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The potential of alcohol release doorplates to reduce surface contamination during hand contact

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SUMMARY

Background: Optimal hand hygiene may be compromised by contact with contaminated environmental surfaces.
Aim: To investigate the in-vitro efficacy of a novel alcohol-release doorplate to reduce surface contamination during hand contact.
Methods: Prototype, horizontally held, Surfaceskins, alcohol gel-impregnated and control (aluminium) doorplates were challenged ($N = 72$ per micro-organism) with *Staphylococcus aureus*, *Eschericia coli*-, *Enterococcus faecalis*-, or *Clostridium difficile*-contaminated fingers. *S. aureus* and *E. faecalis* were used for challenges (90 per micro-organism) of vertical (modified design) doorplates, on days 0, 3, 4, 6, and 7. Surface contamination was measured pre and immediately post challenges using agar contact plates.
Findings: Horizontal test, but not control, doorplates demonstrated bacterial killing of *S. aureus*, *E. faecalis* and *E. coli*, but not of *C. difficile;* hence, only testing of *S. aureus* and *E. faecalis* was continued. Vertical Surfaceskins, but not control, doorplates demonstrated rapid killing of *S. aureus* over seven days. There were significant reductions (>90% up to day 6; $P \leq 0.01$) of surface bacterial colony counts compared with controls immediately post challenge. There were also significant reductions in Surfaceskins doorplate enterococcal colony counts compared with controls on every day of testing ($P \leq 0.004$). There was no evidence that bacterial recovery was greater from the tops of Surfaceskins doorplates (i.e. due to pooling of contents).
Conclusion: Surfaceskins doorplates were efficient at reducing surface contamination by *S. aureus*, *E. faecalis*, and *E. coli*. Reducing microbial contamination of frequently touched door surfaces, and so bacterial transfer via hands, could feasibly reduce the risk of healthcare-associated and other infections.

Introduction

Hands and especially fingertips are strongly implicated in the cross-transmission of microbial pathogens [1]. The introduction of multiple methods for achieving and maintaining clean hands aims to reduce the prevalence of pathogens persisting within the environment, and so break the cycle of infection. Alcohol-based hand rubs (liquid, gel, or foam) are widely used for routine hand disinfection in healthcare settings when hands are not visibly soiled. Alcohol gels are effective at reducing healthcare-associated infection within healthcare environments, and are highly effective at removing pathogens

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from the hands of healthcare workers and visitors before entering a ward environment [2–4].

The bacteria on hands may be divided into two categories: resident and transient. Resident flora include coagulase-negative staphylococci, propionibacteria, and micrococci that reside under the superficial cells of the stratum corneum and on the surface of the skin [5]. Transient potential pathogens such as *Staphylococcus aureus*, enterococci and Gram-negative enterobacteria colonize the superficial skin layers. These bacteria, which do not usually proliferate on skin but can survive and may sporadically multiply, are more amenable to removal by routine hand hygiene than are resident flora [6]. Transient organisms tend to be acquired by healthcare workers, especially during direct contact with patients or contaminated environmental surfaces [7].

We have evaluated *in vitro* during simulated use the effectiveness of a new device, Surfaceskins doorplate, that aims to maintain the cleanliness of hands after opening doors via push plates, i.e. it is designed to prevent contamination of (clean) hands upon touching a contaminated door surface. The alcohol gel-releasing doorplate, developed by Surfaceskins (University of Leeds, Leeds, UK), is designed to replicate a standard door plate in size and function and is mounted on to a door in the normal position. The Surfaceskins doorplate is composed of a disposable alcohol gel-filled pad with a porous membrane on the top. This fits into a permanent plastic holder mounted on to the door. When pressure is applied by a hand on to the surface of the doorplate, a small amount of alcohol gel is released through small pores on the device surface, which is deposited on to the hand.

