The contribution of peracetic acid releasing Sporicidal wipes in environmental cleaning to produce a sustained reduction in *Clostridium difficile* rates.

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Abstract

This paper describes the impact of introducing peracetic acid releasing Sporicidal wipes into the environmental cleaning regimen of an acute NHS London trust and subsequent observed reduction in *Clostridium difficile* infection (CDI) rates. These wipes replaced traditional chlorine-based products, which were felt to be a possible contributing factor to poor compliance by staff with hospital cleaning regimens. CDI rates were monitored in patients over 2yrs of age from April 2006, until the wipes were introduced in April 2008 and then monitored for a further 18 months. In-patient bed days were monitored to ensure any findings were not attributed to changing patient numbers. Although other measures are also necessary to reduce CDI, no further initiatives were introduced at this time. Over previous years, CDI rates had fluctuated, but remained relatively constant within the trust. After the introduction of the peracetic acid Sporicidal wipes the CDI rates had reduced by 72%.

Key words:

Clostridium difficile, sporicidal wipe, peracetic acid, environmental cleaning, infection prevention and control

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Background: Traditional chlorine-based cleaning products for environmental cleaning, alongside good infection prevention measures such as hand washing, isolating affected patients and policing antibiotic usage have long been standard processes for controlling *Clostridium difficile* in acute healthcare settings[1]. In order to drive significant reductions, rather than maintaining control in *Clostridium difficile* rates, these processes and products must be reviewed and improved.

Methods: In this observational before/after study at an acute tertiary referral hospital, all in-patients over the age of two years were studied. Chlorine-based cleaning regimens and products were changed to the use of peracetic acid generating sporicidal wipes. Rates of *Clostridium difficile* before and after the change were monitored.

Results: The mean *Clostridium difficile* rate per 1,000 patients per year was over six before the introduction of the peracetic acid wipes and fell to two after their introduction. This rate has fallen below two in the first half of the following year.

Conclusion: The introduction of peracetic acid wipes was followed by a significant fall in *Clostridium difficile* rates which supports the need to review and enhance traditional environmental cleaning regimens, for controlling *Clostridium difficile* in healthcare settings and improving patient experience and outcomes.

Introduction

Clostridium difficile infection (CDI) can cause severe illness and suffering to people, particularly the elderly and those suffering debilitating illness or who are on antibiotic treatment. This tends to make hospitals the predominant setting in which CDI is identified. Key elements in the occurrence of *Clostridium difficile* (CDI) include the fact that certain antibiotics disturb normal gut flora and this can allow *Clostridium difficile* to produce two principle toxins, A and B which can cause diarrhoea and colitis. CDI is also predominantly transmitted in the form of spores which contaminate the environment for long periods of time and are resistant to cleaning. CDI attack rates are sporadic, making the epidemiology of occurrence and outbreaks complex[1].

To prevent and tackle these elements the most effective tools are: focused antibiotic management to reduce gut disturbance, hand washing instead of alcohol gel or rub use when caring for patients with diarrhoea, isolation of patients with diarrhoea to contain the source of CDI and effective environmental cleaning to reduce transmission from contaminated surfaces[2.3.4.] This observational study, in a single centre, investigates whether changing from a chlorine-based product to peracetic acid wipes in the element of effective environmental cleaning contributes to a reduction in CDI rates sustained over time.

Method

This study was commenced in April 2006. The sporicidal wipes were introduced in April 2008. The study included all in-patients over two years of age in an acute tertiary referral, London teaching hospital. CDI cases were identified using Department of Health, England (dh) and Health Protection Agency, England (HPA) definitions[5.] Diarrhoea was defined as stool loose enough to take on the shape of its container, (Bristol stool chart 5-7)[6], not attributable to any other causes, occurring at the same time as a positive toxin assay. Cases were counted in

individuals over two years of age that occurred over 48 hours post admission. More than one case for the same patient was counted if there was a 28 day period between samples and symptoms had resolved within this time. Occupied 'bed-day' data was also collected on a weekly basis during the study so that any fall or rise of CDI rates could not be attributed to changes in patient numbers.

Clostridium difficile spores are known to survive in the environment for months or even years, across a range of surfaces and equipment used in patient care. The contaminated environment is richly evidenced as a source for CDI acquisition[1,7.] Enteric isolation measures are the norm for actual or suspected diarrhoea[8], within the hospital, whether CDI is identified or not. In order to reinforce this, the source isolation category used within the trust was specifically split in January 2008 to ensure that enteric isolation measures became a category in their own right, in which environmental cleaning with a sporicidal product and hand washing rather than alcohol gel use, could be focussed on. Cleaning procedures had included the use of a chorine-based product for the environment of patients with CDI. Although the trust moved to a microfibre environmental cleaning system in 2007, isolation room cleaning for diarrhoea and confirmed CDI had remained with chlorine solution and disposable cloths.

