®, is a simple mechanical device designed to disinfect door handles after each use. The automated system utilizes the energy created by the opening/closing motion of the door to operate. It contains a single-use cartridge that delivers ~4000 cycles of disinfectant. Two different disinfectant types were used, to show that suitable fluids, regardless of type, work effectively in the disinfection system. Both disinfectants were verified as safe for human contact and utilized in accordance with manufacturer's instructions. Steri-7 (broad-spectrum disinfectant) was used in weeks 2 and 9–11, and Dew (hypochlorous acid) in week 15.

The average daily usage of the doors was monitored using digital tally systems that were fitted to each door. Usage variations were noted for comparison purposes, with the patient's side-room having the lowest daily average usage of 26 openings/closes recorded per day. The busier doors including staff, public, and main patient facilities had higher weekly averages of almost 1500 uses per week each ($>$200 uses each per day). The Handle Hygiene® system was temporarily fitted and removed from the doors on three occasions (week 2, weeks 9–11, and week 15), providing an opportunity to compare the level of microbial growth that accumulated on the surfaces of their handles, in the presence versus the absence of the door handle system.

Microbial samples were collected from each handle throughout the course of the study by the infection prevention and control (IPC) team at the hospital, using Hygicult TPC contact slides with built-in neutralizing agents Lecithin and Tween 80. These slides have a surface area of 5 cm^2 either side with a total plate count agar, which supports rapid growth of the most widely encountered bacteria and fungi. Each slide collected two samples from each handle, one from either side, top/bottom or front/back. Samples were analysed by Abbott Analytical Laboratory in the UK, a UK Accreditation Service-certified microbiology testing laboratory.

A total of 1120 microbial samples were collected from the various door handles (560$\times$2 per slide). Of these, 312 were taken while the Handle Hygiene® system was in use and 808 while the system was not in use (156 and 404 slides respectively). The slides were incubated for 24 h $\pm$ 4 h at 36 $\pm$ 1 °C, as per the manufacturer's instructions. Cfu counts were then performed on both sides of the slides and totalled for each slide.

To avoid any sudden up-lifting of normal cleaning standards while the study was in progress, the IPC lead altered the timing for collecting the samples. All samples were gathered throughout the normal working day, 06:00 to 18:00 Mon–Fri, with an almost balanced 50:50 mixture of morning/afternoon sampling.

Normal cleaning schedules remained in place throughout the study: door handles were cleaned three times per day with a blue cloth, one wipe using a disinfectant spray. During the weeks in which the system was not in place, the standard 'Trionic' cleaning and disinfection spray was used. When the door handle system was in place, its disinfectant was utilized to protect against any chemical inter-mix. Furthermore, as a means of identifying any sudden increase in cleaning standards while the system was in place, one of the doors had a system fitted that was not operational. This test door was used during weeks 9–11 and 15. Cleaning staff were unaware of this intervention.

Results

The results are shown in Table I. When the door handle system was used in conjunction with either of the sample

