Major Article

Reproducible elimination of *Clostridium difficile* spores using a clinical area washer disinfector in 3 different health care sites

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Background: Following a *Clostridium difficile* infection outbreak, the Infection Prevention and Control team at our institution queried the risk of transmission via bedpans reprocessed in washer disinfectors (WDs). This study's objective was to determine the effectiveness of the mechanical action, detergent, and temperature on the eradication of *C difficile* spores in 1 type of WD model.
Materials and methods: Three types of reusable bedpans/pots were inoculated with sterile human feces that contained 1×10^7 CFU/mL *C difficile* spores. The 0.3 mL fecal-spore suspension was inoculated in sealed cryovials. These items were reprocessed using the longest wash cycle of WDs in 9 clinical units, and then tested for residual *C difficile* spores. The number of colonies on each replicate organism detection and counting plate was recorded after anaerobic incubation at 35°C for 48 hours, and the log reduction was calculated.
Results: All 9 WDs met the manufacturer's operational specifications. Forty-three (96%) of 45 bedpans had no viable spores (>5.9 $\log_{10}$ *C difficile* spore reduction). Two bedpans had 1 to 2 spores remaining. Viable *C difficile* spores were isolated from all 9 cryovials.
Discussion and conclusions: Results demonstrated that when operating the WD as stipulated, *C difficile* spores were satisfactorily eliminated from bedpan surfaces. Temperature alone was insufficient to kill *C difficile* spores. It also suggested the importance of staff training, machine maintenance, and WD purchase specifications.
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The increased incidence of *Clostridium difficile* infection (CDI) with cases caused by hypervirulent strains seen nationally[1,2] was becoming evident at the local level and resulted in the declaration of a major CDI outbreak at 1 of Island Health's regional acute care hospitals. The Infection Prevention and Control team reviewed all possibilities for transmission in an effort to reduce the spread.

CDI results in the shedding of spores, which are hardy and capable of surviving for long periods of time within the environment. Patients experiencing CDI often require the use of bedpans (eg, bedpans, slipper pans, or commode pots) to manage their frequent loose stools. Washer disinfectors (WDs) located in often small, soiled utility rooms in clinical areas are used to process these utensils, rather than sending them to centralized medical device reprocessing departments (MDRDs). These WDs are operated by nursing staff who have acutely ill patients, time constraints, and minimal training on the machine's operation, which leads to the circumvention of the correct loading and management of the utensils. Older model WDs often lack alarms or controls to prevent inappropriate use. Because bedpans are capable of being a vehicle for transmission,[3-5] it is critical that at minimum the WDs are capable of eliminating or killing spores. There is a scant amount of literature published regarding this issue.

Our study focused on how effective a WD, commonly used among Health Authority facilities was in eliminating or killing *C difficile* spores when appropriate mechanical action, temperature, and use of an alkaline detergent were used.

MATERIALS AND METHODS

WDs

Island Health uses a number of different types of WDs in its acute care hospitals and long-term-care facilities. The DEKO-190 Washer Disinfector (Franke Medical, Oy, Naarajarvi, Finland) was assessed

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in this study because it was the WD used predominantly in the hospital where the CDI outbreak occurred. Because Island Health provides health care services throughout Vancouver Island and the islands of the Georgia Strait, 3 clinical units, in 3 acute care hospitals inclusive of the outbreak site, located in different cities on the island were selected for the study.

The DEKO-190 uses a microprocessor to control washing and thermal disinfection to clean and disinfect a variety of reusable ward utensils, such as bedpans, urinals, washbasins, bowls, and other noncritical equipment used in patient care. It has the capacity to include multiple items in 1 load. It has 5 automated programs, with users selecting the program that they believe is appropriate for the items being cleaned and how soiled the item is.

Although the manufacturer sets each of the 5 selectable programs to an established time frame, each can be adjusted to extend the duration of time for both washing and steam disinfection. In addition, the volume of detergent supplied to the cleaning cycle can be adjusted. The thermal decontamination phase of the cycle has a fixed temperature of 91°C that is maintained for 1 minute. The WD has a display panel that indicates to the user the cycle and the water temperature, and if the detergent is low and in need of refilling. The DEKO-190 is ISO-registered[6] and meets European Electrical Standards and Canadian Standards Association[7-9] requirements.