Product choice

As recommended[2] and as clinical studies suggest[9,10], chlorine releasing agents have been the trust's traditional product of choice for cleaning in cases of suspected or actual infectious diarrhoea. Unfortunately it is unpopular with users in terms of irritating fumes, dilution and preparation issues. It has a damaging effect on some furnishings and equipment, indeed, some equipment and medical device manufacturers are reluctant to, or cannot, recommend the use of chlorine solutions as cleaning agents. The recommendations[2] stated not only that chlorine-

based products must be used, but that a sporicidal agent may be used too, so an effective sporicidal alternative was sought. As the use of a sporicidal agent was in line with national recommendations, ethical approval was not needed for this change. Disposable equipment and devices are an option for some items, but can be costly and have many disposal problems including cost, environmental impact and quality. Detergents have been shown to have the potential to allow *Clostridium difficile* spores to germinate, allowing persistence of CDIs[11]. Technologies such as vaporised hydrogen peroxide (VHP) are effective[12] but are limited again by cost, consideration of time and the need for an empty room. VHP has since been introduced into the trust but not until July 2008 and again cannot be used unless the room is empty, which is a rare occurrence in times of high bed occupancy. This technology has only been occasionally used following discharge of known CDI patients, whereas a product is needed for daily cleaning of these isolation rooms during the patients stay in hospital, not just on discharge.

A product was sought that had specific proven sporicidal activity, was in a format that is user friendly, environmentally friendly, had non-toxic fumes, was not damaging to furnishings and equipment and had non-selective action so would not promote microbial resistance. With so many products claiming sporicidal activity, the validity and reliability of sporicidal activity needed to be scrutinised to ensure sporicidal data was from an accredited laboratory. The log kill count had to be effective and within a short enough contact time to ensure realistic use in the work place. The Clinell® Sporicidal wipe (Gama Healthcare Ltd UK) generates peracetic acid and hydrogen peroxide. Peracetic acid is identified as one of the safest, most effective bactericidal, sporicidal and viricidal agents[13,14], but is difficult to keep in a stable form. The wipes contain no alcohol or organic solvents and can therefore be used on all fabrics.

The wipes contain a stable, safe and inert precursor formulation in dry form and only generate active peracetic acid on demand by the simple addition of water onto a dry wipe. The wipes are

capable of generating 3000 parts per million of peracetic acid in one minute when placed in 75 millilitres of water.

All testing was conducted at the Hospital Infection Research Laboratory (Birmingham, UK) and showed a greater than 6 log kill count of spores in a one minute contact time as well as viricidal activity against viral makers: adenovirus and poliovirus and proven antimycobacterial activity and also antibacterial activity against Staphylococci, *Pseudomonas*, Enterococci and *E.coli*.

The Sporicidal wipes were identified by users as preferable to handle than chlorine, easy to activate and use in practice. They are environmentally friendly as the peracetic acid breaks down into vinegar, carbon dioxide and water, there is therefore no risk to the patient, user or the environment and there are no toxic residues. There are no toxic fumes produced and so the wipes are safe to be used in close proximity to patients.

The Sporicidal wipe works in highly soiled conditions and there is no need to pre-clean areas as with chlorine, which saves valuable time during the cleaning process. Unlike many chlorine-based products, many of which need carefully measured dilution or are complex to make up prior to use, the wipes are ready immediately on contact with water.

Peracetic acid is delivered on demand at the site of need. The wipes provide a non selective action and hence there is no risk of microbial resistance. The Sporicidal wipes are able to be stored at room temperature out of direct sunlight, therefore easily stored within the ward environment.

Implementation.

In 2007 the D of H requested bids for initiatives to reduce *Clostridium difficile* in NHS trusts. This trust submitted a successful bid for peracetic acid Clinell® Sporicidal wipes for environmental cleaning. The main driver for the bid was to improve patient care and to achieve,

or better, the D of H mandatory CDI reduction target for the trust. Other drivers included the consideration of the national increase in deaths associated with CDI, the costs associated with treating both individual cases of CDI, the costs associated with any outbreaks that may occur and the cost of antibiotic therapy. The bid was based on the estimated usage of Sanitising and Sporicidal wipes for a period of one year, based on the previous years CDI rates. The Sporicidal wipes were ordered and delivered on a monthly basis directly to the infection prevention and control (IPC) nurses, who distributed the wipes on a case-by-case basis to ensure efficient and effective use.