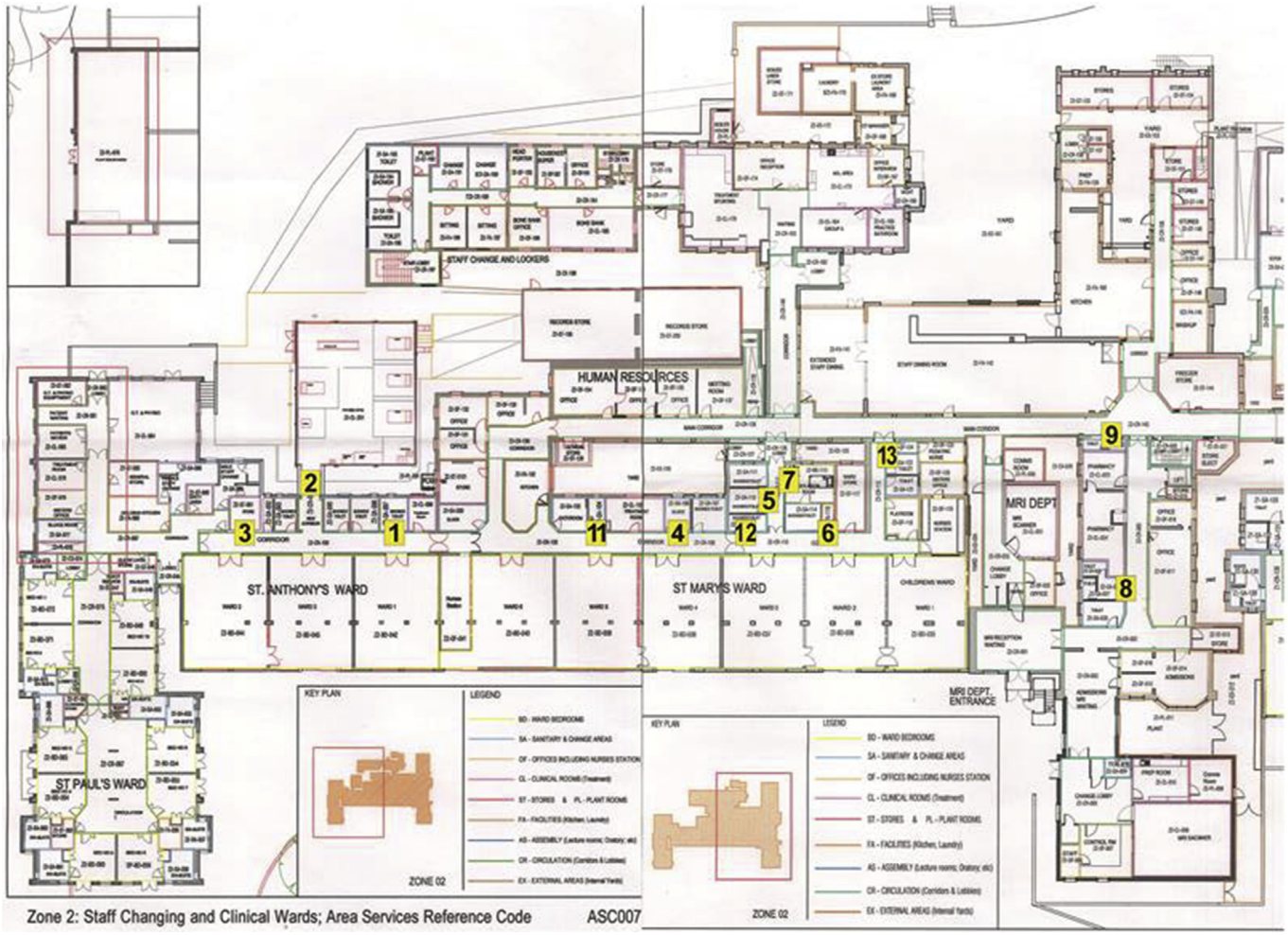

Figure 1. A floor plan showing the doors sampled in St Anthony's and St Mary's wards where the study was conducted. 1. Patients' shower/toilet. 2. ARU gym. 3. Staff changing rooms. 4. Sluice room. 5. Patients' shower/toilet. 6. Linen room. 7. Patient side room. 8. Staff toilet. 9. Public toilet opposite restaurant. 10. Public toilet at reception (not in image). 11. Patients' shower/toilet. 12. Patients' shower/toilet. 13. Patients' toilet.

Table I
Descriptive statistics from Hygicult contact slide samples

Treatment	Standard	Standard + Steri-7	Standard + Dew
No. of Hygicult contact slides	404	111	45
Total no. of colonies[a]	4190	280	235
Median no. of colonies (IQR)	7 (2–16)	0 (0–0)	0 (0–10)
Proportion of slides with $\leq$2.5 cfu/cm^2	74.5%	91.9%	93.3%
Proportion of slides with 0 cfu/cm^2	13.6%	73.0%	51.1%
Proportion of slides with TMTC colonies	13.6%	6.3%	4.4%

IQR, interquartile range; TMTC, too many colonies to count (>100 colonies).
[a] Number excludes samples where there were too many colonies to count (>100 colonies).

disinfectants, microbial levels were within the desired safe level of $\leq$2.5 cfu/cm^2 on 92.3% of samples analysed (odds ratio (OR): 4.11; 95% confidence interval (CI): 2.19–7.71). Where a level of >2.5 cfu/cm^2 was recorded, the door handle disinfection system reduced this to a negligible level by the time the next sample was taken, compared with several days while no system was in place.