For the purpose of this study, the longest wash and disinfection program (Cycle 5) was selected. This cycle lasts for a minimum of 11 minutes and consists of a 5-second cold water rinse followed by a 5-second warm water rinse, 5-minute circulated warm water wash with detergent, 15-second hot water rinse, ending with thermal disinfection via steam at 91°C for 1 minute. The additional time for the cycle is the time needed to fill the WD with water at the appropriate temperature for each of these components; with time dependent on the water pressure at the site. An alkaline detergent with a pH of 12 used regularly in Island Health was selected for the wash cycle. This detergent does not contain an enzymatic. A new bottle was obtained for each site to prevent the possibility of prior contamination and to ensure that the correct dilution was used.

Before the study, all 9 machines underwent a preventative maintenance check by an Ekotek Global Inc, Sudbury, Canada) technician who also inspected and cleaned all valves and spray nozzles. The correct alkalinity of the detergent was verified and the temperature for Cycle 5 was calibrated to 91°C.

It was hypothesized that the water hardness might affect the efficacy of the detergent. In discussion with members of the Facility Maintenance and Operations Department at these 3 hospitals, it was determined that all areas had water classified as soft. This was, therefore, constant in the study and had no influence on the results.

Utensils and cryovials

Well-used reusable plastic bedpans (n = 45), plastic slipper pans (n = 9), and stainless steel commode pots (n = 3) were collected from clinical units. This mix was used to determine if there were differences in cleaning effectiveness based on the style of bedpan/pot used. All were cleaned and disinfected at the same MDRD to ensure baseline cleanliness at the start of the study. They were then transported to the microbiology laboratory for labeling and inoculation. The test and negative control bedpans were labeled with the site, washer number, and test number. The bedpans were designated as 45 test bedpans (T1-T5), 9 negative control (T6), and 3 positive controls (not numbered and retained in the laboratory). Bedpan T1 was a slipper pan at all sites. The commode pots were marked as T5 and tested at the single acute care site where they are used regularly. The remaining test pans were regular plastic bedpans that were marked

Table 1
Sites inoculated on reusable bedpans and commode pots

Sites inoculated on reusable bedpans and commode pots		
Device	Designation	Site inoculated
Plastic slipper pan	T1	Outside bedpan on underside surface
		Inside bedpan under front lip
Plastic bedpans	T2-T5	Outside bedpan on underside surface
		Inside bedpan under seat side lip
Stainless steel commode pot	T5 (1 hospital only)	Outside bedpan on underside surface
		Inside bedpan under seat side lip
Plastic bedpans	T6 (negative control)	Not inoculated but sites outlined as for T2-T5
Plastic bedpans	Positive control	Outside bedpan on underside surface
		Inside bedpan under seat side lip
		Outside bedpan on seat surface

T2-T5. The inoculation sites for the various bedpans are listed in Table 1.

Twelve cryovials from the microbiology laboratory were used. Nine were placed in mesh holders so they could be hung in the WDs and be exposed to the washing–disinfecting cycle. Three were retained in the microbiology laboratory as the positive control for each day of testing.

Efficacy of WDs in removing and/or killing C difficile spores

The methodology used in a previous study conducted by Alfa et al[10] was followed with some modifications for the study in Island Health, including testing a different type of WD. The concentration of the *C difficile* spore preparation used is supported by published data[11] that show a median concentration of 6.67 $\log_{10}$ CFU/g feces in 203 ToxAB-positive stool samples, after using an alcohol-shock culture method.

Each day of testing, a *C difficile* spore preparation of 1×10^8 CFU/mL was diluted 1:100 with sterile feces (feces sample that was steam sterilized) to give a final volume of 6 mL. The final fecal-spore count was determined by serially diluting this preparation 1:10 from 10^{-1} through 10^{-4}. One hundred microliters of each dilution was plated in triplicate onto CDMN (Clostridium difficile Moxalactam Norfloxacin) media and incubated anaerobically at 35°C for 48 hours. Plates with 20-200 organisms were counted, and the colony forming units per milliliter and the $\log_{10}$ colony forming units per milliliter were calculated.