The company that developed and manufactured the Sporicidal wipes provided product information, which was developed and customised in collaboration with the trust IPC nurses. In order to ensure effective use of the wipes each individual patient identified within the trust as CDI positive was visited by a member of the IPC team to discuss their care face-to-face. A pack was taken directly to the bedside which included: two packets of 25 Sporicidal wipes, the Sporicidal wipe information sheet, patient information sheet on CDI, individualised patient care plan, CDI care pathway with a wall-mounted poster for staff information.

Ward staff were taught at the bedside how to activate the dry Sporicidal wipes with water and how to clean the patient environment with the wipes. Training of the ward-based cleaners and domestics, housekeepers and other allied healthcare professionals (AHPs) involved in direct patient contact was included as they are known to be equally important in maintaining a clean environment[15]. The training included daily environmental cleaning of: horizontal surfaces, patient furniture and medical equipment such as bed frames, commodes, infusion pumps, locker tops, toilet facilities and frequent touch points such as door handles, taps and light switches. The Sporicidal wipes were also used for terminal cleaning following discharge or transfer of patients with CDI and for cleaning of equipment after use throughout the working day. The

teaching was reinforced on annual mandatory IPC updates for all clinical staff and AHPs and was also included on specific IPC awareness days to all trust staff. Individual ward visits included face-to-face discussion with staff. Flyers and newsletters were sent to Matrons to further disseminate information on the use of the wipes to other clinical staff at ward and team meetings.

Weekly ward rounds which included the IPC nurses, a microbiologist and an antimicrobial pharmacist to ensure good practice was still in place and to deliver fresh supplies of Sporicidal wipes, visited all patients identified with CDI. Reminders that wipes were for single patient use was discussed with ward staff and on IPC updates. Wipes were routinely transferred with the patient to subsequent healthcare settings where transfer could not be avoided. If the patients symptoms resolved and the patient was then discharged, unused wipes remaining in the pack were discarded and not used in any other area or with any other patient.

As CDI rates markedly improved within the trust, ward staff recognised the benefit of the Sporicidal wipes and began to independently contact the IPC nurses to request them when stocks were running low. In addition, clinical units such as endoscopy, X ray and theatres requested wipes for cleaning of areas following investigations and procedures on patients with CDI or possible infectious diarrhoea.

Post implementation support

The company have provided visible support at IPC awareness days and have been readily available to IPC nurses for all additional occasions required, including comments on packaging, printed documents and product acceptability information. Dispensers for the wipes are provided and fitted to trust specifications.

Maintaining the momentum.

Three months after the introduction of the Sporicidal wipes, weekly multi-disciplinary ward rounds were introduced. These were aimed at monitoring infection prevention and control measures and patient care. They also included an audit of Sporicidal wipe availability, use and environmental cleaning. When the ward rounds were introduced, there was 70% awareness amongst clinical and cleaning staff of the specific environmental cleaning required and usage of the Sporicidal wipes for patients who are isolated with known CDI. This is now 100%.

This increased awareness has been achieved by incorporating information regarding isolation room cleaning, specifically those relating to CDI patients into teaching sessions. As discussed above, this has been implemented both on orientation and mandatory annual updates for nursing staff and also targeted teaching for domestic staff.

Results

The data collected was composed of the number of cases of CDI, as defined by the HPA and the number of occupied beds in the hospital. It was necessary to know how many patients were in hospital at any given time so that any fall or rise of CDI could not be attributed to changes in patient numbers.

CDI case numbers were provided from April 2006 to September 2009 as was bed occupancy[a]. In order to create a rate, the number of cases was divided by the number of patients occupying beds. This was then multiplied by 1,000 to get a rate per thousand patients in a given week. The rate was calculated using the formula:

$$\text{Rate} = \frac{C_i}{B_i} * 1000$$

Where C_i is the number of reported cases of CDI in week i and B_i is the bed occupancy for week i. Rates that were calculated from this methodology for each of the four years are shown in table 1.

[a]There was no bed occupancy data available for 2/4/06 or 1/4/07 and these two time points are missing from the analysis.