When Steri-7 (Dew) was used in the system, 73.0% (51.1%) of samples showed no microbes recovered, compared with 13.6% for standard cleaning routines (OR Steri-7: 17.13; 95% CI: 10.33–28.43; OR Dew: 6.63; 95% CI: 3.46–12.71).

Results for the test door having $\leq$2.5 cfu/cm^2, where a handle system was in place but did not contain any fluid vs no system in place, were found to be insignificant (continuity corrected χ^2-test: $P = 0.61$).

Furthermore, the colony morphology of the most frequently occurring bacteria was used to select colonies for further testing, which subsequently confirmed the presence of

several pathogenic organisms from the *Streptococcus* and *Entero-coccus* species. Resistance to meticillin was also tested for and found positive, confirming the presence of meticillin-resistant *Staphylococcus aureus* (MRSA).

Discussion

The research objective was to examine microbial levels on the handles of frequently used doors in an orthopaedic hospital. The addition of a door handle disinfection system reduced the number of colonies found on the fomite surfaces to within the recommended level in 93% of samples, compared with 75% without the additional system in place.

Many studies call for improved cleaning methods and procedures in the interest of public health and infection control, particularly in environments where immunocompromised/immunosuppressed individuals reside [10]. Other studies confirmed that pathogenic organisms not only exist, but, in certain conditions, can thrive on environmental surfaces. Organisms including *Clostridium difficile*, MRSA, vancomycin-resistant enterococci, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and norovirus pose a real risk for onward transfer to patients. Although this study did not highlight the presence of all these organisms, it did confirm the presence of several pathogenic organisms from the *Streptococcus* and *Enterococcus* species.

The study confirmed that the microbial load on door handles varies widely, where high levels can increase the potential for hand-based transmission. The addition of a door handle disinfection system, such as Handle Hygiene®, addresses this problem, through its constant disinfecting of the handle after each use. When used in conjunction with a suitable disinfectant, this system offers an effective solution to reducing microbial levels on frequently touched door handles. As an automated solution, it ensures compliance, with minimal additional costs to resources. A simple mechanical device, requiring no batteries or power supply, in addition to routine cleans, can guarantee regular disinfection of the fomite surface, increasing the rate of compliance with safe guidelines. It should be considered an important addition to any strategy, designed to limit the spread of pathogenic organisms in a healthcare environment.

By incorporating a door handle disinfection system into standard hospital cleaning protocols, it should be feasible to reduce the target to $\leq$1 cfu/cm^2, significantly reducing the risk of cross-contamination.

Acknowledgement

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Conflict of interest statement

The study was designed by Clever Hygiene Solutions Ltd in collaboration with two independent academic experts in microbiology and the IPC lead at the National Orthopaedic Hospital, Dublin, Ireland. The IPC lead selected the door locations for the study. Clever Hygiene Solutions Ltd had no active involvement with either sample collection or analysis. The samples were collected by the IPC team. The slides were analysed by Abbott Analytical Laboratory in the UK, a UKAS-accredited microbiology testing laboratory, with further analysis conducted by the Charles River laboratories. The statistical analysis was conducted by V. O'Neill. The paper was written, edited, and approved by B. Cunningham (Clever Hygiene) and V. O'Neill, M. Devereux, D. McGann, and J. O'Hora. This study does not promote any specific brand or make of disinfectant. Disinfectants were selected in consultation with the on-site IPC team, who were best qualified to decide which disinfectant was most suited for use in their particular environment.

Funding sources

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