The base of a replicate organism detection and counting plate was used to make 2 circles on each bedpan to be tested and 3 circles on each of the positive and negative control pans (Table 1). Working in the biological safety cabinet, 100 uL prepared fecal-spore suspension was inoculated and spread over the surface of each test and positive control circle. When dry, the inoculated areas were protected by taping either the lid or base of a sterile Petri dish over the inoculation area. Each test and negative control bedpan was put into a sterile zip-top bag. The positive control bedpan (1 per day of testing) was left in the biological safety cabinet. Three hundred microliters of the fecal-spore suspension was added to each labeled cryovial (the vial was labeled with the site and WD number) and 100 uL to the positive control cryovials (1 per day of testing). Each test vial was put into a mesh sack and placed into a zip-top bag. The positive control vial was refrigerated.

Inoculated bedpans numbered T1-T5, the negative control bedpan number T6, and test cryovial were collected from the microbiology laboratory at a prescheduled time. This ensured that all bedpans would be washed and disinfected within 24 hours of their being inoculated with the fecal-spore suspension. The zip-top bags of bedpans and cryovials were placed into a large cooler for off-site transport or onto a clean covered trolley for clinical units at the same

site as the microbiology laboratory. An infection preventionist (IP) was dedicated to the study and responsible for following an established testing procedure.

To prevent contamination of the test materials, the counter spaces adjacent to the WDs were cleared, cleaned with accelerated hydrogen peroxide at strength of 1:16, and then disinfected with bleach 5,000 ppm. The interior of the WD was wiped down with accelerated hydrogen peroxide and disinfected with bleach using the same concentrations. The WD was inspected and checked to ensure all sprayers were free moving and clear of any blockages. The WD was then run empty on Cycle 5.

Beginning with the first bedpan (a slipper pan) numbered T1, the pan was removed from under the protective cover, the Petri dishes were removed from the test sites, and the bedpan and a single cryovial were placed in the WD. The protective cover and Petri dishes were disposed of in a biohazard bag. The bedpan was then run through the Cycle 5 clean. During the cycle, the volume of detergent was measured with the use of a graduated cylinder and recorded. The highest temperature achieved was also recorded. Upon completion of the cycle, the bedpan was removed from the WD, visually inspected, and the marked inoculated sites were covered with clean Petri dishes and secured with tape. The bedpan was then placed into a new protective cover. The pan was placed on the previously cleaned and disinfected counter.

This process was repeated for each bedpan T2-T5. After the completion of all test bedpans, the negative control bedpan (T6) was run through the Cycle 5 clean and handled in the same manner as T1-T5. The intent of the control bedpan was to determine if spores could remain in the WD and adhere to items in subsequent loads. All processed and bagged bedpans were returned to a disinfected stainless steel cart or into coolers for immediate transportation back to the microbiology laboratory. To ensure that clinical areas were not contaminated during testing, the WD and adjacent counters were cleaned and disinfected.

This process at the 3 hospitals resulted in data from 45 test bedpans (9 plastic slipper pans, 3 stainless steel chamber pots, and 33 plastic regular bedpans) and 9 cryovials. The cryovial testing was not completed in conjunction with the bedpans at 1 site because they were mistakenly left behind. Three cryovials were transported by the microbiology laboratory staff 2 days later and run through Cycle 5 in the 3 designated test WDs at that site.

Upon return of the cleaned and disinfected utensils and cryovials to the lab, replicate organism detection and counting plates of CDMN were gently pressed for 5 seconds on all inoculated areas indicated on all bedpans, inclusive of the positive and negative control utensils. The cryovial fecal-spore count was determined by serially diluting each preparation (including the positive control) 1:10 from 10^{-1} to 10^{-4}. One hundred microliters of each dilution was plated in duplicate onto CDMN media. All plates were incubated anaerobically at 35°C for 48 hours. The number of colonies on each replicate organism detection and counting plate was recorded and the log reduction was calculated. Colonies on plates from the cryovial subcultures were also recorded and the colony count and log reductions were calculated.

Following the microbiology laboratory's collection of samples for the study, bedpans were transported in sealed bags to the MDRD to be washed, sterilized, and bagged for storage.