Table 1. Mean Average Rate per 1000 Patients C. Difficile Infection Rate

Mean Average Rate per 1000 Patients C. Difficile Infection Rate												
Month	**2006/7**			**2007/8**			**2008/9***			**2009/10***		
	Number of Obser-vations	**Mean Avg Rate per 1,000**	**Standard Deviation**	**Number of Obser-vations**	**Mean Avg Rate per 1,000**	**Standard Deviation**	**Number of Obser-vations**	**Mean Avg Rate per 1,000**	**Standard Deviation**	**Number of Obser-vations**	**Mean Avg Rate per 1,000**	**Standard Deviation**
April	4	4.82	2.03	4	6.20	3.65	4	3.41	4.14	4	1.20	0.80
May	4	5.93	2.17	4	8.94	4.25	4	0.86	1.00	5	1.27	1.34
June	4	6.65	7.66	4	8.71	4.13	5	1.45	1.47	4	1.32	1.66
July	5	4.30	2.00	5	7.75	3.90	4	2.23	1.67	4	1.66	1.92
Aug	4	3.79	3.22	4	7.52	1.57	4	2.31	0.95	5	2.71	2.56
Sept	4	6.70	5.48	5	6.56	2.51	4	3.51	0.15	1	1.59	*na*
October	5	7.81	8.97	4	4.83	0.05	4	2.93	2.11			
November	4	8.64	2.89	4	15.52	12.60	5	2.96	2.43			
December	5	8.26	2.02	5	4.34	3.51	4	0.40	0.80			
January	4	6.20	1.54	4	2.90	1.59	4	1.68	2.29			
February	4	6.28	4.36	4	6.41	2.06	4	1.66	1.40			
March	4	5.50	3.71	5	5.20	2.77	5	1.26	1.34			

*New cleaning product introduced.

In the first two years, 2006/7 and 2007/8, a different cleaning product was being used before a new cleaning product was introduced in April 2008. To test what effect the new cleaning product had on the CDI rates, comparisons were made using a one-way ANOVA analysis comparing the four years of infection rates to one another. Calculations were carried out using PROC ANOVA in SAS 9.1.3 for Windows.

To investigate the distribution of rates by year, box plot were used (see figure 1). The box on each plot represents the middle 50% of the recorded rates for a year with the line crossing the area of the box representing the median value (middle value). Arithmetic means for each year are represented by the red plus sign on the box plot. Tails above and below the box represent the range of the distribution.