Methods

Determination of the number of bacteria on the fingertips of healthcare workers

In order to simulate the process of touching a doorplate with fingers (contaminated with bacteria), we first needed to determine the approximate number of bacteria present on the skin of the three (index, middle and ring) fingers that primarily touch a doorplate. To do this, we randomly recruited and sampled a wide range of healthcare workers from within the hospital to screen for hand bacteria. Staff were asked (with no prior warning) to dab their index, middle and ring fingers on to a tryptone soy agar (TSA) plate (E&O Laboratories, Bonnybridge, UK). They were also asked whether they had washed or decontaminated their hands in the last 30 min. Following testing, all TSA plates were incubated and colonies counted after 24 h. We also assessed the total surface area of skin (of the three fingers) that came into contact with the doorplate during the process. Ten people were asked to dip their fingers into endorsing ink, and then to touch graph paper to give a representation (in cm^2) of the surface area of a 'three-finger touch'.

Preparation of bacterial strains for doorplate challenge experiments

A single strain each of four widely occurring healthcare-associated pathogens were used (*S. aureus* ATCC29213, *Eschericia coli* NCTC10418, *Enterococcus faecalis* NCTC2421, and *C. difficile* P24 strain ribotype (CE)001). These were cultured overnight in TSA broth (Schlaedlers broth for *C. difficile* to provide a predominantly spore inoculum), and a suspension of bacterial cells (10^5 cfu/mL) in a Petri dish was used for inoculating gloved fingers (Latex Free, nitrile examination gloves, Healthline, Milton Keynes, UK) and used for each challenge experiment. This was to simulate bacterial contamination on three fingers, and was measured via replicate plate counts (by a process of dipping fingers into the suspension, dabbing on a paper towel and colony counts on TSA; data not shown).

Experimental set-up for challenge experiments

Surfaceskins door plates ($N = 3$) were removed from packaging and placed into the plastic holders and secured horizontally on the bench. Control doorplates ($N = 3$) used were standard aluminium doorplates that had been thoroughly cleaned using disinfectant wipes (PDI Sani-Cloth, Flint, UK), were also secured horizontally. For the vertical tests, the Surfaceskins doorplates ($N = 3$) in the holders were secured on to a vertically mounted hand-pressure detector, providing a force reading (in kgf), and control doorplates ($N = 3$) as above were secured horizontally (for ease of testing, and given the absence of a gel layer). On to each doorplate (Surfaceskins and controls) three separate circular areas (each 6 cm diameter) were allocated for testing, i.e. a top, middle and lower area. A plastic template, with three cut-out circles (top, middle, and low) was secured over the top of each doorplate (Surfaceskins and control doorplates) to define the areas for testing and so to determine whether bacterial kill was achieved/maintained in all areas.

Testing process for doorplate challenge experiments

Doorplates were tested first in the horizontal plane, and then (using a modified different Surfaceskins doorplate design that comprised different key components and configuration) in the vertical plane. For the horizontal doorplate challenges, four bacteria (*S. aureus*, *E. faecalis*, *E. coli*, and *C. difficile*) were used and testing was carried out on days 0, 2, and 7. In total, 72 challenges (pre- and post-samples) were performed for each micro-organism (36 on Surfaceskins doorplates and 36 on control doorplates). For the vertical doorplate challenges, two bacteria were used (*S. aureus* and *E. faecalis*), and testing was carried out on days 0, 3, 4, 6 and 7. Challenges were carried out in triplicate (three doorplates were used) and three different areas on each doorplate were sampled, to give nine challenges per organism per testing day. In total, 90 challenges (pre and post) were performed per micro-organism (45 on surface skin doorplates and 45 on control doorplates).

For each challenge experiment, the process involved the following steps. First, a pre-inoculation sample of the doorplate was taken by pressing a contact agar plate (Count-Tact Agar plate; bioMérieux, France) on to the defined area (top, middle or low) of the doorplate to be tested. Gloved fingers were then dipped into the suspension of bacterial cells in the Petri dish. Fingers were briefly dabbed on to paper towel to remove excess fluid, and were then pressed against one of the defined areas of the door plate, to reach a pressure of 5 kgf. After no longer than 30 s, a second contact plate was used to

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