RESULTS

All 9 WDs reached a cycle temperature of 91°C and a wash cycle of 5 minutes for the detergent wash stage. The manufacturer's stated time of 11 minutes for the entire cycle was achieved by all machines. There was a wide range in the amount of detergent drawn automatically by each machine and also by the individual loads within the same machine. The study demonstrated a range from 25-100 mL detergent. The variation could not be explained, but did not appear to correlate with the efficacy of either cleaning or removal of *C difficile* spores (Table 2).

Three types of bedpans (plastic regular, plastic slipper pans, and stainless steel commode pots) were used in this study to determine if style made a difference in cleaning efficacy. Of the 45 bedpans, all were visibly clean following the cleaning cycle. Two regular plastic bedpans had viable spores remaining (1 bedpan had 1 spore on 1 of the 2 test areas; another bedpan had 2 spores on 1 of the 2 test areas). There was no correlation with hospital site, WD, cycle temperature, cycle time, or amount of detergent dispensed to explain the reason for these residual spores. The remaining 43 bedpans had no viable spores after being cleaned and disinfected (Table 3 and Figure 1). The bedpans labeled T6 were not inoculated with fecal-spore suspension, but were marked for testing. These simulated areas were sampled using replicate organism detection and counting plates pressed directly onto the marked areas. This provided the opportunity to determine if spores remained in the WD from inoculated utensils and could potentially adhere to subsequent bedpans. None of these 9 bedpans had any spores, indicating that there was no cross-contamination between loads. All of the 9 positive bedpans retained in the lab had growth identified as "too numerous to count."

To test the effectiveness of temperature alone on killing *C difficile* spores, cryovials containing the same fecal-spore suspension were placed in the WD with bedpan T1 for the entire cycle. Spores in the cryovials were not subjected directly to the mechanical action or detergent wash of the cycle. Viable *C difficile* spores were isolated from all 9 of the cryovials tested, although many showed a significant log reduction. The log reduction of the cryovials ranged from 3.2-2 (Table 3 and Figure 2). The 3 positive cryovials retained in the microbiology laboratory had no log reduction in *C difficile* spores.

DISCUSSION

WDs are being used more frequently in acute care hospitals and long-term-care facilities to reprocess bedpans, urinals, and

Table 2
Results of parameters evaluated for the washer disinfectors (WDs), by site (S)

Site-WD	Cycle time	Temperature reached	Detergent amount	Visual inspection	Bedpan log reduction
S1-WD1	13 min	92°C	25-35 mL	All visibly clean	5.95
S1-WD2	13 min	92°C	40-45 mL	All visibly clean	5.95
S1-WD3	18 min	92°C	30-35 mL	All visibly clean	4.64-5.95
S2-WD1	Not recorded	92°C-93°C	50-52 mL	All visibly clean	5.92
S2-WD2	12 min	92°C-93°C	40-60 mL	All visibly clean	4.92-5.92
S2-WD3	13 min	92°C-93°C	35-40 mL	All visibly clean	5.92
S3-WD1	13 min	91°C-92°C	80-100 mL	All visibly clean	5.92
S3-WD2	13 min	92°C-93°C	45-50 mL	All visibly clean	5.92
S-WD3	11 min	91°C-93°C	35 mL	All visibly clean	5.92

Table 3
Clostridium difficile (CD) spore reductions on bedpans, commode pots, and cryovials postwashing in a washer disinfector (WD)