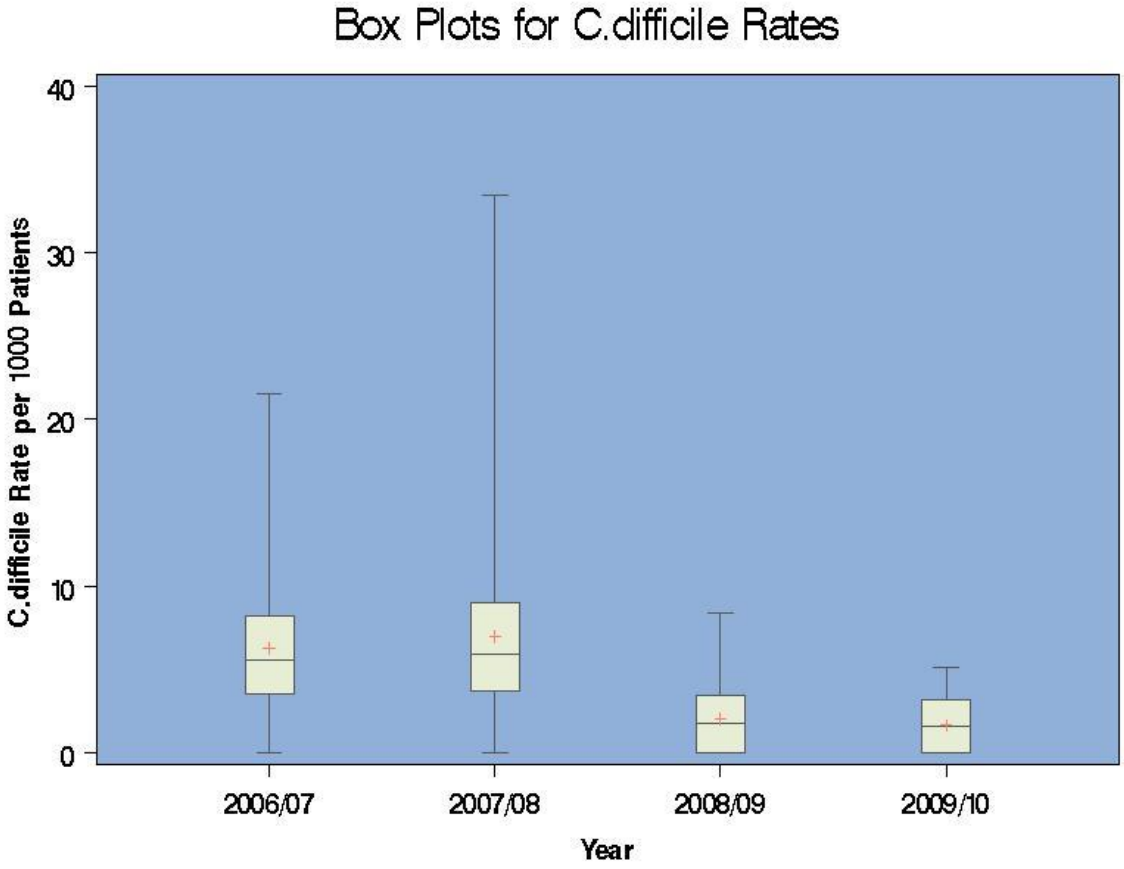

Figure 1. Distribution of CDI rates by year

It can be derived from the above box plots that the spread of CDI rates were much higher in the two preceding years before 2008/9 before the new cleaning product was introduced. There is an especially wide range of infection rates in the year 2007/8. Another notable change in 2008/9 to the preceding two years is that both the mean and median infection rates appear to be much lower in both 2008/9 and 2009/10.

Mean average infection rates for each year are displayed in figure 2 and table 2 (below). These indicate quite a large drop in infection rates in the year 2008/2009 and 2009/2010 compared to the previous two years.

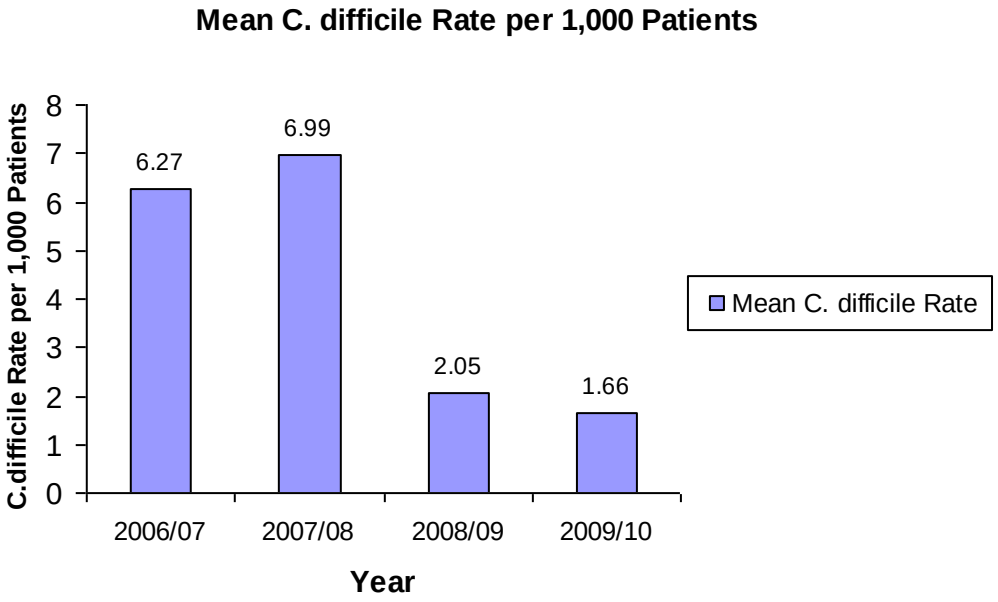

Figure 2. Mean CDI rates per 1,000 patients

Table 2. Mean Average C. difficile Rate by Year

Mean Average C. difficile Rate by Year				
Financial Year	**Number of Weeks**	**Mean C. difficile Rate**	**Standard Deviation of C. difficile rate**	**Median C. difficile Rate**
2006/07	51	6.27	4.29	5.54
2007/08	52	6.99	5.01	5.95
2008/09	51	2.05	1.94	1.74
2009/10	23	1.66	1.68	1.59

Results of the one-way analysis of variance (ANOVA) are shown in table 3. The ANOVA tests the differences between the mean infection rates over the three years. A Levene Test was carried out to test the equality of variances in the three years. This test is used in order to decide whether the data is suitable to use an ANOVA[2]. The test was found not to be

[2] An ANOVA test makes an assumption of equal variances.

significant in this instance (p=0.1975) so the assumption that the variances were equal was accepted. The resulting ANOVA was significant at the p<0.0001 level.

