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Effectiveness of deep cleaning followed by hydrogen peroxide decontamination during high *Clostridium difficile* infection incidence

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SUMMARY

Background: *Clostridium difficile* infection (CDI) remains an infection control challenge, especially when environmental spore contamination and suboptimal cleaning may increase transmission risk.

Aim: To substantiate the long-term effectiveness throughout a stroke rehabilitation unit (SRU) of deep cleaning and hydrogen peroxide decontamination (HPD), following a high incidence of CDI.

Methods: Extensive environmental sampling (342 sites on each occasion) for *C. difficile* using sponge wipes was performed: before and after deep cleaning with detergent/chlorine agent; immediately following HPD; and on two further occasions, 19 days and 20 weeks following HPD. *C. difficile* isolates underwent polymerase chain reaction ribotyping and multi-locus variable repeat analysis (MLVA).

Findings: *C. difficile* was recovered from 10.8%, 6.1%, 0.9%, 0% and 3.5% of sites at baseline, following deep cleaning, immediately after HPD, and 19 days and 20 weeks after HPD, respectively. *C. difficile* ribotypes recovered after deep cleaning matched those from CDI cases in the SRU during the previous 10 months. Similarly, 10/12 of the positive sites identified at 20 weeks post-HPD harboured the same *C. difficile* ribotype (002) and MLVA pattern as the isolate from the first post-HPD CDI case. CDI incidence [number of cases on SRU per 10 months (January–October 2011)] declined from 20 before to seven after the intervention.

Conclusion: HPD, after deep cleaning with a detergent/chlorine agent, was highly effective for removing environmental *C. difficile* contamination. Long-term follow-up demonstrated that a CDI symptomatic patient can rapidly recontaminate the immediate environment. Determining a role for HPD should include long-term cost-effectiveness evaluations.

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Introduction

Clostridium difficile is highly transmissible in hospitalized patients and control measures to limit cross-infection are part of routine practice.[1] It has become increasingly important to determine how transmission is occurring and to establish effective interventions to minimize these risks.[2] Control methods to limit *C. difficile* transmission in healthcare environments include barrier methods, isolation of infected patients and compliance with hand hygiene measures to minimize the dissemination of spores.[3] *C. difficile* spores represent a particular challenge to effective decontamination because they are shed in high numbers by infected patients and they are resistant to desiccation and to some disinfectants.[4] Strict adherence to environmental cleaning and disinfection policies including surfaces and equipment have been shown to be important in reducing spore contamination and *C. difficile* infection (CDI) rates.[5,6] Admission to a room previously occupied by a patient with CDI is a risk factor for the acquisition of *C. difficile*.[7] Despite implementation of control measures, hospitals still experience CDI case clusters, prompting a search for ways to reduce and limit environmental contamination.

There are many alternatives for decontamination of ward environments, including (sometimes deep) cleaning with various detergents and disinfectants and use of gas/vapour technologies. HPD has recently increased in popularity for decontamination of hospital wards and for the terminal disinfection of rooms.[8–10] Some reports claim that HPD is more effective than manual cleaning for removing environmental microbial contamination, for example by MRSA.[11] Hydrogen peroxide is a powerful oxidizing agent that penetrates microbe cell walls by passive diffusion and inactivates vegetative bacteria and bacterial spores.[12] It causes cell death through mechanisms which, although not fully elucidated, include the production of hydroxyl radicals, causing irreversible damage to bacterial DNA.[12,13]

We aimed to determine, using extensive environmental sampling and ribotyping, the extent of environmental contamination of a hospital ward by *C. difficile*, and to establish the immediate effectiveness of deep cleaning and HPD on microbe prevalence. Additionally, we carried out follow-up extensive sampling to determine the extent of recontamination by *C. difficile* after resumption of clinical activity in a high CDI risk setting.

Methods

Background to the outbreak and setting

Leeds Teaching Hospitals NHS Trust is a large UK teaching hospital and tertiary referral centre with ~2000 beds. At the time of testing the stroke rehabilitation unit (SRU) contained 30 beds and was divided into male and female sections. The male section comprised three four-bedded bays, three single rooms, a small day-room and bathroom facilities. In the female section there were four four-bedded bays and bathroom facilities. In the central area of the ward there was a large day-room which was used for multiple activities including meetings with therapists or carers, serving food and storage of equipment. The single rooms did not have en-suite facilities, and so patients nursed here in isolation for infection control purposes used in-room commodes.

Between January 2011 and October 2011, 20 cases of CDI were diagnosed in patients in the SRU. Investigations led to the findings that, of these cases, 11 represented transmission between patients, eight were probably imported infections, and one represented a patient with recurrent CDI. Ribotyping provided evidence suggestive of transmission between cases and a number of clusters of cases were identified. During this period a number of practice changes were implemented within the ward, including reviews of antimicrobial prescribing, transfer of patients with CDI to an alternative ward and further staff training. Despite this, it was concluded that the measures which had been taken to reduce the incidence of CDI in the SRU had been ineffective. A decision was made in October 2011 to close the ward for 10 days and decant the patients into alternative accommodation so that HPD could be used.

Deep cleaning

The deep cleaning of the SRU took place over one week and involved an intensive, prolonged, manual clean, which aimed to restore all surfaces to the best possible condition, leaving them free from ingrained dirt, debris and marks. This involved a dedicated team of six trained personnel, and included cleaning the walls, vents, radiators, floors and all patient shared equipment, and changing of all curtains. The chlorine-based sporicidal disinfectant 'Chlor-Clean' (Guest Medical Ltd, Aylesford, UK) at a chlorine concentration of 1000 ppm (from Chlor-Clean tablets) with launderable microfibre mops (one per single room or bay) and cloths (number used per room determined on the level of soiling encountered, amount of equipment, items contained within the room and the nature of the surface being cleaned) were used for surface decontamination. Cleaning was carried out in a systematic manner with the single rooms being cleaned first, followed by the bed bays, then the general areas, corridor areas and out to the ward entrance.

Hydrogen peroxide decontamination

Hydrogen peroxide decontamination was achieved using the Deprox system (Hygiene Solutions, Kings Lynn, UK). Mobile generators using high frequency ultrasound to atomize hydrogen peroxide were placed into the ward following closure and deep cleaning. All windows and doors were sealed and the generators were used to release hydrogen peroxide droplets of size 2 μm into the environment to achieve a hydrogen peroxide concentration of 87 ppm for a predetermined length of time, dependent on the size of the area to be decontaminated. According to the manufacturer the small size of the droplets enables them to be hypermobile and to achieve a high level of spatial distribution through natural convection currents throughout the space. Fans were also used to circulate the air throughout the decontamination time. Air was then blown into the environment which displaced all remaining hydrogen peroxide. Entry was allowed into the ward when levels had fallen to 1 ppm, which was measured by equipment sensors.

Organization of environmental sampling

Environmental sampling was carried out on five separate occasions: sampling 1 was carried out immediately following the move of all patients and staff into an alternative ward,