Site 1	Prewash log	Rodac plate count	Log reduction	Site 2	Prewash log	Rodac plate count	Log reduction	Site 3	Prewash log	Rodac plate count	Log reduction
WD1				WD1*				WD1			
T1[†]	5.95	NG	5.95	T1[†]	5.92	NG	5.92	T1[†]	NG	5.92	5.92
T2	5.95	NG	5.95	T2	5.92	NG	5.92	T2	NG	5.92	5.92
T3	5.95	NG	5.95	T3	5.92	NG	5.92	T3	NG	5.92	5.92
T4	5.95	NG	5.95	T4	5.92	NG	5.92	T4	NG	5.92	5.92
T5	5.95	NG	5.95	T5[‡]	5.92	NG	5.92	T5	NG	5.92	5.92
Vial[§]	5.95	—	3.43	Vial[§]	5.92	—	3.38	Vial[§]	—	5.92	1.12
WD2				WD2				WD2			
T1[†]	5.95	NG	5.95	T1[†]	5.92	NG	5.92	T1*	NG	5.92	5.92
T2	5.95	NG	5.95	T2	5.92	NG	5.92	T2	NG	5.92	5.92
T3	5.95	NG	5.95	T3	5.92	NG	5.92	T3	NG	5.92	5.92
T4	5.95	NG	5.95	T4	5.92	1 spore[¶]	4.92	T4	NG	5.92	5.92
T5	5.95	NG	5.95	T5[‡]	5.92	NG	5.92	T5	NG	5.92	5.92
Vial[§]	5.95	—	1.96	Vial[§]	5.92	NG	3.49	Vial[§]	—	5.92	3.75
WD3				WD3				WD3			
T1[†]	5.95	NG	5.95	T1[†]	5.92	NG	5.92	T1[†]	NG	5.92	5.92
T2	5.95	2 spores[‖]	4.64	T2	5.92	NG	5.92	T2	NG	5.92	5.92
T3	5.95	NG	5.95	T3	5.92	NG	5.92	T3	NG	5.92	5.92
T4	5.95	NG	5.95	T4	5.92	NG	5.92	T4	NG	5.92	5.92
T5	5.95	NG	5.95	T5[‡]	5.92	NG	5.92	T5	NG	5.92	5.92
Vial[§]	5.95	—	1.192	Vial[§]	5.92	—	2.98	Vial[§]	—	5.92	2.65

NG, no growth; *Rodac*, replicate organism detection and counting.
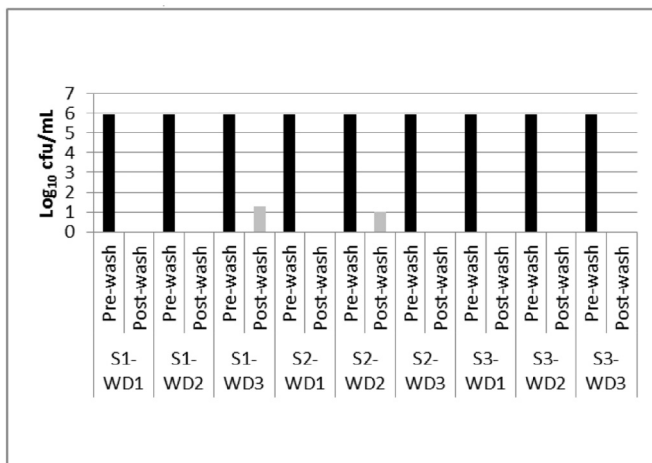*Was missing lower sprayer arm at the time of data collection.
[†]Slipper pan.
[‡]Commode pot.
[§]Cryovial placed in same cycle as T1.
[‖]2 spores found on one of the two test areas on bedpan – inside bedpan under seat side lip.
[¶]1 spore found on one of the two test areas on bedpan – inside bedpan under seat side lip.

Fig 1. Results of log reduction of *Clostridium difficile* (CD) spores on bedpans (combination of mechanical action, alkaline detergent, and thermal disinfection). Bedpans were soiled with feces and CD spores and dried overnight (see Materials and Methods). The level of CD spores prewash is shown by black bars and postwash by gray bars. *WD*, washer disinfector.
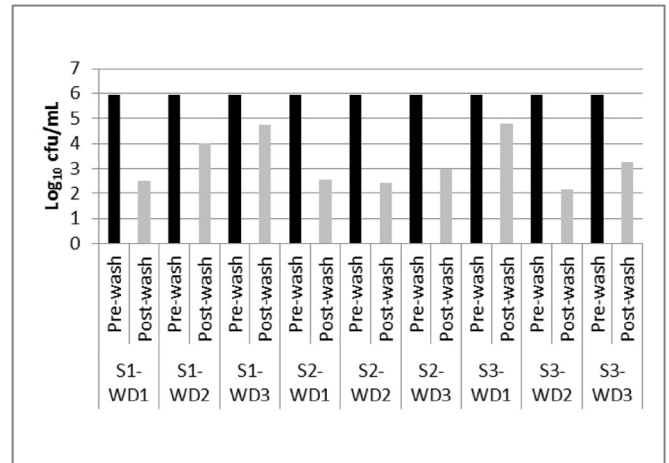
Fig 2. Results of log reduction of *Clostridium difficile* (CD) spores in cryovials (thermal disinfection only). Cryovials contained feces and CD spores (see Materials and Methods). The level of CD spores prewash is shown by black bars and postwash by gray bars.

washbasins in clinical areas, rather than sending these utensils to MDRDs. There are a number of different types and models of WDs used for this purpose. With the increasing incidence of hypervirulent *C difficile* strains, importance of preventing and controlling health care-acquired infections, increasing medical acuity of patients and increasing work and time constraints on nursing staff, a determination of the efficacy of WDs in eliminating or killing infectious organisms on reusable bedpans/pots is required.