Table 3. ANOVA Statistics for Comparison of C. difficile Rates per 1000 Patients by Year.

ANOVA Statistics for Comparison of C. difficile Rates per 1000 Patients by Year						
Comparison	**Degrees of Freedom**	**ANOVA Sum of Squares**	**Mean Square**	**F Value**	**F Probability**	**Levene Test for Homogeneity of Variances**
Year	3	970.04	323.35	22.85	**<.0001**	0.1975

The significant ANOVA test indicates that there is a significant difference between at least two of the years. However, it does not indicate which years are different from one another. A post-hoc test is required to investigate this further. The simplest of these is the Least Significant Difference test. This methodology is essentially a number two sample t-tests comparing each of the possible differences.

Results of the post-hoc analysis reveal that there was no significant difference in CDI rates in 2006/7 and 2007/8. However, the year the new cleaning product was introduced, 2008/9, was found to show significantly lower infection rates that both 2006/7 and 2007/8 as was 2009/10. CDI rates were, therefore, significantly lower after the introduction of the new cleaning product.

Table 4. Least Significant Difference Comparison of Means

Least Significant Difference Comparison of Means				
Financial Year Comparison	**Difference Between Means**	**95% Confidence Limits**		**Significance**
2007/08 - 2006/07	0.71	-0.75	2.18	
2007/08 - 2008/09	4.94	3.48	6.40	Significant
2007/08 - 2009/10	5.33	3.47	7.19	Significant
2006/07 - 2007/08	-0.71	-2.18	0.75	
2006/07 - 2008/09	4.23	2.76	5.70	Significant
2006/07 - 2009/10	4.61	2.75	6.48	Significant
2008/09 - 2007/08	-4.94	-6.40	-3.48	Significant
2008/09 - 2006/07	-4.23	-5.70	-2.76	Significant
2008/09 - 2009/10	0.39	-1.48	2.25	
2009/10 - 2007/08	-5.33	-7.19	-3.47	Significant
2009/10 - 2006/07	-4.61	-6.48	-2.75	Significant
2009/10 - 2008/09	-0.39	-2.25	1.48	

The peracetic acid wipes had cost £6,566, which was part of the successful D of H bid. The cost per patient for CDI has been studied and is estimated to be £4,000[16,17,]. When this cost per patient is multiplied by the actual number of fewer cases in 2008/09 compared to 2007/08, the cost saving is £660,000, although it is recognised that other variables may have impacted on this saving which are not part of this observational study.

Discussion

Reports from both Stoke Mandeville Hospital, Buckinghamshire, UK[18] and Maidstone and Tunbridge Wells NHS Trust Hospitals, UK[19] outbreaks noted that environmental cleaning was an area where there could have been improvements. This provided a focus for the trust to improve its CDI rates. Although there are other measures necessary to reduce CDI as already mentioned, but not included in this study and may therefore be considered as variables within this observational study, the change in cleaning product has coincided with the timing of reduction in rates and has demonstrated a significant impact on rate reduction. There was no other change in protocol for environmental cleaning during the time of product change.

Patients who are symptomatic with diarrhoea have always been, and continue to be, a priority for isolation. Isolation within the trust is mandatory when CDI is confirmed. The method for collecting stool samples and laboratory testing for *Clostridium difficile* has also not changed during the introduction of the product. Prior to their introduction, rates of CDI were reported at fortnightly IPC meetings to clinical, division, nursing, operational and medical leads and this continues. Indeed, this has been an essential forum of key trust staff, chaired by the Director of Infection Prevention and Control who drive forward the trust IPC programme.

Conclusion

Strategies to prevent and control CDI must include a range of approaches. This observational study demonstrates the positive impact of introducing a dedicated sporicidal product into environmental cleaning on CDI rates. Persistent monitoring to maintain the momentum of implementation proved important in fostering ownership by bedside staff to ensure sustained use of the sporicidal wipe. Do they work? CDI rates for the trust have fallen by over 70% and the improvement has been sustained. The cost savings demonstrated during this study have underlined the cost benefits of investigating and implementing proven improvement processes, such as this change to peracetic acid Sporicidal wipes in environmental cleaning. These Sporicidal wipes have provided an invaluable investment in reducing CDI rates, improving patient safety and quality of care and have been evaluated by users as an essential product of choice.

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