Our study provides evidence that when operated in the manner specified by the manufacturer, the DEKO-190 WD, 1 type of WD used in the industry, satisfactorily eliminated *C difficile* spores. There was

96% elimination of *C difficile* spores (>5.9 $\log_{10}$ reductions) from 3 different types of bedpans/pots (43 of 45 bedpans). Two plastic bedpans had viable spores remaining (1 to 2 spores on 1 of the 2 test sites—under front lip of bedpan). There was no correlation with hospital site, WD, cycle temperature, cycle time, or amount of detergent dispensed to explain the reason for these residual spores. The evidence of spores in the cryovials indicated that temperature alone was insufficient to adequately kill or eliminate *C difficile* spores. This suggests there is a narrow margin of safety for the WD that requires a combination of proper maintenance and operation of the machine, appropriate detergent selection and use, as well as adequate initial and ongoing education for staff using the WD to ensure its effectiveness.

The current guidelines[8,9,12-14] on reprocessing of reusable containers exposed to feces do not specify that there must be complete elimination of *C difficile* spores. There is a lack of evidence to define the number of spores required to cause human infection. There are studies that show a correlation between *C difficile* fecal load and positive results on routinely used diagnostic tests.[11,15] More studies are needed to address the concerns regarding *C difficile* spore survival on reprocessed bedpans/pots so that WD manufacturers and health care users can know what level of eradication of *C difficile* spores is appropriate. It is also suggested that these studies look at the effect on patient outcomes.

Although there is a limited amount of data published on the efficacy of WDs in eradicating infectious organisms, those that are available have reached similar conclusions. Alfa et al[16] found that *C difficile* spores could be eliminated from bedpan surfaces by using the intensive cycle of the tested WD in conjunction with an alkaline detergent and a thermal disinfection phase of 85°C for 1 minute. Dempsey et al[17] concluded that WDs have the potential to improve cleaning processes for patient utensils used in the clinical unit. Other studies conclude that the thermal disinfection standards set in the EN ISO 15883-1[6] (ie, 80°C for 1 minute followed by 90°C for 6 seconds) are not sufficient to eliminate *C difficile* spores from bedpans.[10,18,19]

Metcalf et al[4] identified the potential for increased *C difficile* spore contamination after reprocessing bedpans in an aging cart washer using an acidic detergent. Bryce et al[3] identified the human factors (eg, not processing bedpans promptly allowing human waste to dry on surfaces, double stacking utensils in WDs, empty detergent dispensers, and use of machines when spray heads were obstructed), that can influence the functioning of the WD.

A limitation of our study is that the DEKO-190 WD was tested under ideal conditions; that is, 1 bedpan per cleaning cycle rather than multiple items as it is designed to hold, and established study procedures conducted by an IP who ensured that the surrounding area was clean and the WD was functioning and operated properly, alkaline detergent was available and dispensed appropriately, and the bedpan was placed properly. It did not address the operational and human factors identified by Metcalf et al[4] and Bryce et al[3] that can impede effectiveness.

To provide additional data on the efficacy of the DEKO-190 in eliminating *C difficile* spores, it would be worthwhile conducting further clinical studies to assess the WD when clinical staff are reprocessing bedpans/pots used by patients with known CDI when there is a full WD load. In addition, the influence of clinical staff members' circumvention of proper operating practices because of work and time constraints, lack of WD alarms and controls, and environmental space limitations, on the WD's efficacy in eliminating *C difficile* spores needs to be more fully studied.

CONCLUSIONS

This study identified the potential for using WDs to reprocess bedpans/pots in clinical areas. It also suggested the need for health care organizations to ensure that appropriate training of staff, maintenance of machines, and purchase specifications forcing proper operations are in place to support infection control reprocessing practices.

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